ISLAMIC UNIVERSITY OF TECHNOLOGY

Navigation: A novel approach for indoor localization with improved accuracy

By:

Taufiq Al Din (094407)

Md. Nasid Ahmed (094418)

Supervised by:

Kashif Nizam Khan

Assistant Professor

Department of Computer Science and Engineering

A thesis submitted in partial fulfilment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering

Academic Year: 2012-2013

Department of Computer Science and Engineering

Islamic University of Technology.

A Subsidiary Organ of the Organization of Islamic Cooperation.

Dhaka, Bangladesh.

October 23, 2013

Declaration of Authorship

We, Taufiq Al Din & Md. Nasid Ahmed, declare that this project titled,'Navigation: A novel approach for indoor localization with improved accuracy ' and the work presented in it are our own. We confirm that:

- This work was done wholly while in candidature for a Bachelor degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.

Submitted By:

Taufiq Al Din (094407)

Md. Nasid Ahmed (094418)

Navigation: A novel approach for indoor localization with improved accuracy

Approved By:

Prof. Dr. M.A. Mottalib
Head of the Department,
Department of Computer Science and Engineering,
Islamic University of Technology.

Kashif Nizam Khan
Thesis Supervisor,
Assistant Professor,
Department of Computer Science Of Technology,
Islamic University of Technology.

ISLAMIC UNIVERSITY OF TECHNOLOGY

Abstract

CSE
Department of Computer Science and Engineering

Bachelor of Science in Computer Science and Engineering

Navigation: A novel approach for indoor localization with improved accuracy

by
Taufiq Al Din
Md. Nasid Ahmed

Localization has been one of the most talked topics for its use in different areas of human life.Much of recent thesis work has been done on this basis.As outdoor localization has not been able to identify people in indoor environment,indoor localization has come to solve this problem.In this thesis paper we focus on indoor localization for its latest application,need of modern time and different techniques.Indoor localization helps to locatee people in indoor environment as well as show route to certain destination.We tried to introduce new techniques as well as reviewing most of technologies based on indoor localization.In this thesis paper we introduce LASER based indoor localization technique.

Acknowledgements

Special thanks to:

Prof. Dr. M.A. Mottalib

Head of the Department

Department of Computer Science and Engineering

Special thanks to:

Kashif Nizam Khan

Thesis Supervisor

Assistant Professor

Department of Computer Science and Engineering

Contents

List of Figures

Dedicated to our parents....

Chapter 1

Introduction

1.1 Background

Navigation is one of the most needed parts of human's life. As human being for our basic needs we have to go out and visit unknown places. So we need localization information. Localization is called positioning or navigation. It is a technique for determining one's position accurately whether he is in indoor or outdoor. This technique also provides the user orientation and routing information along with the exact location of the user. So be located and be guided in an unknown location this technique is essential.

1.2 Motivation

Thanks to free Global Positioning System (GPS) signals broadcast by satellites, and free online maps from companies like Google, Nokia and Apple, all you need is a smartphone with an internet connection to pinpoint your location on the Earth surface and call up maps, directions and local information. But when we are in indoor locations and even we are outdoors in a built-up area, the lack of a clear view of the sky can prevent GPS working properly, because its satellite signals are easily blocked by roofs, nearby buildings or even trees. For positioning to work indoors, where people spend most of their time, new technologies are needed. GPS satellites work by broadcasting ultra-accurate time and position data using on-board atomic clocks, allowing a receiver to calculate its location by comparing signals from four or more satellites. But in indoor if we want to locate out correct position we have to think in different way and that way should be an easy one which can provide us an accurate location. For this many works is now going on. Many researchers are now doing research on it to make it easy and correct. Accurate indoor localization on smartphones, however, remains elusive. But they are facing challenge in making the floor plan and correcting the location of the user. For accuracy there are some recent commercial offerings such as Google Maps 6.0 and Shopkick [ ], they either have errors up to 10 meters [ ], or only give room level accuracy. There has been a plethora of academic work on indoor localization. Those achieving high accuracy usually require special hardware not readily available on smartphones [ ], or infrastructure expensive to deploy [ ]. Indoor Atlas proposed a technique with high accuracy, but needed magnetic field and other extra features [ ]. WiFi-based localization leverages prevalent wireless access points can be a solution. But the feasibility of leveraging the most prevalent WiFi infrastructure for high accuracy localization on smartphones is still an open question. For making the process dynamic there many technique is used. Some tried to make the floor plan dynamically [ ], and collect the fingerprint of that location. But problem is found in room recognition and separating the fingerprints in different rooms. And they can only offer it in an office environment, where people have to walk through a corridor. For solving these problems many works are going on. To accurate the mapping and make it dynamic now a challenge to solve.

1.2.1 Objectives

The objective of indoor localization is to give navigation facility to a person in indoor environment. The system has to give user his current position with direction to reach his destination. For this the system should be wireless and has ability to communicate with the user when user needs its services. For this many people are working on many different fields. Most common indoor localization technique is WiFi based technique. The methodology of this technique is given below.

1.2.2 Methodology

Majority of the system use receive signal strength (RSS) as metric. RSS fingerprints can be easily obtained from most off-the-shelf wireless network equipments, such as WiFi- or ZigBee-compatible devices. In these methods, localization is divided into two phases: training and operating.

In the first stage, traditional methods involve a site survey process, in which engineers record the RSS fingerprints (e.g., WiFi signal strengths from multiple Access Points, APs) at every location of an interested area and accordingly build a fingerprint database in which fingerprints are related with the locations where they are recorded. Next in the operating stage, when a user sends a location query with his current RSS fingerprint, localization algorithms retrieve the fingerprint database and return the matched fingerprints as well as the corresponding locations.

1.2.3 Scopes

In the above process there is some limitations. First of all in training face site survey is not a easy process. site survey is time-consuming, labor-intensive, and vulnerable to environmental dynamics, it is inevitable for fingerprinting-based approaches, since the fingerprint database is constructed by locationally labeled fingerprints from on-site records.

1.2.4 Limitations

Indoor localization suffers from some limitations. Cost of localization process has been a concern for long time. Accuracy is also a matter of concern. Accurate map construction is often costly and time consuming. User contribution is also a key factor for dynamic processes. Extra infrastructures are needed in some process which is not readily available. Device heterogeneity causes lesser accuracy.

Chapter 2

Literature Survey

2.1 Related work

To locate in indoor environment and also to reduce the cost of process several techniques have been adapted. There are several kinds of indoor localization techniques available to provide indoor localization with greater accuracy. Cost has been a major concern in this respect. So several techniques have been proposed to reduce the cost. Several interesting location-aware applications for indoor environments are emerging in the research fields. Some of them are: Asset tracking and monitoring : tracking the objects like projectors for ease of finding as well as theft protection. In academic building and office environment projectors can be tracked through this application. People tracking : This application helps to track human like doctor in a hospital to quickly route the nearest doctor to emergencies. Can be used to track suspicious persons also. Shopping assistance: in shopping malls by giving the users the ability to find the locations of specific items in stores as well as displaying information about those items such as the price and where is the cheapest place to get them. Museum guide systems : inform the visitors of a museum with the location of the various attractions as well as providing specific information about those attractions once the user is near them. some of localization techniques are:

2.2 Global Positioning System

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of

Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS. satellites transmit signals to equipment on the ground. GPS receivers passively receive satellite signals; they do not transmit. GPS receivers require an unobstructed view of the sky, so they are used only outdoors and they often do not perform well within forested areas or near tall buildings. Each GPS satellite transmits data that indicates its location and the current time. All GPS satellites synchronize operations so that these repeating signals are transmitted at the same instant. The signals, moving at the speed of light, arrive at a GPS receiver at slightly different times because some satellites are farther away than others. The distance to the GPS satellites can be determined by estimating the amount of time it takes for their signals to reach the receiver. When the receiver estimates the distance to at least four GPS satellites, it can calculate its position in three dimensions. Once it has information on how far away at least three satellites are, your GPS receiver can pinpoint your location using a process called trilateration.

2.2.1 Trilateration :

Trilateration falls under the category of Triangulation where the geometric proper-ties of triangles are used to compute the objects' locations. trilateration is the process of determining absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres or triangles. In addition to its interest as a geometric problem, trilateration does have practical applications in surveying and navigation, including global positioning systems (GPS). In contrast to triangulation it does not involve the measurement of angles. In two-dimensional geometry, it is known that if a point lies on two curves such as the boundaries of two circles then the circle centers and the two radii provide sufficient information to narrow the possible locations down to two. Additional information may narrow the possibilities down to one unique location. In three-dimensional geometry, when it is known that a point lies on three surfaces such as the surfaces of three spheres then the centers of the three spheres along with their radii provide sufficient information to narrow the possible locations down to no more than two. If it is known that the point lies on the surface of a fourth sphere then knowledge of this sphere's center along with its radius is sufficient to determine the one unique location. The trilateration

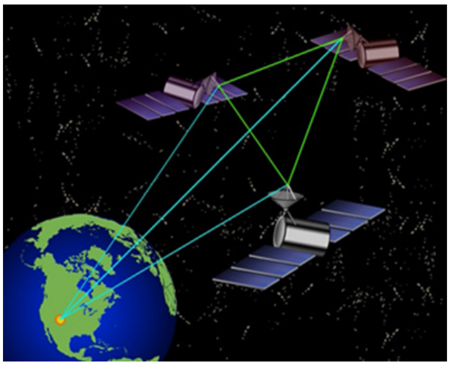

Figure 2.1: GPS system for outdoor positioning

technique works by measuring the distance to three distinct non-collinear reference points from the object of interest X and then applying a triangulation algorithm to obtain the position of the object. The triangulation algorithm is achieved by drawing a circle of radius d which centered at the reference point, where d is the measured distance from the access point to the object of interest at X. Using three access points, three circles could be drawn which would intersect at a point X. This point would indicate the location of the user. In order to measure such distance, three general approaches exist .

2.2.2 Direct:

This method involves physically measuring the distance between the mobile object and three different reference points which is infeasible and inapplicable to the applications of indoor positioning. It generally involves robots that measure the distances through extension of probes .

2.2.3 Time-of-flight:

Time-of-flight works by recording the time it takes for a signal to propagate from a transmitter to a receiver at a known velocity. Since this method involves time measurement, a specific clock resolution must be attainable by the system according to the timing technology used. Ultrasound based systems do not require a very good resolution as the waves travel at the speed of sound so the differences to be measured are usually in the milliseconds range. On the other hand, systems using RF Signals [12] such as WLAN and Blue-tooth would need to have a much higher clock resolution since radio waves travel at the speed of light so the time difference is usually in the nanosecond range which is 6 times less in the order of magnitude than the ultrasound based technologies . According to the timing technology, two systems for measuring the time-of-flight exist. In the first one, which could be used with ultrasound, the devices must have highly accurate synchronized clocks so that the difference in the time of transmission of the signal and the time of its arrival at the other end can be measured and converted into a distance. For the other system that can be used with WLAN, a method based on round trip time is used where the sender sends a signal and expects a reply. The time it takes for receiving the reply implies the distance between the two nodes [10]. This system overcomes the need for an accurately synchronized clock because the sender's clock would only need to be accurate enough for it to measure the round trip time. A challenge that has to

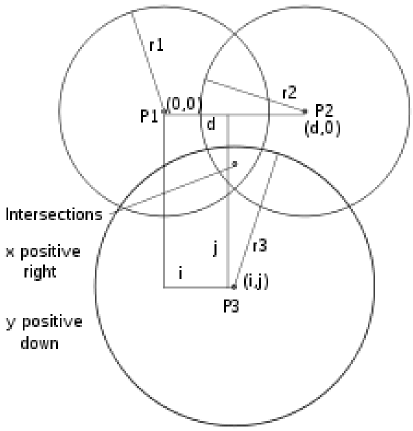

FIGURE 2.2: Triangulation

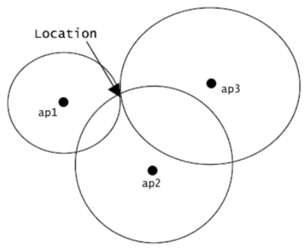

Figure 2.3: Triangulation

FIGURE 2.3: Triangulation

be faced when using the time-of-flight method is how the receiver could distinguish between the direct pulses and pulses arriving after reflecting the objects in the environment, specially that they look identical to the receiver.

Such reflecting pulses would have traveled a longer path and hence have a longer time-of-flight which would imply to the receiver that the sender is further away than the actual distance resulting in a reduced accuracy. Some implementations such as [10] make use of statistical analysis and analysis of the reflective properties of the environment to prune some of the pulses which are reflected, resulting in improved accuracy Some of the systems that are based on the time-of-flight method include GPS[13], ActiveBat[10], Cricket[8], Bluesoft[14] and PulsON. Attenuation: The intensity of the emitted signal is inversely proportional to the square of the distance from the source. Using this relation and given the signal strength at the source, the measured signal strength could be used to estimate the distance of the object from the source. Measuring the distance using attenuation is usually less accurate than using time-of-flight especially in environments with many obstructions which cause a lot of signal reflection.

2.3 Indoor Localization:

An indoor positioning system (IPS) is a network of devices used to wirelessly locate objects or people inside a building [1]. Generally the products offered under this term do not comply with the International standard ISO/IEC 24730 on real-time locating systems (RTLS). There is currently no de facto standard for an IPS systems design, so deployment has been slow. Nevertheless, there are several commercial systems on the market. Instead of using satellites, an IPS relies on nearby anchors (nodes with a known position), which either actively locate tags or provide environmental context for devices to sense. The localized nature of an IPS has resulted in design fragmentation, with systems making use of various optical,[3] radio,[4] or even acoustic technologies. Received signal strength indication (RSSI) is a measurement of the power level received by sensor. Because radio waves propagate according to the inverse-square law, distance can be approximated based on the relationship between transmitted and received signal strength (the transmission strength is a constant based on the equipment being used), as long as no other errors contribute to faulty results. The inside of buildings is not free space, so accuracy is significantly impacted by reflection and absorption from walls. Non-stationary objects such as doors, furniture, and people can pose an even greater problem, as they can affect the signal strength in dynamic, unpredictable ways. A lot of systems use enhanced Wi-Fi infrastructure to provide location information.[4][5][6] None of these systems serves for proper operation with any infrastructure as is. Unfortunately, Wi-Fi signal strength measurements are extremely noisy, so there is ongoing research focused on making more accurate systems by using statistics to filter out the inaccurate input data. Wi-Fi Positioning Systems are sometimes used outdoors as a supplement to GPS on mobile devices, where only few erratic reflections disturb the results. Other approaches for positioning of pedestrians propose an inertial measurement unit carried by the pedestrian either by measuring steps indirectly (step counting) or in a foot mounted approach,[18] sometimes referring to maps or other additional sensors to constrain the inherent sensor drift encountered with inertial navigation. Inertial measures generally cover the differentials of motion, hence the location gets determined with integrating and thus requires integration constants to provide results.

Systems design shall take into account, that unambiguous locating service requires at least three independent measures per target. For smoothing to compensate for stochastic errors there must be a mathematical over-determination that allows for reducing the error budget. Otherwise the system must include information from other systems to cope for physical ambiguity and to enable error compensation.

2.4 Indoor Localization Techniques:

2.4.1 Bluetooth Beacon Based Technology:

Bluetooth based indoor positioning system has been deployed in recent years to locate user in indoor environment (such as building, shopping mall, conference). In Bluetooth based technology Bluetooth has been used as beacon to identify one's position. As Finding a person in a public place, such as in a library, conference hotel, or shopping mall, can be difficult. The difficulty arises from not knowing where the person may be at that time; even if known, navigating through an unfamiliar place may be frustrating. So Bluetooth beacon can be an efficient solution to address the problem. A the current techniques use dynamic localization techniques user input and contribution is necessary to populate the signal map as well as increase the accuracy of positioning. After prompting for user input, the mobile device not only submits Wi-Fi fingerprint to a map server, but also enables Bluetooth beacons to disseminate/share its location and fingerprint information to quickly populate the signal map. Then, subsequent user devices entering the area can discover the Bluetooth beacons and are able to instantly obtain room-level location information without causing unnecessary prompting to users. Bluetooth beaconing capability aims to provide room-level accuracy, yet avoiding expert-based site-survey cost. The use of Bluetooth beacons provides several additional benefits: 1) It facilitates the bootstrapping and decrease unnecessary user prompting, which can improve user experience. 2) It provides room-level accuracy with high confidence even when only few fingerprints are available for the targeted area. This trait also ensures that the quality of such obtained fingerprints can be fair enough to be used for a signal map, which expedites the map construction process. location information shared by beacon reduces the need of frequent communication with a remote map server for evolving updates, and thus potentially helps in power conservation. 4) Bluetooth protocol is designed to minimize interference, and beacons are set up in an ad-hoc and on-demand manner. These properties enable beacons to grow automatically to provide scalability. Use of Bluetooth beacon increases Prompting Efficiency. When a user is located at unknown locations, a localization system should promptly ask for user inputs in order to improve the map coverage. However, frequent prompting will disturb users, and this becomes even worse if the system cannot distinguish explored areas from unexplored areas with a high probability. By introducing Bluetooth beacon, users in explored areas will not be falsely prompted, thus improving prompting efficiency and usability of the system. It also provides accuracy with High Confidence. While existing Wi-Fi crowd-sourcing localizer produces meaningful estimate only after the certain amount of fingerprints have been accumulated over a large part of the areas, using Blue-tooth beacons system can immediately provide accurate result with high confidence in areas where a user(s) has explored and beacon is set up. It helps in accelerating Map Growth. Bluetooth beacons can work as a projection from signal map to physical space. Knowledge conveyed via beacons helps other devices generate reliable fingerprints, and thus quickly populate the signal map without frequent prompting, when the physical area is densely populated. When the signal maps need to be downloaded into local cache, beacons can be used as indices to minimize the size of map downloads. There should be a central map server for aggregating finger-prints measured by crowd-sourcing devices. During a bootstrapping period, a Wi-Fi crowd-sourcing localizer needs to frequently communicate with the server to obtain timely updates contributed by other contemporary users. Beacon in the physical space helps in reducing communication overheads, thus improving power efficiency.

2.4.1.1 Papers under bluetooth beacon based technology:

- Human Localization using Mobile Phones, MobiCom'10.
- Problem statement

Finding a person in a public place, such as in a library, conference hotel, or shopping mall, can be difficult.. This paper proposes an electronic service called ESCORT that uses mobile phone sensors and opportunistic user-intersections. By periodically learning the walking trails of different individuals and how they encounter each other in space-time, a route can be computed between any pair of persons. Using a audio beacon ESCORT guides a user to the vicinity of a desired person in a public place.

- Challenges:

1. When Alice wants to find Bob in shopping mall-problems are
2. Bob's location unknown
3. Even if known still require- WALK-able routes to Bob,
4. in his vicinity, identify Bob.
5. As the current localization techniques relies on too heavy infrastructure requirements, this paper proposes a lightweight technique (ESCORT)

- Methodology
- Trail calculation:

Mobile phones capture users' "movement traces" using accelerometer and compass measurements. When other phones are in the vicinity, each phone also records these "encounters" with a corresponding time stamp. A ¡movement trace, encounter¿ report is periodically uploaded to a remote server. From this information the remote server calculates the trail of users.

1. TRAIL=¡ ¡displacement, direction,time¿

As accelerometers are noisy and its hard to correct a entire trail, a beacon is used that is randomly placed. The beacons position can be viewed as the origin of a virtual coordinate system. Any user that encounters this beacon can be ap-proximately repositioned to this origin. Thus his error gets reset. when this repositioned user en-counters other users (for some time in the future), the other users can correct their own positions in respect to this user.

- Trail graph and route computation:

Users trails are periodically uploaded to a cloud server through WiFi connection. The server computes the trail graph by taking the intersection points of user trails. By taking the positions of intersection points and device current position the server computes the TRAIL GRAPH through the user can be routed the destination.

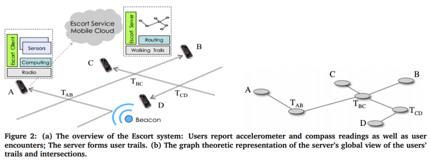

FIGURE 2.4: ESCORT system

- Trial Correction:

As calculated TRAIL differs from actual TRAIL . So it needs to be corrected. It can be corrected through-

1. correcting User Location
2. correcting user TRAILS.

User location can be corrected with the help of beacon. Each of the device including the beacon periodically sends audio tone and also receives tone from other devices. When a user encounter a beacon the amplitude of the audio will be greater than a predefined threshold. It also indicates that the user has joined the ESCORT system. When the user device encounters the beacon its position can be counted as accurate with respect to beacon. User device can also correct its position if it encounters a device that has already encountered the beacon. As user TRAILS can be drifted because of compass bias. It needs to be corrected also. using a correction vector (v) compass bias problem can be corrected.

- Visual Identification:

If two person are not known to each other then after going to his/her vicinity, to identify the destination user the user who is routed through ESCORT must take as many photos as possible to generate fingerprint. For a given event/venue, each mobile phone will opportunistically take pictures of its owner . characteristics of the user's appearance, such as clothing color and texture, can be summarized into a "fingerprint". If the fingerprint with person's name is periodically beaconed, other mobile devices can utilize them to pinpoint the individual.When Alice has reach Bob, she can take photos of surroundings. Recorded images will be analyzed and each individual in the picture isolated through image processing. The fingerprint of the isolated individuals can be computed and compared against the beaconed fingerprint.

- Problems of the paper:

1. Routing through physical obstacles
2. Long Routing Paths
3. Routing Instructions under Low Location Accuracy
4. Phone Placement
5. Behavior under heavy user load.

- Improving Crowd-Sourced Wi-Fi Localization Systems using Bluetooth Beacons. 2012 IEEE
- Problem Statement

This paper presents a crowd-sourcing localization system that uses both Wi-Fi scene analysis and Bluetooth beacons to address the insufficient contribution challenge. When users are asked for location, besides adding the location record to signal map they can also choose to encode this location information and the current Wi-Fi signal observation into a Bluetooth beacon. subsequent user devices entering the area can discover the Bluetooth beacons and are able to instantly obtain location information without causing unnecessary prompting to users.

- Challenge:

1. construction of map with accuracy and speed.
2. use of Bluetooth to share the location for subsequent user

- Methodology
- Faster and Accurate map construction

In order to construct a map indoor localization uses two phases:

1. training
2. query

In the training phrase fingerprints from the access points (AP) are collected. These fingerprints are collected from referenced points. This procedure is called scene analysis or site survey. Wi-Fi finger print consists of a position descriptor, a list of visible access points and corresponding RSSI statistics, namely observation. For areas of interest, a map of fingerprints, the signal map is compiled through site survey. When a mobile user is localizing, Wi-Fi observation at unknown location is collected and then is matched against reference fingerprints in the signal map. This procedure is called query or matching.

- Modified Distance Metric

In this paper A mobile device issues ten consecutive Wi-Fi scans, and then RSSI values are calculated for each visible AP. Finally, they are stored as fingerprint along with a valid record count (w), which keeps the number of observations for each AP in the 10-round-scan. Each fingerprint collected from different time and locations may include the list of different observed Aps. So before applying the distance metric different fingerprints have to be formatted into such lists that consist of the same set of Aps. a fusion step is necessary to examine all fingerprints and generate an aggregated AP list. Aps that are not observed in certain fingerprints, their RSSI values are replaced with an 'invalid' one (i.e., -100dBm). Throughout our experiment, some Aps (transient Aps) temporarily appear on site-survey phase and then disappear on localization phase or vice versa. These APS becomes the source of errors. To avoid such errors, we define and use the valid record count (w), which is defined as the ratio of record count over total scans. The experiment space is gridded into 1m2 tiles. Total 109

$$D_{om} = \sqrt{\frac{1}{c}\sum_{i=1}^{n} w_i (r_i^o - r_i^m)^2},$$

FIGURE 2.5: Distnace metric

fingerprint is collected for experiment. map with the highest resolution is denoted as 1m2 map. map construction has following two methods:

- Remove

granularity region with unit grid is selected and sample is removed randomly and only 1 sample is left.

- Merge:

samples are merged using Gaussian distribution and Resulting parameters define each region. all collected samples are given as input into the 1-NN-based localizer with the modified RMSE metric. 1-NN-based localizer can achieve an better accuracy.

- Bluetooth EIR as localization beacon

Bluetooth has two components:

1. Frequency hopping inquiry process for neighbor discovery
2. Extended Inquiry Response (EIR)

This paper proposes to use inquiry process for neighbor discovery and EIR to carry fingerprint from the beaconing node.

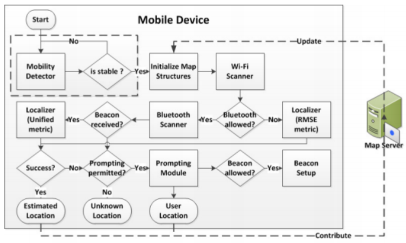

Fig. 2. System architecture

FIGURE 2.6: Beacon based architecture

- System Design

- Problems of the paper:

1. User Incentive
2. MAC address revealed
3. Erroneous Contribution

2.4.2 Mobile Sensor Based Technology:

Various mobile sensor (accelerometer, compass, Gyroscopes) has been used to locate user at indoor environment. Its been called indoor navigation system. Accelerometer and compass has been used to continuously calculate via dead reckoning the position, orientation, and velocity (direction and speed of movement) of a moving object without the need for external references. Gyroscopes measure the angular velocity of the system in the inertial reference frame. By using the original orientation of the system in the inertial reference frame as the initial condition and integrating the angular velocity, the system's current orientation is known at all times. This can be thought of as the ability of a blindfolded passenger in a car to feel the car turn left and right or tilt up and down as the car ascends or descends hills. Based on this information alone, the passenger knows what direction the car is facing but not how fast or slow it is moving, or whether it is sliding sideways. Accelerometers measure the linear acceleration of the system in the inertial reference frame, but in directions that can only be measured relative to the moving system (since the accelerometers are fixed to the system and rotate with the system, but are not aware of their own orientation) tracking both the current angular velocity of the system and the current linear acceleration of the system measured relative to the moving system, it is possible to determine the linear acceleration of the system in the inertial reference frame. Performing integration on the inertial accelerations (using the original velocity as the initial conditions) using the correct kinematic equations yields the inertial velocities of the system, and integration again. A compass is a navigational instrument that shows directions in a frame of reference that is stationary relative to the surface of the earth. The frame of reference defines the four cardinal directions (or points) - north, south, east, and west. Intermediate directions are also defined. Usually, a diagram called a compass rose, which shows the directions (with their names usually abbreviated to initials), is marked on the compass. When the compass is in use, the rose is aligned with the real directions in the frame of reference, so, for example, the "N" mark on the rose really points to the north. The magnetic compass was first invented as a device for divination as early as the Chinese Han Dynasty (since about 206 BC).[1][2][3] The compass was used in Song Dynasty China by the military for navigational orienteeringThe magnetic compass consists of a magnetized pointer (usually marked on the North end) free to align itself with Earth's magnetic field. A compass is any magnetically sensitive device capable of indicating the direction of the magnetic north of a planet's magnetosphere. The face of the compass generally highlights the cardinal points of north, south, east and west. Often, compasses are built as a stand alone sealed instrument with a magnetized bar or needle turning freely upon a pivot, or moving in a fluid, thus able to point in a northerly and southerly direction. The compass greatly improved the safety and efficiency of travel, especially ocean travel. A compass can be used to calculate heading, used with a sextant to calculate latitude, and with a marine chronometer to calculate longitude. It thus provides a much improved navigational capability. Camera has been used recently in indoor localization techniques to identify a person. Through camera we can get visual identification of the person we are searching. The front camera and the back camera take picture of the surroundings and upload it to a server. The server applies image processing algorithm on the pictures to locate the desired object. we can use camera to create fingerprint in database. increasing number of sensors on mo-bile phones presents new opportunities for logical localization. We postulate that ambient sound, light, and color in a place convey a photo-acoustic signature that can be sensed by the phone's camera and microphone. In-built accelerometers in some phones may also be useful in inferring broad classes of user-motion, often dictated by the nature of the place. By combining these optical, acoustic, and motion attributes, it may be feasible to construct an identifiable fingerprint for logical localization. Hence, users in adjacent stores can be separated logically, even when their physical positions are ex- tremely close. When a mobile phone user visiting an unknown store. The phone senses the ambience automatically. The sensed values are recorded, pre-processed, and transmitted to a remote server. Once the sensor values arrive at the server, they are forwarded to the fingerprinting factory. The fingerprinting factory segregates the type of sensor data (sound, color, light, WiFi, accelerometer) and distributes them to respective fingerprinting modules. These modules perform a set of appropriate operations, including color clustering, light extraction and feature selection.

2.4.2.1 Papers Under Mobile Sensor Based Technology:

- Zee: Zero-Effort Crowdsourcing for Indoor Localization, MobiCom'12
- Problem statement

To reduce the site survey effort this paper proposes a system called zee that enables training data to be crowdsourced without any explicit effort on the part of users.users carry smartphones in which this software will be installed.

- Challenges:

To track users without any a priori, user-specific knowledge such as

1. user's initial location
2. stride-length
3. phone placement

- Methodology:

Zee employs a suite of novel techniques to infer location over time:

1. Placement-independent step counting and orientation estimation(PIME)
2. Augmented particle filtering to simultaneously estimate location
3. user-specific walk characteristics such as the stride length(APF)

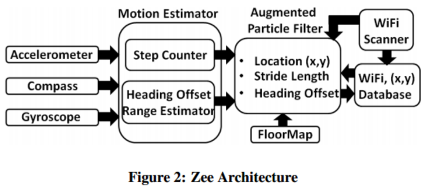

Figure 2.7: ZEE Architecture

4. Back propagation to go back and improve the accuracy of localization in the past
5. WiFi based particle initialization to enable faster convergence

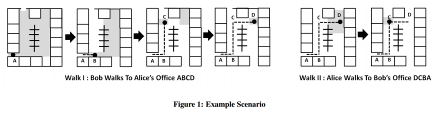

Figure 2.8: ZEE example scenerio

- Placement Independent Motion Estimator (PIME) :

PIME uses mobile sensors such as the accelerometer, compass, and gyroscope to estimate the user's motion. PIME performs three key functions:

1. user moving or not.
2. the angle between the orientation of the phone and the user's direction of motion(heading off).
3. A key feature of PIME is that it is independent of device placement. All these information are given to Augmented Particle Filter (APF).

- Augmented Particle Filter (APF):

The APF uses the motion estimates from PIME and the floor map as input to track the user's location on the floor. The key function of the APF is to track the probability distribution of a user's location as he/she walks on the floor. APF estimates step length, direction and head off. When a user walk for a longer period of time in indoor environment, the possibilities for the user's path and location shrink progressively. As a user walks in the indoor environment while going about their routine, Zee continually eliminates possibilities that violate wall constraints, until eventually only one possibility remains. Zee uses probability distribution to calculate location. When a user walks zee estimates users distance and direction through accelerometer and eliminates possibilities of walking through obstacles. by simply tracking his movements, Zee is able to eliminate all alternative possibilities and eventually determine location.

- Problem of The Paper:

1. Need frequent user walking for better location estimation.

2.4.3 Wi-Fi Based Technology:

Wi-Fi based technology has been among the most used ones.in stead of wired technology wireless technology has been used to localization. Rssi (received signal strength indication) from AP (access point) is received through mobile device. WIFI based technology mainly rely on fingerprinting method for indoor localization. Two procedure has been developed two incorporate the localization process. Static and dynamic. In the static process the test place is divided into grid of fixed length. Then the company that is supporting the facility will conduct a process of choosing the importing points where there is the chance of maximum density of people. This process is called reference points selection. This is a static process. From the reference points RSSI along with other information like signal strength, location is stored in the database as fingerprint. When a new user comes to the location and wishes to know of his own location signal from his device will be sent to database with the help of access points. This signal is sent from unknown points. When this new signal is arrived at the database it will be matched against the stored fingerprinting to find out the location. localization approaches employ Received Signal Strength (RSS) as a metric for location determination. RSS fingerprints can be easily obtained for most off-the-shelf equipment's, such as WiFi compatible devices. In these methods, localization is divided into two phases: training and serving. In the first phase, traditional methods involve a site survey process, in which engineers record the RSS fingerprints (e.g., WiFi signal strengths from multiple Access Points, APs) at every position of an interesting area and accordingly build a fingerprint database. Next in the serving phase, when a user sends a location query with its current RSS fingerprint, localization algorithms retrieve the fingerprint database and return the matched fingerprints as well as corresponding locations. Although site survey is time-consuming, labor-intensive, and easily affected by environmental dynamics, it is inevitable for those RSS fingerprint matching based approaches based on RSS fingerprint matching, since the fingerprint database is constructed based on on-site fingerprint collection. In scene analysis based, collect fingerprints of a scene and then estimate the location of a user by matching the fingerprint of the user with the collected fingerprint database. There are a few methods within this category including kNN (k nearest neighbor) and probabilistic methods. But now dynamic system has been deployed the engineer for indoor localization. In wifi based localization normally radio frequency is used to locate a person in indoor environment. Radio Frequency (RF) fingerprinting, based on WiFi or cellular signals, has been a popular approach to indoor localization. However, its adoption in the real world has been stymied by the need for site-specific calibration, i.e., the creation of a training data set comprising WiFi measurements at known locations in the space of interest. While efforts have been made to reduce this calibration effort using modeling, the need for measurements from known locations still remains a bottleneck. In static wireless indoor localization techniques a site survey procedure is required. A process used to determine the number and placement of access points (AP) that provides adequate coverage throughout the facility. With wireless systems, it's difficult to predict the propagation of radio waves and detect the presence of interfering signals without the use of test equipment. As a result, it's often necessary to perform a RF site survey to fully understand the behavior of radio waves within a facility before installing wireless network access points.

The ultimate goal of a RF site survey is to supply enough information to determine the number and placement of access points that provides adequate coverage throughout the facility. In most implementations, adequate coverage means support of a minimum data rate. A RF site survey also detects the presence of interference coming from other sources that could degrade the performance of the wireless LAN. Site survey involves intensive costs on manpower and time, limiting the applicable buildings of wireless localization worldwide. localization approaches utilize Received Signal Strength (RSS) as a metric for location determinations. RSS fingerprints can be easily obtained from most off-the-shelf wireless network equipments, such as WiFi- or ZigBee-compatible devices. In these methods, localization is divided into two phases: training and oper-ating. In the first stage, traditional methods involve a site survey process (a.k.a. calibration), in which engineers record the RSS fingerprints (e.g., WiFi signal strengths from mul-tiple Access Points, APs) at every location of an interest-ed area and accordingly build a fingerprint database (a.k.a. radio map) in which fingerprints are related with the loca-tions where they are recorded. Next in the operating stage, when a user sends a location query with his current RSS fingerprint, localization algorithms retrieve the fingerprint database and return the matched fingerprints as well as the corresponding locations. Although site survey is time-consuming, labor-intensive, and vulnerable to environmental dynamics, it is inevitable for fingerprinting-based approaches, since the fingerprint dat-abase is constructed by locationally labeled fingerprints from on-site records. In the end of 2011, Google released Google Map 6.0 that provides indoor localization and navigation available only at some selected airports and shopping malls in the US and Japan. The enlargement of applicable areas is strangled by pretty limited fingerprint data of building interiors. The development of wireless and embedded technology has fostered the flourish of smartphone market. Nowadays mobile phones possess powerful computation and communi-cation capability, and are equipped with various functional built-in sensors. Along with users round-the-clock, mobile phones can be seen as an increasingly important information interface between users and environments. These advances lay solid foundations of breakthrough technology for indoor localization.

2.4.3.1 Papers Wi-Fi Based Technology:

- Locating in Fingerprint Space: Wireless Indoor Localization with Little Human Intervention.
- Problem Statement

Most radio-based solutions require a process of site survey. Site survey involves intensive costs on manpower and time, limiting the applicable buildings of wireless localization worldwide. This paper proposes a system that constructs the radio map floor plan to eliminate the site survey process. It uses mobile sensors and user motion to construct the map.

- Challenges:

Building a stress free floor plan from the floor plan of building and fingerprint space from user motion and map them to build a fingerprint database that returns the location queried by user.

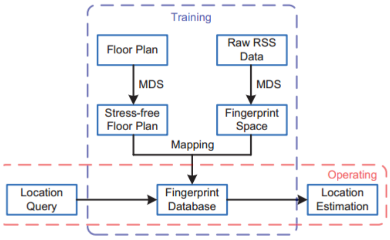

Figure 1: System architecture.

FIGURE 2.9: Wi-Fi based architecture

- Methodology:

This technology uses 2 key parameter:

1. Stress-free Floor Plan
2. Fingerprint Space

- Stress Free Floor Plan:

Using the MDS (multidimensional scaling) stress-free floor plan is made from the floor plan of the building. Multidimensional scaling (MDS) is a set of statistical techniques used in information visualization for exploring similarities or dissimilarities in data. MDS algorithm starts with a matrix of item-item dissimilarities, and then assigns a location to each item in d-dimensional space, where d is specified a prior. To make a stress-free floor plan at first floor plan is sampled with a unit length (=2m). Due to the constraints (walls, doors and other obstacles), Geographical distance between two locations does not necessarily equal to their walking distance. Construct stress-free floor plan in high dimension Euclidean space using MDS

- Fingerprint Space:

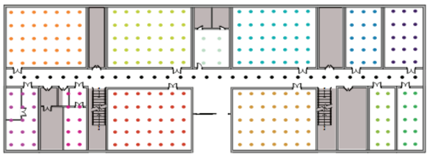

Figure 3: Floor plan with sample locations.

FIGURE 2.10: Floor plan with location

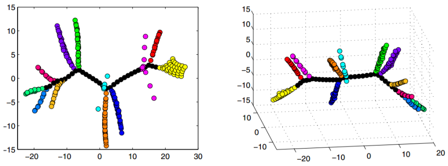

Figure 5: 2D stress-free floor plan. **Figure 6: 3D stress-free floor plan.**

FIGURE 2.11: Stress free floor plan

Fingerprints and users' mobility data are collected (only acceleration in LiFS) during their routine indoor movements .Fingerprints are clustered from the same or close locations.

According to distance matrix, transform all points into a d-dimension Euclidean space, i.e., the fingerprint space, using MDS.

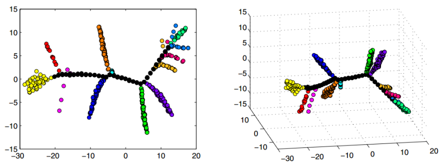

Figure 8: 2D fingerprint space. **Figure 9: 3D fingerprint space.**

FIGURE 2.12: Fingerprint space

- Mapping:

Mapping the fingerprint space to the stress-free floor plan to obtain fingerprint location database.

- Corridoor Recognition:

From the between ness algorithm corridors are separated from rooms. At corridor mapping has the height between nesses.

- Space Transformation:

Sample locations from each room are mapped to d-dimension stress-free floor plan.

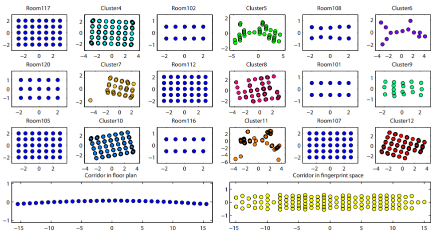
Figure 18: Fingerprints clusters vs. floor plan rooms.

FIGURE 2.13: Fingerprint cluster

- Problem of The Paper:

LiFS fits a majority of office buildings but may fail in large open environments, such as hall, atrium, gymnasium, or museum.

- Push the Limit of WiFi Based Localization for Smartphones
- Introduction:

The work is for highly accurate indoor localization of smartphones. It used WiFi localization for this purpose. They proposed a peer assisted localization approach to eliminate large errors. It obtains accurate acoustic ranging estimates among peer phones, then maps their locations jointly against WiFi signature map subjecting to ranging constraints.

- Works on this field::

Google Maps 6.0 and Shopkick provide maps. But they have error up to 10m. Some academic works are there but it requires special hardware or they are expensive. WiFi localization is used, but they have error 6m to 8m. One work of high accuracy exists, but only less than 100s of Aps.

- System Design Goals and Challenges:

1. Peer assisted localization:

Exactly what is the algorithm to search for the best fit position and quantify the signal similarity so that to reduce large errors?

1. Fast and concurrent acoustic ranging of multiple phones:

How to design and detect acoustic signals?

1. Ease of use:

Need to complete in short time. Not annoy or distract users from their regular activities.

- System Design:

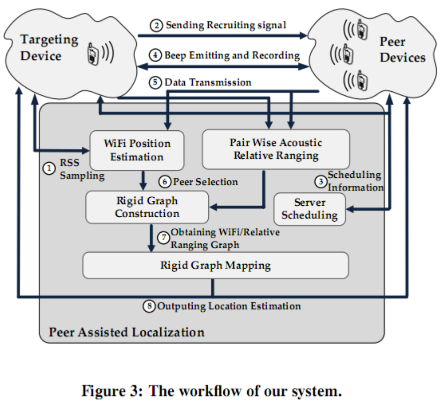

FIGURE 2.14: Peer assisted architecture

1. Target broadcasts a special audio signal to "recruit" nearby peers.
2. Those receiving the recruiting signal send their identifiers to a server.
3. The server comes up with a schedule about which phone should emit a beep signal at which time slot.
4. They record the beeps from others and send the files back to the server.
5. All peers also conduct WiFi sampling and send the measurements to the server.

6. The server determines the locations of peers from WiFi samples, and distances among them from acoustic ranging based on the recorded sound files.

7. Finally the server computes the new location estimate of the target using our peer assisted localization algorithm, and sends back the result to the target.

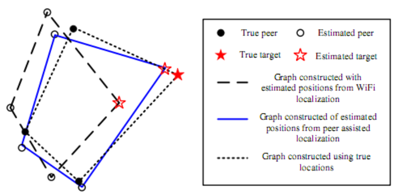

Figure 4: Illustration of using physical constraints to perform peer assisted localization.

FIGURE 2.15: Peer assisted localization

- Acoustic Relative Ranging:
- Problem:

1. How signal from different phone does not interfere?
2. Sound signal does not carry MAC address
3. Which phone emitted which sound?

- Solution:

1. Beep Signal Design and Detection
2. Acoustic Ranging Principle - Ranging can be done by Time-of-Arrival (TOA) method.
3. Beep Design - Frequency band between 16kHz and 20kHz.
4. Beep Detection - Change-Point Detection Method.

- Server Based Emission Schedule:

1. Identify Nearby Peers:

2. Beep Emission Strategy - time-division multiplexing.

- Discussion:
- Peer Involvement:

1. Peers need to run a recruiting signal detection thread
2. Server may send push notifications
3. after a timeout threshold, a peer will stop the thread

- Movements of users:

1. Movements affect the accuracy only when they occur during the sound-emitting period:

- Triggering peer assistance:

1. If nearby users request for help simultaneously server can detect and provide assistance one at a time.

- Contribution:

1. Discover the root cause of large errors of WiFi method.
2. Proposed a peer-phone assisted localization approach and peer-assisted localization algorithm.
3. It reduce the maximum error from 6 - 8m to 2m

- Limitations:

1. If peers are aligned almost on a straight line, or clustered together and located far away from the target.
2. High quality peers are needed..
3. Cloths or human body may attenuate the sound signal.
4. If two nearby target request for help simultaneously there may be delay.

- Wireless Indoor LocalizationWithout Site Survey (infocom 12):
- Introduction:

A majority of previous localization approaches employ Received Signal Strength (RSS) as a metric for location determination. Localization is usually divided into :

1. Training
2. Serving.

- Training

- involve the site survey process in which engineers record the RSS fingerprints at every position of an interesting area and build a fingerprint database

- Serving

- user sends a location query with its current RSS fingerprint, localization algorithms return the matched locations.

But the problems of site survey are many. They are

1. Time-consuming
2. labor-intensive
3. Easily affected by environmental dynamics

so they different method in there thesis. They are

- wall-penetrating effect

1. signals may encounter a considerable abrupt change while passing through a wall
2. RSS of a same AP can vary significantly in two rooms

- Tri-axial accelerometers:

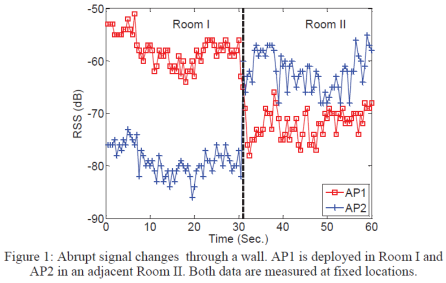

FIGURE 2.16: Room detection by signal

1. obtain user movements and utilizes moving traces to assist localization
2. explore reachability between different areas

- WILL Architecture:

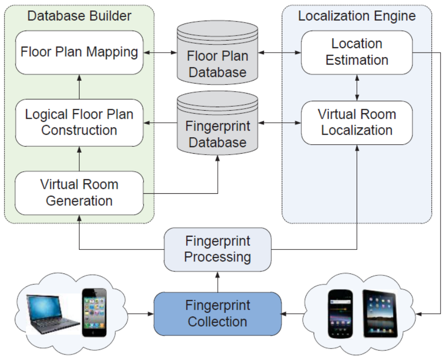

FIGURE 2.17: Will architecture

- Fingerprint Collection:

1. users do not need to deliberately collect data:

The information of WiFi signals and sensor readings is collected automatically by their smart phones

1. Continuous vs. discontinuous records:

If the records are measured during user's movements or not

- Fingerprint Processing:

1. Due to signal instability, it is inadequate to utilize absolute RSS values directly for location estimation
2. RSS stacking difference
3. cumulative difference between one AP and all other Aps

- Floor Plan Mapping:
- Skeleton Mapping

1. Betweeness centrality
2. st is the number of shortest paths from s to t
3. Vertices that occur on many shortest paths between other vertices have higher betweenness
4. A certain number of vertices which have higher betweenness are mapped to the corridor segments

$$C_B(v) = \sum_{s \neq v \neq t \in V} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

FIGURE 2.18: Betweeness centrality

- Branch-knot mapping:

1. the rest vertices are mapped using Kuhn-MunKras Algorithm [23]

$$w(v) = \sum_{u \in P,\ u \neq v} d(v, u)$$

FIGURE 2.19: Branch-knot mapping

1. as weight, solve the weighted minimum bipartite matching

$$\sum_{v \in V} |w(v) - w(p(v))|$$

FIGURE 2.20: Branch-knot mapping1

Algorithm 1 Correction

```
correction = false
for each vertex s in S_P
  if ND(N_P(s), N_M(s)) > |N_M(s)|/2 then
    find v∈ S_P minimizing ND(N_P(s), N_M(v))
    map s to v
    correction = true
  else
    for each vertex v in N_P(s) ∪ N_I(s)-{s}
      if v∉N_P(s) and v∈N_I(t) and v∉S_P then
        remove mapping from s to v
        correction = true
      else if v∈N_P(s) and v is not mapped then
        find u∈N_M(t) minimizing |w(v)-w(p(u))|
        set p(v) = p(u)
        correction = true
      end if
    end for
  end if
end for
```

FIGURE 2.21: Correction Algorithm

- Correction Algorithm:

- Experiment:

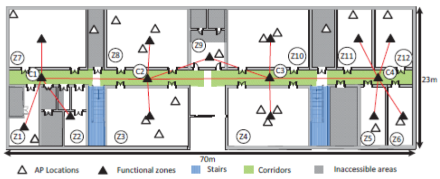

Figure 5: Floor plan of the building in Tsinghua University. APs with unknown locations are not marked.

FIGURE 2.22: Floor plan of building

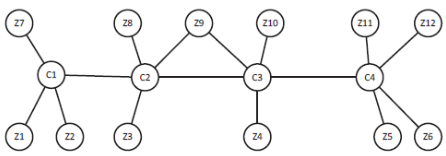

Figure 6: Ground truth floor plan graph. Vertices marked with 'Z' denote physical rooms and vertices marked with 'C' denote corridor segments.

FIGURE 2.23: Ground truth floor plan

- Conclusion:

1. WILL is an indoor logical localization approach without labor-intensive site survey or knowledge of AP locations and power settings
2. It achieves an average room-level accuracy of 86, which is competitive to existing designs

2.4.4 VLC (Visible Light Communication):

The Visible light communication (VLC) is a communication technology which uses visible light as optical carrier for data transmission and illumination. Visible light is free. No company owns property rights for visible light and thus no royalty fees have to be paid nor does expensive patent-license have to be purchased in order to use visible light for communication purposes. VLC offers a real alternatives to radio based communications since the spectrum is free, plentiful, and the cost of implementation is actually less than equivalent radio technology. The visible light spectrum is 10,000 times larger than the radio frequency spectrum. The prime function of LEDs is to provide illumination. VLC is harmless for our health as well as our daily circumstances. VLC utilizes the visible light source as a signal transmitter, the air as a transmission medium, and the appropriate photodiode as a signal receiving component. Visible light is the form in which electromagnetic radiation with wavelengths in a particular range is interpreted by the human brain. Visible light is thus by definition comprised of visually-perceivable electromagnetic waves. The visible spectrum covers wave lengths from 380 nm to 750 nm.

- Visible Light Communication Process:

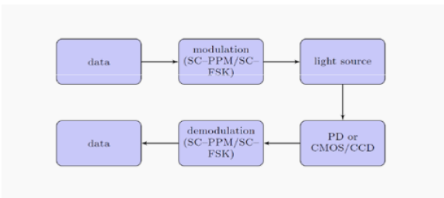

FIGURE 2.24: VLC architecture

In VLC as a transmitter LED is used. LED illumination is used as a communication source. Since the illumination exists everywhere, it is expected that the LED illumination device will act as a lighting device and a communication transmitter simultaneously everywhere in a near future. Photodiode is used as a receiver.

- Using VLC for Locating Person In Indoor Environment:

The lighting can be used as a visible light ID system, which informs an exact location (for example, A corner of Room Number 123, ABC Building, etc). each light has a different ID, which shows a different exact location. This positioning system can be used even in the underground subway station,shopping mall etc, where GPS is not accurately used. The system is also very convenient for the emergency use (Indoor Navigation System). This is used inside hospitals, too.

- Problems of VLC Technology:

1. LOS (LINE OF SIGHT) :

To successfully transmit data, there has to exist a line of sight between sender and receiver, because visible light cannot penetrate solid items or objects.

1. Short Range :

The range of VLC is not too long. So it creates problems.

2.4.5 RFID(Radio Frequency Identification) Technique:

Radio Frequency Identification (RFID) is an automatic identification method. A RFID system consists of a tag, a reader and an antenna. The tag is a transponder that can be attached to or incorporated into a product, animal, or person for the purpose of identification using radiowaves. The reader (i.e., a transceiver) is able to read the stored information of the tag in close proximity. RFID tags contain antennas to enable them to receive and respond to radiofrequency queries from an RFID transceiver. There are various typesof tags; i.e., passive, active and semipassive tags. Passive RFID tags do not have their own power supply and the read range is less than for active tags, i.e., in the range of about a few mm up to several meters. Active RFID tags, on the other hand, must have a power source, and may have longer ranges and larger memories than passive tags. Many active tags have practical ranges of tens of meters, and a battery life of up to several years. Another advantage of the active tags compared to the passive tags are that they have larger memories and the ability to store additional information (apart from the tags' ID) sent by transceiver. For these reasons, the applications described in this paper make use of active RFID tags with a frequency range of 865.6-867.6 MHz. RFID (Radio Frequency Identification) is a type of automatic identification system: portable tags stuck on any kind of product (clothes, smartcards, currency) transmit data wirelessly to readers, which are often connected to computer networks, facilitating the transfer of data to databases and software applications that process the data according to the needs of a particular use. The data stored by the tag may provide identification or location of the product attached to, or specifics characteristics about the product tagged, such as price, color, or date of purchase. To employ RFID for positioning and tracking of objects, one strategy is to install RFID readers at certain waypoints (e.g. entrances of buildings, storage rooms, shops, etc.) to detect an object when passing by. For that purpose an RFID tag is attached to or incoporated in the object. This concept is employed for example in theft protection of goods in shops and in warehouse management and logistics. A second approach for using RFID in positioning would be to install RFID tags at known locations (e.g. at active landmarks) especially in areas without GPS visibility (e.g. in tunnels, under bridges, indoor environments, etc.) and have a reader and antenna installed in the mobile device carried by the user. When the user passes by the tag the RFID reader retrieves its ID and other information (e.g. the location). In the case of cell-based positioning, i.e., Cell of Origin (CoO), the maximumrange of the RFID tag defines a cell of circular shape in which a data exchange between the tag and the reader is possible. Using active RFID tags the positioning accuracy therefore ranges between a few meters up to tens of meters. In our approach the maximum range of the signal can then be set at around 20 m. Higher positioning accuracies can be obtained using trilateration if the ranges to several tags are determined and are used for intersection. For 3-D positioning range measurements to at least three tags are necessary. The ranges from the antenna of the reader to the antenna of the tag is deduced from the conversion of signal power levels into distances.

- Problems of VLC RFID:

A double-edge sword, No tag presence awareness. No reader presence awareness, Silent readings, Line of sight, ID disclosure. Public identification, Product information leakage, Individual's tracking(location information and profiling), Corporations privacy threat.

2.4.6 Infrared Technique:

Infrared (IR) light is electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of the visible spectrum at 700 nanometres (nm) to 1 mm. This range of wavelengths corresponds to a frequency range of approximately 430 THz down to 300 GHz,[1] and includes most of the thermal radiation emitted by objects near room temperature. Infrared light is emitted or absorbed by molecules when they change their rotational-vibrational movements. Slightly more than half of the energy from the Sun arrives on Earth in the form of infrared radiation. The balance between absorbed and emitted infrared radiation has a critical effect on Earth's climate. Infrared energy elicits vibrational modes in a molecule through a change in the dipole moment, making it a useful frequency range for study of these energy states for molecules of the proper symmetry. Infrared spectroscopy examines absorption and transmission of photons in the infrared energy range.[2] Infrared light is used in industrial, scientific, and medical applications. Night-vision devices using active near-infrared illumination allow people or animals to be observed without the observer being detected. Infrared astronomy uses sensor-equipped telescopes to penetrate dusty regions of space, such as molecular clouds; detect objects such as planets, and to view highly red-shifted objects from the early days of the universe.[3] Infrared thermal-imaging cameras are used to detect heat loss in insulated systems, to observe changing blood flow in the skin, and to detect overheating of electrical apparatus. Thermal-infrared imaging is used extensively for military and civilian purposes. Military applications include target acquisition, surveillance, night vision, homing and tracking. Humans at normal body temperature radiate chiefly at wavelengths around 10 ?m (micrometers). Non-military uses include thermal efficiency analysis, environmental monitoring, industrial facility inspections, remote temperature sensing, short-ranged wireless communication, spectroscopy, and weather forecastin. Sunlight, at an effective temperature of 5,780 kelvins, is composed of nearly thermal-spectrum radiation that is slightly more than half infrared. At zenith, sunlight provides an irradiance of just over 1 kilowatts per square meter at sea level. Of this energy, 527 watts is infrared radiation, 445 watts is visible light, and 32 watts is ultraviolet radiation.[5] On the surface of Earth, at far lower temperatures than the surface of the Sun, almost all thermal radiation consists of infrared in various wavelengths. Of these natural thermal radiation processes only lightning and natural fires are hot enough to produce much visible energy, and fires produce far more infrared than visible-light energy.

The INFRARED system was developed by the Olivetti Research Laboratory .It uses infrared transmitters that are attached to users' badges. Infrared sensors are attached throughout the building. A central server collects the unique tags that are transmitted by the users' badges and associates them with the infraredsensor that is fixed inside the room. ActiveBadge localization system is room based localization system, and it provides a programmable application interface that allowsapplications to be developed on top of the system. An IR repeater system takes Infrared (IR) light coming from your remote controller and converts it to an electrical signal that can be easily distributed over electrical wiring to one or more IR remote controllable components.

- Problems of Infrared Technique:

Receiver required for everyone, must have direct LOS, cant cover the receiver when put in pocket, high intensity cause interference, large area required for multiple emitter channel, quality varies with company.

2.4.7 Ultrasound Identification:

Ultrasound Identification is a real-time locating system (RTLS) or indoor positioning system (IPS) technology used to automatically determine and identify the location of objects with room accuracy. The approach is using simple, inexpensive nodes (badges/tags) attached to the surface of persons, objects and devices, which then transmit an ultrasound signal to communicate their locations to microphone sensors. Because ultrasound signal wavelengths have short reach, they are confined to lesser distant locations than with wireless transmissions with higher susceptibility to multiple reflection, multipath and through-the-wall multiple room responses. Hence ultrasound-based RTLS is considered a more robust alternative to passive radio-frequency identification (pRFID) and even to active radio-frequency identification (aRFID) in complex indoor environments (such as hospitals), where radio waves get multiply transmitted and reflected, thereby compromising the positioning accuracy. Generally the ultrasound signal does not interfere with sensitive medical equipment.[1] A handicap of ultrasound nodes is the exposition of the sound transducer at the surface, which prevents from hermetically encapsulating the node. Vapour sterilisation is not offered with these nodes. ultrasound-based IPS say that sound waves can more accurately pinpoint people and objects than radio-frequency waves, which can be picked up by multiple sensors, making it difficult to figure out the exact proximity of a particular object to a given sensor. ”If you have an RF [radio-frequency] tag, it is emitting radiation through its antenna,” says Wilfred Booij, chief technology officer of Sonitor Technologies, AS, based in Oslo, Norway. The accuracy of RF waves is diminished within buildings, where the waves reflect off of metallic or ceramic objects. ”If you have a very open area, you can have very good accuracy with RF-between five and 10 meters [16 and 33 feet],” he says. But in complex buildings like a hospital, accuracy is more like 15 meters [49 feet]. Ultrasound is detected by microphones placed in rooms where the tracking is to be done. When ultrasound signals-which have short wavelengths-are emitted, the walls and doors confine the signals to that room. Sonitor is trying to improve the accuracy of its ultrasound system by shaping the sensitivity of its detectors to create subzones. The Cricket localization system uses ultrasound technology. Emitters are distributed within the environment and the receivers are embedded within the objects to be located. The devices that are to be located perform triangulation and time-of-flight calculations in order to locate themselves. The Cricket system can identify and ignore ultrasound signals that result from reflection, thus increasing the accuracy. Embedding the receivers in the devices and forcing them to computer their own location increases the power and processing requirements of such devices. A microphone can be designed to be more sensitive in a particular direction. We can shape the sensitivity of our detectors so that rather than picking up all the signals in a room, they pick up a specific signal that can be specific to a particular doctor or patient.

2.4.8 Camera:

The central idea of the new indoor positioning system is based on the fundamentals of stereo photogrammetry. But instead of using a second camera, it can be replaced with a device (called laser-hedgehog) that projects well-distributed laser spots as flexible reference points on the ceiling, walls and furniture in any indoor environment . The projecting light source consists of several focused laser-beams that originate from a static, well-defined central point. The 3D directions of the laser-beams are also precisely known through a previous calibration. Since the concept of camera pinhole projection and the projection of laser spots from a central origin rely on the same principle, namely the central projection, the beams of the laser-light emitting device simulate the light path of a camera. Hence, the second camera can be simulated by the projecting device. During the measurement phase the digital camera observes the reference field. Having carried out the point identification for the individual laser beams in the camera image, the relative orientation can be derived by solving the coplanarity constraint of the epipolar geometry . For solving the coplanarity constraint a 5-point-algorithm has been chosen. Unfortunately the 5-point-algorithm provides up to 10 solutions for every camera position. In order to identify the correct essential matrix, the algorithm has been embedded into a RANSAC algorithm. Then, the correct essential matrix is decomposed into a translational vector b and a rotational matrix R and finally refined by a least-squares estimation of the relative orientation parameters.

- Problem:

1. Accuracy problem
2. expensive
3. security problem
4. greater in amount needed.

2.4.9 Laser Meter:

Laser stands for Light Amplification by Stimulated Emission of Radiation. It is based on the fact that an excited atom returns to a lower energy state by either spontaneously emitting a photon or being stimulated to do so by electromagnetic radiation. The photon emitted by stimulation is emitted in the same direction as and in phase with the stimulating radiation. An emitted photon can help stimulate other atoms to emit photons, thereby causing an avalanche effect. As all atoms strive to be in as low energy state as possible, few atoms are in an excited state under normal condition. The idea in a laser is that by pumping the laser media, i.e. exciting the atoms so that a much higher percentage than normal is excited (called inverse population), the stimulated emission of photon is going to be the dominating effect. By putting a pair of respective surfaces at the end of the laser cavity, the wave will be reflected back and forth, increasing the energy with every pass in the direction of the cavity. In order to sustain the inverse population, energy has to be feed into cavity to pump the feed into cavity to pump the media. By making one of the surfaces only partially reactive, part of the wave can be taken out of the cavity. The transmitted energy forms the laser beam. media. By making one of the surfaces only partially reflective part of the wave can be taken out of the cavity. The transmitted energy forms the laser beam. Having found applications in so many areas, it is not surprising that the laser has been used to measure distances. Already in the 1970s NASA made use of laser techniques for this purpose. At that time the technique had not reached the right level of maturity to be applicable in a large scale. It is obvious that measuring distance with light requires high precision electro optics.The dominating techniques for laser base measurements are TOF-techniques and phase-shift-techniques. In a TOF system a short laser pulse is sent out and the time until it returns is measured. The ranging principal is thus the same as for the standard sonar sensor. A sensor of this type is often referred to as laser radar or lidar. In order to realize such a system, a high precision means for measuring time is needed. terms of a robot application a range resolution in the order of centimeters is desirable. This means that the precision in time has to be in the orderof100ps,correspondingto a frequency of 10 GHz. It is not difficult to understand that this puts high demands on the equipment. One advantage with the short pulses is that higher levels of powers can be used, giving better range coverage, but still keeping a high safety level and low power consumption. Commercially available systems today have reached below centimeter accuracy.

2.4.10 iGPS:

iGPS (indoor Global Positioning System) is a laser?based 3D measurement system which can be used for high precision industrial measurements. Its name 'iGPS' is misleading, because the measuring principle is different from its space?based counterpart GPS. iGPS consists of two or more static transmitters which continuously send out two rotating fan?shaped laser beams and a reference infrared pulse Based on Time Difference of Arrival (TDoA) between the three signals, the relative horizontal and vertical angles with respect to a receiver are determined.In order to establish a time?dependency between the arrival of the laser planes and the vertical angle, the rotation axis of the laser planes are tilted by an elevation angle of an?el = 30. The first laser plane follows the second at a 90 angle delay (one plane is tilted 30 to the left, the other 30 to the right). The horizontal angle to a receiver is estimated from TDoA between a laser plane and the reference pulse. A receiver's 3D position is determined from two angles of at least two orientated transmitters whose coordinates have been determined in a prior set?up phase. One can say that iGPS is based solely on triangulation, or more precisely on spatial resection. The system scale is introduced from the fixed length between two receivers .Two receivers mounted on a fixed stick(the so?called vector?bar) allow for determination of the stick's full pose. Accuracy of 3D positions is 0.2 mm.

2.4.11 Indoor atlas:

IndoorAtlas Ltd. is the world's first company to utilize magnetic anomalies inside buildings and smartphones to pinpoint positions indoors. Working procedure of indoor atlas:

- Step 1: Sign up

Create a free IndoorAtlas account.

- Step 2: Submit floor plans

The IndoorAtlas Floor Plans is a web application to add new buildings and floors, and to submit floor plans to IndoorAtlas for mapping.

- Step 3: Collect data

The IndoorAtlas Mobile app is used to record sensor data, to create maps by uploading the data to IndoorAtlas, and to test navigation.

- Step 4: Build apps with API

Indoor atlas buiids application and maps through this database IndoorAtlas' upcoming app uses the built-in compass found in most modern smartphones to detect changes in the earth's natural magnetic field - the same technique used by homing pigeons. These tiny alterations correspond to the position of man-made objects such as desks and shelves, as well as a building's fundamental materials, allowing users to reliably navigate around pre-prepared floor plans without the need for GPS or other positioning systems its technology provides accuracy of up to 10 centimeters, easily enough to navigate in most public places. With a recently-launched API program, it's opening up its so-called Indoor Positioning System (IPS) to select third-party developers, with the aim of creating an ecosystem around the technology before its public release.

2.4.12 Locata:

Locata, an Australian company, offers beacons that send out signals that cover large areas and can penetrate walls. Locata receivers work similarly to how GPS receivers work. The U.S. Department of Defense is an early Locata user. The Locata positioning system can give an end-user cm-level positioning. Our system works in exactly the same way as GPS. For a Locata receiver to calculate its position it has to see three transmitters, so that the system can "triangulate". One critical requirement for GPS systems to work is that the signal has to leave the transmitter at exactly the same time - in other words, all the clocks have to be synchronized to each other. (Any reader who really wants to delve into GPS basics should consult Wikipedia or other such sites.) To make this happen in GPS, every satellite contains 3 or 4 atomic clocks; they are incredibly accurate clocks - they will only lose 1 second in 300,000 years! Despite this incredible clock accuracy, these satellites still require an incredibly complex "GPS ground segment" to remain synchronized. It requires a large number of US military specialists running the system 24/7, to keep all of the atomic clocks in space synchronised to "a master atomic clock" on the ground. Think of this like a conductor with an orchestra. Locata completely breaks this paradigm - the core of what Locata has invented is a new way of synchronising transmitters without the atomic clocks, without the ground segment, without any assistance whatsoever. When you turn our LocataLite transmitters on, our system goes through a new synchronisation process we call TimeLoc (it's a play on time, location and lock). TimeLoc synchronises our transmitters without an atomic clock, without any assistance whatsoever. I hope I can impress the engineers and physicists reading this now the Locata network self-synchronizes to better than a nanosecond that's one-billionth of a second without an atomic clock. And we believe we can get it even better than that in the future. This is - seriously - a completely new way of providing the same functionality as GPS, without costing around 40 billion dollars to get a system of 24+ satellites into space. The synchronisation, timing and accuracy are simply amazing, and are the magic behind Locata technology. The most important outcome of our developments, however, is the fact that in the future you can make this signal available everywhere it's required. As this is an easy integration into a GPS we need people to understand what we have created last week we were granted a trademark by the USPTO which hopefully will encapsulate what we have achieved. The trademark is "GPS 2.0" - it's intended to convey that Locata is the "next generation", an essential improvement of this type of technology. GPS

2.0 is the world's first and only integration of satellite plus terrestrial GPS systems, a technology integration that will become one seamless positioning technology. This is truly a new development. I know from our history that there is not one industry analyst, anywhere, who predicted the arrival of our technology. Frankly, it's because nobody thought what we've done was possible. No analyst conceived the notion that a private company would develop a system that, in a local area, would provide a capability that had cost the US taxpayer 40 billion, and which you had to be a super-power to launch. The core invention that allows Locata Technology to relicate GPS on the ground is a completely new and patented synchronization method called TimeLoc. Locata positioning is capable of centimetre-level accuracy - outdoors and indoors. However, the positioning accuracy of a LocataNet can be designed to meet the specified accuracy requirements of a particular application, e.g. guiding automated forklifts in a warehouse. It is possible to design and build "custom" LocataNets because Locata is an autonomous terrestrial system. Locata navigation positions are generated by a "carrier-phase single-point solution". Locata can achieve such accuracy without requiring any external augmentation, differential correction or other information input. Survey-grade GPS technology is also able to deliver centimetre-level carrier-phase positioning, but not as a "single-point solution". To obtain high precision positioning from GPS, surveyors require access to other complex, additional technologies, such as reference receivers that are pre-deployed and surveyed into known positions, differential correction networks and communication data links that transmit corrections to an end-user. These additional systems remove the large errors in the standard (i.e. uncorrected) GPS system position solution. Professional survey-grade GPS receivers cost up to US10,000, and therefore are not affordable for general consumer use. Any desired "reference frame" can be provided by a LocataNet. If LocataLite transmit antennas are surveyed to be referenced to, say, the global WGS84 standard then the entire LocataNet will adopt and broadcast that reference base. However, surveyors often have to work within a "local reference" such as a local coordinate frame used in areas like open-cut mines. Setting up a LocataNet to utilize the same coordinate frame is relatively straightforward, which means that position calculations do not require conversion between different data sets. LocataLites are designed to be stationary when deployed, so they do not present a Doppler shift (except for any shift generated by user movement, of course). This greatly simplifies the search strategy required to acquire a Locata signal because the frequency shift is inherently much smaller than what is expected from satellite-based signals. Hence, when a Locata receiver acquires just one

LocataLite signal, it can almost instantly acquire all the others. The maximum signal power for devices in the ISM band is restricted by international regulation to +8 dBm within a 3 kHz bandwidth and to a maximum of 1 Watt. The generally accepted global guidelines for the ISM band are laid out in the United States' FCC Part 15B regulations, and Locata devices comply with this ordinance. The range of a LocataLite signal is generally in the order of tens of kilometres however, the range is limited mainly by terrain, much the same as mobile phone systems. At this time, Locata does not recommend separation of more than 5 km between LocataLites, except for specialist purposes such as military aircraft applications where higher-powered systems have been operated at distances of up to 50 km (30 miles) between LocataLite base stations.

2.4.13 ByteLight:

A company called ByteLight has brought a system called bytelight for indoor positioning system that works by using LED lighting. LED lighting provides devices with accurate location data. ByteLight's indoor location system works by controlling the pulses of LEDs so they work in a certain pattern. This pattern is not detectable to the human eye (it's working in the range of a hundreds of hertz), but can be picked up by the camera in a smartphone or tablet. Using the data gleaned from the LED modulation, the device works with an app and performs client-side calculations to figure out where it is within the structure. WiFi isn't needed so networking is not a problem, and the calculations are performed on the device, so everything happens quickly. Taking out smartphone and pull up the convention's app. The app triggers the camera, which scans the LED lighting in the area and uses that data to find current location - the more lights one is are under, the more accurate the location data. One can then hold the phone and navigate to one's destination, which is labeled on the built-in map, with location data updating in near real-time. If there are any notable booths along the way, the app could notice one's presence and inform about them. Using a form of visible light communication (VLC), ByteLight has a good shot at becoming a legitimate indoor location system. Before making any headway, the company will need buildings to move over to LED lighting, more specifically LED lighting with Byte Light-compatibility built-in. The good news here is that ByteLight apparently has no impact on the lights from a performance standpoint, and the cost of adding ByteLight's logic to a product is negligible. The bad news is that existing LED systems are not upgradable - ByteLight's tech needs to be built in from earlier on, which means companies need to partner with the startup. So far, ByteLight has only signed on Solais, though other partnerships are said to be in the works. ByteLight, as a product, is rather confusing. The startup doesn't make lights, it doesn't make lighting controllers, and it doesn't even make drivers (the part inside an LED lamp that provides the power). ByteLight bills itself as a middleware provider, as it doesn't sell the bulbs and it doesn't sell the chips in the bulbs. Rather, it sells the technology that powers the chips and handles the apps that work with the cameras that read the LEDs. It's not the easiest thing to explain, but someone has to be behind the scenes making sure everything plays together nicely. As for the relaying of information, it's very simple: there is no data transferred. The lamp can be read as a unique ID. It has been described as essentially being a QR code on the ceiling. ByteLight is certainly a clever idea, and it's poised to ride the growing LED lighting trend, the nature of the technology causes some limitations. First of all, any companies that have already made the move to LED lighting will not be able to consider ByteLight for their indoor location needs - the LED controls have to be built in from the start cost of adding ByteLight is said to be small, as no beacons or networking equipment is needed. Also, it could be easily added to a product like the next generation. ByteLight is, it's not the only indoor positioning game in town. Nokia is developing a Bluetooth 4.0-powered positioning system, and Apple, whose iPad was used in ByteLight's demo.

Chapter 3

Our Proposal

3.1 Proposal

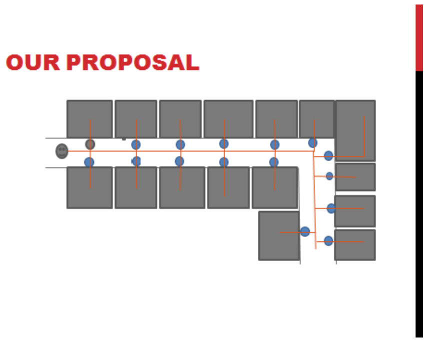

FIGURE 3.1: Our proposal1

3.1.1 Methodology

This system will provide user with better accuracy. The user needs to have smartphones equipped with accelerometer and compass. The accelerometer will help to measure the step count and will give displacement¡step size*number of steps¿. Compass will be used to measure the direction. Every indoor localization techniques has 2 phases

- Training
- Matching

3.1.2 Training Phrase

Through training phrase signal map is constructed through several techniques. This is also called site survey. In the above scenario a person(representative) One person will go with smartphone embedded with accelerometer, compass. There are some access points in indoor environment .The person will measure RSS(received signal strength)from AP through smartphone. Periodically persons distance, direction,(from accelerometer and compass) and RSS(from APS) will be taken. This information will be uploaded to a server through WiFi connection. The RSS of the initial point and point in front of the doors should be recorded. This will provide information to separately identify room from corridor.

3.1.3 Matching Phrase

User location is determined in the matching phrase. The users will walk through the indoor environment for routine works. user has to carry smartphones embedded with all modern facilities. When the user will encounter these points ,his position can be calculated by the server with respect of stored information.

3.1.4 Problem

Same kinds of devices must be carried by the user, Server may encounter calculation problem, Only for office environment.

3.2 New Proposal

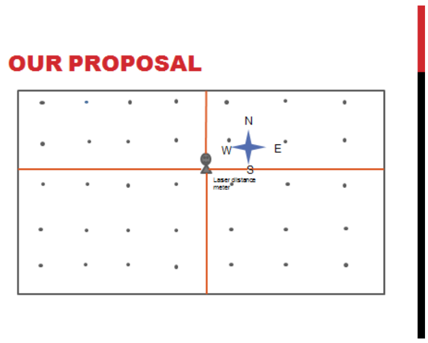

FIGURE 3.2: LASER based architecture

3.2.1 Methodology

In this techniques site survey will be eliminated. First of all we need to get a floorplan of the building where localization techniques will be implemented. The floor plan is divided into grids of equal length(2 meter). Using MDS(multidimensional scaling) stress free floorplan can be made from floorplan of building. This stress free floorplan will be stored in the server. When user enters the building(office environment), this stress free floorplan will be provided to the user. User will carry smartphones that has the facility laser meter and compass. The laser meter will help to measure the distance . Compass will be used to measure the direction. User will measure his distance from the walls with laser meter and direction with compass. This distance and direction information will be uploaded to server. The server will store the information as ¡distance, direction¿. when the user will need to know his location ,information of user location will be sent to his device from server.

In office environment rooms with same length will be a problem , Currently laser meters can not measure distance over 100m.

3.2.2 Problem

1. Laser meter must be present in user mobile device
2. costly
3. detection of room of same length is a problem

Chapter 4

Conclusion

Our main objective was to bulid an indoor localization system that will detect the location of a user in indoor environment.We tried to make the techniques more accurate.Although our techniques work well in most of the cases still there may be some error in room level accuracy.As concept of LASER is very new in the field of indoor positioning system and mobile device has to be equipped with this facility to detect a person,it is expected to make better impact when implemented in large scale.We are working on its accuracy part to make it a better indoor localization system for the user.

Chapter 5

Reference

- Book: Indoor Localization using Wireless LAN infrastructure
- Improving Crowd-Sourced Wi-Fi LocalizationSystems using Bluetooth Beacons.
- Wireless Indoor Positioning techniques.
- Zee: Zero-Effort Crowdsourcing for Indoor Localization
- Did You See Bob?: Human Localization using Mobile Phones , MobiCom'10.
- Posterization: crowdsourced radiomap for room level place recognition in urban environment
- Brightness: Localization using laser
- Gamma:Push the Limit of WiFi based Localization for Smartphones(mobicom 12)
- Contrast:Locating in Fingerprint Space: Wireless Indoor Localization with Little Human Intervention (mobicom 12)
- Ambient magnetic field-based indoor location technology (IndoorAtlas Ltd)