INDOOR LOCALIZATION

SYSTEM USING BEACONS

**Purpose of the system:**

Today Location Based Services (LBS) are being used in different applications. Since location awareness have become important need of people, location based services are largely used in mobile devices. However, the global navigational satellite system (GNSS) can satisfy the needs for most outdoor situations, when people go to any new place GPS can be used to locate and find path to their destination. GPS is not precise for small scale. GPS does not work properly inside building therefore the need of indoor positioning arises. For providing the location based services inside the building we have implemented the indoor positioning application in our project using the Bluetooth enabled beacons which broadcast the packets of data in short time intervals. These packets contain information about the beacon, as well as telemetry readings commonly used in distance calculations from certain predefined indoor positions which are fixed.

**Problems in the existing system:**

The positioning system that deployed, presented the following

categories of challenges: accuracy, availability, stability. By

accuracy problem we denote that the system didn't always

provide the correct position within the specified allowances

(nearly 1.5m). Availability problems are defined as not providing

results within a constrained time limit (nearly 3 sec). Stability

problems refer to not providing consistent results (especially

when a user is in a borderline position). The problems in each

of these categories can be further classified as inherent,

constrained, or implementation-related. Inherent refers to

the fact that this is a built in feature of such systems. For

example a system can't determine the line of gaze

(i.e. which exhibit is the user is looking at). Constrained

concerns itself with the fact that the system in its present

technology has certain limits (i.e. a position can be

determined only within nearly 1.5m). Implementation problems

are connected with the specific implementation of the system,

like bugs, ill-defined API, responsiveness, etc. There are

variety of reasons for these problems, rooted in the specific

characteristics of the technology, as well as the specific

environs:

• Transmission power setup, and threshold patterns impact the area A where a Beacon is detected by Blinds and cause “false negative”

person not detected at positions.

• Human body shield detection by the Beacon and may cause

“false negative”.

• Metal, glass and other reflective surfaces may cause

erroneous” false positive” detections in wrong places.

**Solution of these problems:**

The proposed solution is formulated via a multi-layered

approach. On the hardware level (Beacons, Blinds, gateways

antennas), the solutions consisted of using different antennas,

individual configuration of Beacon transmission power, and

physical location of Beacons and gateways. Beacon

transmission power is constrained as follows: the higher the

power the better the detection, the drawback interference and

detection of Blinds while they are in nearby positions. So the

power levels are tweaked in order to provide an optimal

solution as possible. Solutions at the firmware level consisted

The proposed solution is formulated via a multi-layered approach. On the hardware level (Beacons), the solutions consisted of using different, individual configuration of Beacon transmission power, and physical location of Beacons. Beacon transmission power is constrained as follows: the higher the power the better the detection, the drawback interference and detection of Blinds while they are in nearby positions. So the power levels are tweaked in order to provide an optimal solution as possible. Blind A may be in close proximity to Blind B but not detected at any specific position, while Blind B may be detected at a certain position, we infer that A is at the same position as B. While the above provided solution to “false negatives”, it didn't deal with reflections and irregularities of antenna patterns. As part of our attempt at a solution we introduced a software filtering layer whose purpose was to consider the spatial layout. The reasoning in this layer is based on the time it takes a user to move from a place to another.

**Scope of the project:**

1. Performance of the positioning system can be further improved by using algorithms namely Extended Kalman Filter and Unscented Kalman Filter.

2. Accuracy of the position system may be still improved by the appropriate deployment and proper number of fixed wireless receivers.

3. Experimental model could be developed to validate the accuracy of the different positioning systems.

4. This work can be extended to the development of Disaster Recovery Systems to save the lives of people during earthquakes, train accidents and tsunamis.

5. It could also be used to recover humans and pets etc. when they are trapped due to a fire outbreak on the top floors of a building.

**Functional components of the project:**

1. **Function**: measuring, computing and storing of the data received from the IBeacon into distance.

**Description**: all the signals received from the BLE emitting beacon are used to compute a distance for a given beacon. The distance is then stored into a database where an identifier, a date and the location of the object are added.

**Inputs**: BLE signals

**Source**: IBeacons

**Outputs**: Distance computation for a beacon

**Action**: acquisition of data with computation of distance

1. **Function**: using the received data in order to display the information into a map

**Description**: The Android device receives locations of beacons. It uses the API to display the items on a map.

**Inputs**: Beacons location as markers

**Source**: The beacons transmitting the data packets which computes the distance and displays on the map on accurate position.

**Outputs**: A map displaying every beacon.

**Action**: Rendering the beacons on the map by marking them in an overlay.

**Non-functional requirements**:

**Pre-condition**: The positions are not ambiguous, not duplicated.

**Post-condition**: Every beacon has its representative figure on the screen

**Study of the system:**

Indoor positioning application helps to locate and guide visitors to navigate through certain area using their mobile devices. Bluetooth Low Energy advertising signals from beacons are the base of our indoor positioning system. Beacons are placed at several locations inside the area. Placement of Beacon device is a very important step to ensure that the desired accuracy is achieved in positioning. Beacon constantly broadcast advertising signal with a unique identifier to nearby mobile devices. Mobile application on smartphone will first locate its position using GPS and then use beacons signal for positioning. Mobile devices can approximately determine their distance to the beacon via quality of signal strengths. Beacons transmits advertising signal to smart phones using Bluetooth Low Energy (BLE). This advertising signal gives location information to mobile device. Mobile application can interpret the signals, and trigger an action that is specified in the application. Approximately based on strength of BLE advertising signal received by mobile device distance is estimated. A routing algorithm calculates the optimal path from user location to destination. The API gives approximate distance to a beacon in meters. In this way, it is possible to determine user’s location and continuously and navigate them in area. Mobile application not only help users to know their position but also help them to find route to their destination inside the area. Thus indoor positioning system can be used to provide better experience to users. BLE advertising signal consists of three identifying fields which used to unique identify each device.

A. UUID

UUID stands for "Universally Unique Identifier". It is specific to beacon vendor.

B. Major-ID

Different smaller subset of beacons can be identified by using major id. It is specific to a region such as college area.

C. Minor-ID

It is used to uniquely identify individual beacon. It is 16-bit long. It is specific to a sub region, such as department within the area.

Modules involved are:

1. Data Acquisition Module
2. Data Processing Module
3. Data Management Module

* 1) The data collection module collects various data from the user’s mobile device. The user’s mobile device runs an application that collects data from a beacon using Bluetooth communication and sends it to the data acquisition module of the indoor positioning system. The data acquisition module communicates with the mobile device through the mobile application and receives the message authentication code (MAC) value of the device, the identifier of the beacon, the TX power, and the RSSI. The identifier of the beacon is collected to identify the user’s absolute location in the indoor space. In this system, Eddy stone EID frame is used as an identifier to distinguish beacons belonging to the system.
* 2) The data processing module preprocesses the data to reduce the error range using a filtering algorithm to correct the RSSI data received from the data acquisition module. This module uses the RSSI data and TX power data of the beacons collected by communicating with the mobile devices in the collection module to calculate the distance between each beacon and the mobile device, and then uses those distances to calculate the position of the user in the indoor space.
* 3)The data management module specifies the location of a user’s mobile device and manages various data required by the indoor positioning system after the data processing module has analyzed the data collected by the acquisition module. Information about the computed location is stored in the local database of the indoor positioning system. To manage the beacons in the system, beacon identifiers and information about the actual location where each beacon is located in the indoor space are also stored in the system database, as are the distance data measured from each beacon in the indoor space. Additionally, several tables for aggregation are defined and to further facilitate data management. In the data management module, the Configuration GATT Service can be used to communicate with the beacons to set TX power, signal interval, and so on.

**Performance requirements:**

Performance is measured in terms of the output provided by the application. Requirement

specification plays an important part in the analysis of a system. Only when the requirement

specifications are properly given, it is possible to design a system, which will fit into required

environment. It rests largely in the part of the users of the existing system to give the

requirement specifications because they are the people who finally use the system. This is

because the requirements have to be known during the initial stages so that the system can be

designed according to those requirements. It is very difficult to change the system once it has

been designed and on the other hand designing a system, which does not cater to the

requirements of the user, is of no use.

The requirement specification for any system can be broadly stated as given below:

1. The system should be able to interface with the existing system
2. The system should be accurate
3. The system should be better than the existing system

The existing system is completely dependent on the user to perform all the duties.

**Feasibility Report:**

**Technical Feasibility**

Technical issues involved are the necessary technology existence, technical guarantees of accuracy, reliability, ease of access, data security, aspects of future expansion.

1. Technology exists to develop a system.

ii. The proposed system is capable of holding data to be used.

iii. The proposed system is capable of providing adequate response and regardless of the number of users.

Hence, we can say that the proposed system is technically feasible.

**Operational Feasibility**

If the system meets the requirements of the customers and the administrator, we can say that the system is operationally feasible. The proposed system will be beneficial only if it can be turned into a system which will meet the requirements of the store when it is developed and installed, and there is sufficient support from the users.

i. The proposed system will improve the total performance.

ii. Customers here are the most important part of the system and the proposed system will provide them with a convenient mode of operation for them.

Hence, the proposed system is operationally feasible.

**Economic Feasibility**

 Economic Feasibility is the most frequently used method for evaluating the effectiveness of the proposed system if the benefits of the proposed system outweighs the cost then the decision is made to design and implement the system.

i. The cost of hardware and software is cheaper.

ii. High increase in the amount of profit earned by going global.

iii. Easy and cheap maintenance of the system possible.

iv. Very cheap price for going global.

Hence, the proposed system is economically feasible.

**PROTOTYPE:**

