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# iBeacon: Newly Emerged Technology for Positioning and Tracking in Indoor Place

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**Abstract:** Indoor tracking is a variant of wireless tracking. It is an excellent way to monitor and track the location of people or valuable objects within a specific area, such as a building, hospital etc. where no other positioning technology works like GPS. Bluetooth Low Energy(BLE) is the newly emerged technology in the context of indoor tracking. Indoor tracking can be achieved when scattering BLE device such as iBeacons, which is attached to particular asset in various location of particular area. The Received Signal Strength Indicator (RSSI) is the parameter used as basis for the positioning and tracking approaches.With an iBeacon tag attached on asset, it is possible to track asset by various RSSI algorithms and techniques. The Web-Application or Android Application can be introduced to analyze the result of asset tracking.

**Keywords:** iBeacon, BLE, Indoor, RSSI, Asset.

## I. INTRODUCTION

Nowadays, positioning technologies are used in a wide variety of areas such as location finding and tracking valuable assets. Since the Global Positioning system (GPS) becomes a de facto standard for outdoor positioning application. But no similar widespread technique as GPS is available for indoor positioning and tracking. There are various technologies such as Wi-Fi, Bluetooth, Zig-Bee, ultra wideband radio is available for indoor positioning but none of this technology is widely accepted standard like GPS is used for outdoor positioning. In June 2010, the specification for the Bluetooth 4.0 technology was released [1]. The specification which is introduced named as "Bluetooth Low Energy" (BLE) or "Bluetooth Smart".The technology operates between 2400MHz to 2485MHz divided into different channels. The BLE technology introduces 40 channels with 2MHz Spacing, Out of which 3 channels are dedicated for advertisement purpose. It is low-cost, low power consumption, low complexity and low bandwidth technology. A major advantage of using BLE technology is that it is a technology with high penetration in society.

An iBeacon is a small Bluetooth Low Energy (BLE, Bluetooth 4.0) device that can be powered by a coin cell, batteries or through an external power supply [2].An iBeacon is a device that only sends a packet in specific data format. To take an advantage of iBeacon, Apple provided iBeacon supports in iOS version 7.0 and Google added it in Android version 4.3.Windows phone does not supports iBeacon, which means currently there is no any way to create an application for iBeacon support for this operating system. Depending on the required functionality, a BLE device may operate in different modes, i.e. advertising when it has to notify its presence, scanning when detecting of smart devices in its vicinity has to be achieved, connected as a master or a slave when data transmission is desirable. When a connection is required, BLE Master device may connect to unlimited slave devices in a star topology piconet, thus outperforming the classical Bluetooth, which only supports seven active slaves in a piconet [3].

The iBeacon data format has a 25 byte payload as shown in Figure 1.

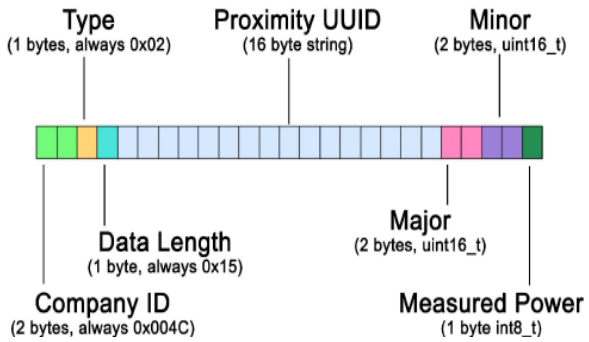


Figure 1: iBeacon data format [2]

It starts with 2 byte for company ID which is followed by 1 byte for type followed by 1 byte for data length. These 4 bytes are fixed and cannot be changed. The next 16 bytes are for the proximity UUID which uniquely identify the iBeacon. The next two bytes is Major and Minor number which is used for identification or to group them. The last byte is for the measured power which can be used to calculate the proximity between an iBeacon and the device which receives the data.

One proposed iBeacon based technique for indoor positioning and tracking is to use Bluetooth Low Energy (BLE) and providing positioning and tracking based on Received Signal Strength Indication (RSSI).

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Table 1 Classic Bluetooth vs. Bluetooth Low Energy [4]

| Technical Specification | Classic Bluetooth | Bluetooth Low energy(BLE) |
|---|---|---|
| Network/Topology | Scatternet | Star |
| Power Consumption | Low (Less than 30mA) | Very Low (Less than 15mA) |
| Speed | 700Kbps | 1Mbps |
| Range | <30m | 50m (150m in open field) |
| RF Frequency Band | 2400MHz | 2400MHz |
| Frequency Channels | 79 channels from 2.400GHz to 2.4835GHz with 1MHz Spacing | 40 channels from 2400MHz to 2480MHz with 2MHz Spacing(includes 3 advertising and 37 data channels) |
| Modulation | GFSK(Modulation Index 0.35) , π/4 DQPSK,8DPSK | GFSK (Modulation index 0.5) |
| Latency in Data transfer between two device | Approx. 100ms | Approx. 3ms |
| Spreading | FHSS | FHSS |
| Link Layer | TDMA | TDMA |
| Message Size(Bytes) | 358(Max) | 8 to 47 |
| Error detection/correction | 8 Bit CRC(header),16 bit CRC,2/3 FEC (Payload),ACKs | 24-bit CRC,ACKs |
| Security | 64b/128b , user defined application layer | 128 bit AES,user defined application layer |
| Application Throughput | 0.7 to 2.1Mbps | Less than 0.3 Mbps |
| Nodes/Active Slaves | 7 | Unlimited |

## II. LITERATURE SURVEY

A RFID and WSNs based hybrid mechanism proposed in [5] for indoor precise localization. In this paper two localization algorithms are proposed: SA-LANDMRAC and COCKTAIL. SA-LANDMRAC is easy to implement, while COCKTAIL has higher localization accuracy [5]. The RFID technology has become increasingly popular over recent years for tracking and positioning applications in indoor environments, as a cost-effective and power efficient solution which can be installed easily on the different object or people [6]. A newly real-time locating system using active RFID for asset management in indoor environments proposed in [7].author introduce this system as the iLocate system, for the IoT. To eliminate the RFID RSSI noise, iLocate employed the frequency-hopping technique. To achieve the fine-grained localization accuracy, it took advantage of the virtual reference tags and the tag–tag communication protocol. To support a large-scale RFID network, iLocate used ZigBee[7]. [8] Present an experimental localization system consisting of two fused solutions. The Ultra-wideband Localization Platform based on the time difference of arrival technique provides accurate positioning in a limited indoor area. The tag integrating functionalities of both localization systems was mounted on a medical test device to demonstrate asset tracking. It was constantly tracked by s-net and, as long as the tag was located outside of the room covered by the UWB subsystem, positioning accuracy was 4 m in 2D. The [9] presents an opportunity for the application of ZigBee technology for asset tracking**.** In cooperation with IEEE 802 Working Group 15, ZigBee is working to address the needs for a low-power and low-cost wireless networking solution for both residential and industrial applications. [10] Illustrates another approach based on infrared technology. This system tried to know the approximate position and orientation of the user's head by using infrared transmitters and Head-Mounted Displays. However, several drawbacks of this system, such as heavy weight of the head unit, restriction of head rotation range, and the large number of beacons in the ceiling, still exists. [11] Utilize the new iBeacon technology for quick deployment and positioning. Since iBeacon is based on Bluetooth LE, it is significantly more energy-efficient. A coin-sized beacon can function for months on a battery. Even with a small amount of training data and a very light-weight distance-based matching module, the positioning accuracy is shown to be fairly high. This allows indoor position service to be deployed quickly even if there is no RF infrastructure such as Wi-Fi. One important thing that should be noticed that for most cases, more training data yields a higher accuracy, but this is not always the case. The reason is that the distance-based match algorithm is not robust against noisy data. [2] Demonstrate that how we can use iBeacon for tracking luggage at airport. Tracking a suitcase with iBeacon has three use cases: First is to know where the suitcase is nearby. So when the device that is searching for the suitcase and when it detects the specific one, it pushes a notification, so that the user knows that the suitcase is in a region of about 30 meters. The second case is about when the suitcase is within reach and we need to calculate the distance between the suitcase and user. The last case applies if the suitcase leaves the tracking region, than it will give the notification that the luggage is more


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than 30 meters away. . From [2] paper it is clears that iBeacon are proximity devices and to detect regions they are working really well.

## III.PROPOSED WORK

Location based services (LBS) have become increasingly popular and a considerable amount of research effort has been directed to developing indoor localization systems. Some latest solutions employ micro-location technology and proximity sensing using wireless beacons. For indoors location tracking, the system includes a fixed beacon on particular asset, the fixed iBeacon periodically emitting a signal indicating the identity of the beacon, remote tracking device securely affixed at the known location, the remote tracking device including a short range transceiver. The iBeacon includes a transmitter for transmitting a short range signal, a movement detector operable to indicate when the beacon has been moved, an internal power supply for the beacon, and a processor connected to the transmitter and movement detector, the processor operable to maintain a log of the movement of the iBeacon.
The location tracking is enabled by disposing a plurality of transmitter tags throughout the area where the location tracking is to be carried out. The transmitter tags comprise a simple electronic circuitry which is configured to broadcast/transmit a unique identifier (UUID) on a radio frequency. The remote tracking (Master) device comprise a circuitry which consists of a scanning device which scans the signal of transmitter tags with RSSI as well as device which sends the information of the have been stored in a database as Linked with the UUID of transmitter tags, unique ID of the remote tracking (Master) device and received signal strength indication (RSSI).The database is accessible by the server and the server is accessible by web-application or mobile-application.

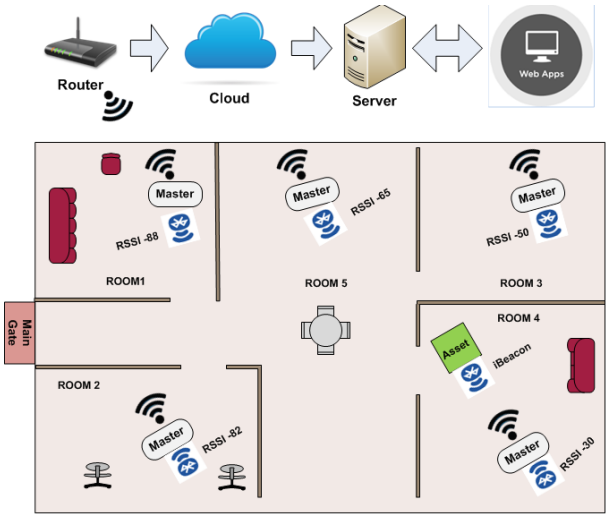


Figure 2: Proposed System Block Diagram [2]

A. Description
As shown in system diagram it represents an indoor place which consists of 5 different rooms. Each room consists of 1 Master or remote tracking device. The iBeacon is attached on particular asset which we want to track in indoor place. It continuously transmits its unique identity (UUID) at regular interval. The master device may consist of two components. (1) Scanning device which is compatible to the BLE technology that can scan the iBeacon in its range with parameters such as its UUID, Major number, Minor number and RSSI which indicates the signal strength between the iBeacon and scanning device. (2) Wi-Fi module collects all the information which is provided by scanning device individually and sends information to the router.
Router sends all the data collected by Wi-Fi module into server database through cloud.
Finally we use this database to make decision that actually at which place or room the asset is located based on the some decision taking algorithms. The decision taking algorithms must be based on RSSI. The Web-Application or Mobile Application can be introduced to see GUI architecture of positioning or tracking.

The block diagram of remote tracking device or master device as shown in Figure.3

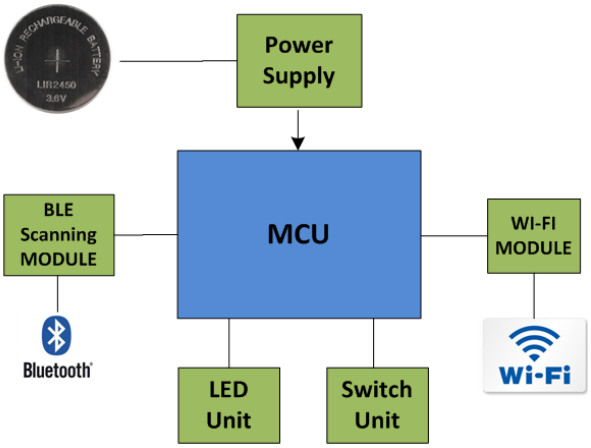


Figure 3: Remote Tracking Device Top Level Diagram

As shown in Figure 3 the master device may consist different components such as MCU, BLE scanning module, Wi-Fi module, Power Supply, LED unit, Switch Unit etc. MCU may provide communication between two different modules like if BLE scanning module scans the iBeacon it can send all data to Wi-Fi through MCU.
Power supply unit will provide supply to all the necessary device which required some supply to make it on.
LED Unit and Switch Unit can also be provided to add extra features like when MCU connected the supply LED will be ON or when if any circuitry required reset condition we can provide through an external reset switch.

B. Received Signal Strength Indicator(RSSI)
RSSI is an indication of the signal strength that is received by the BLE scanning Module. The RSSI value is a signed 8-bit integer value where an increasing value of RSSI indicates a stronger selection. In BLE technology, it allowed to retrieve parameters during active connection as well as passively when receiving advertisements from iBeacons. To convert RSSI to distance several algorithms are available.

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When an asset is moving or it is static every time remote tracking device try to scan iBeacon attached on asset if an asset in the range of remote tracking device. All available remote tracking devices make an entry in database of server with its RSSI. There are various algorithms available based on RSSI such as Triangular, Fingerprint, and Trilateration etc.

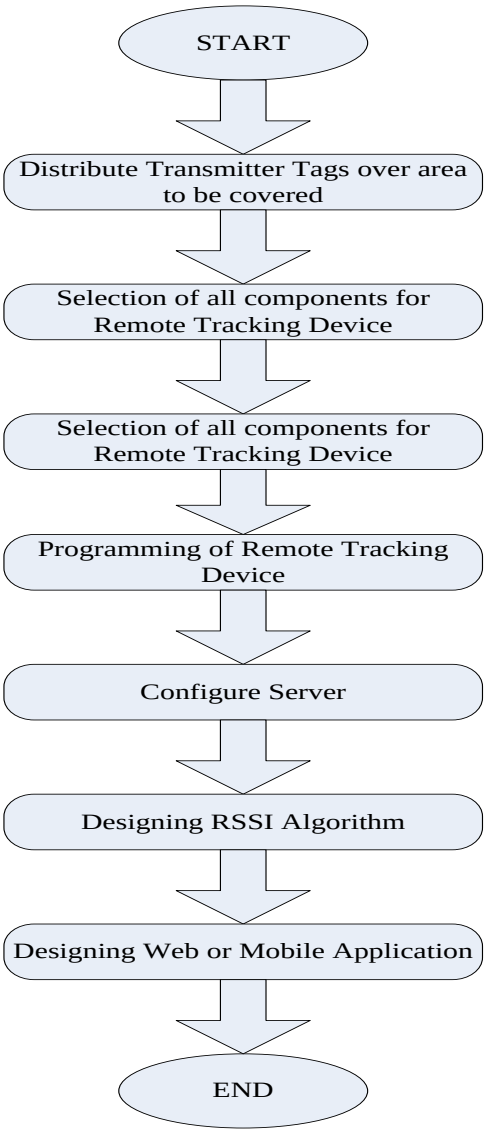


Figure 3: System Work Flow Diagram

## IV. FUTURE WORK

Once all the RSSI value with different remote tracking device stored in server database with suitable RSSI algorithm, we can use this information for tracking a valuable asset. The GUI architecture of tracking asset will be on Web Page. Figure 4 Shows the sample example of tracking that how the location of asset shown on web page in 2 dimensional view.

To provide better accuracy and precision for positioning and tracking using iBeacon, the selection of RSSI algorithms should be carefully evaluated and implemented.

Another potential improvement that can provide significant improvements could be to evaluate a BLE based positioning system using AOA. This can also be achieved by customizing hardware such as using directional antennas or an antenna grid.

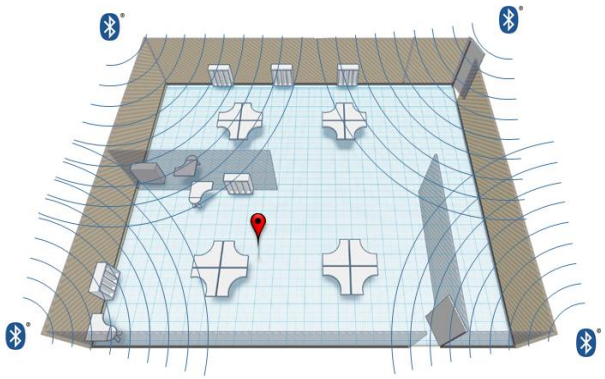

Figure 4: Sample GUI of Web App

## V. CONCLUSION

The iBeacon technology for positioning and tracking has been aimed to design to fulfil the needs of the user for particular Indoor area. It has innumerable use cases in industries, public place, and shopping malls etc. For instance, it can be used to locate and track any valuable asset, where it is actually located and where it moves from one place to other place.

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