Review of BEACON: An Emerging Technology

[1] Shelly, [2] Juhi

[1], [2], Assistant Professor,

UPES Bidholi Campus Dehradun 248001

shelly@ddn.upes.ac.in; jagrawal@ddn.upes.ac.in

Abstract

In today's world, where we cannot live a moment without checking our phone be it for messages, music, purchasing etc. All the activities are completed via our small bucket with a basic thing for connecting us with the complete world and that is popularly known as "Internet". We all will agree on this part that without internet, we cannot imagine our life for a single second but we need to give a second thought to it. What if, there is a place we don't have internet but still we want to complete our tasks and want to connect our self to the world. Then at that time we have a second option of connectivity i.e. "Bluetooth", we all have used it in history for transfer of files popularly but what if we want to transfer our data from a place i.e. not our phone for example a building or shop or any product, then in that case we have a facility of "Beacon" which works on Low Bluetooth Energy and can help you get data from various fields. While positioning system based on Wi-Fi is accurate up to a few meters, its power consumption is a lot higher than a BLE device operation on the same 2.4GHz Band. BLE is also more efficient for short machine to machine message transmission. A standard Beacon device has a battery life of two years. It's an ideal technological solution where we require low latency and fast transaction. The signal Range of a BLE device can span up to 150 meters and max power consumption up to 15mA. It draws current up to 1uA in sleep/rest mode.

Keywords: Beacon; Bluetooth; BLE; Eddy Stone; iBeacon.

Introduction

Beacons are a kind of lighthouse as it keeps on transmitting signals which other devices can connect and like other devices transmit a visible light, beacons broadcast a radio signal comprising of letters and numbers after every $1/10^{th}$ of a second which can be easily detected by smartphones once it comes in the range and shares the data, much like sailors looking for a lighthouse to know where they are.

This paper will give you a complete review of this emerging technology. It consist of these parts:

1. First Part of paper contains the basic introduction about the beacons.
2. Second part consist of all the review of literature work.
3. What are the future prospects or fields where this technology can be used and benefited for society?
4. Conclusion of the topic is given with a point-to-point analysis of the whole technology.

Literature Review

Due to abrupt increase availability and usage of IEEE 802.11(a set of MAC and physical layer specifications for implementing WLAN computer communication in 900Mhz,2.4,3.6,5 and 60 GHz frequency bands) but it becomes very difficult for localization and collecting fingerprints where the Wi-Fi signals are weak or not present and this is where the BLE beacons can be used as they transmit a Bluetooth signal instead of a Wi fi signals due to the low price of the beacons, smaller size and independence of an external power supply ,they seem to be suitable supplements to an existing Wi-Fi network. Also they have a additional advantage that they can be used for energy-efficient geofencing enabling a mobile application to be activated based on approaching of an iBeacon by a smartphone. BLE or a beacon, is basically a small wireless device, can constantly transmits radio signals with unique identifier to nearby mobile devices [3]. If the devices have Bluetooth capabilities turned on while also having an application that can understand the signals being transmitted. After the signals have been interpreted, the application can act on these signals as we program them to.

Basic Working:

1. Firstly, When the beacon detects a mobile device in its range, its sends out location based signals to the phone application, which then act on data as needed.
2. While other location based technologies such as GPS, QR code and NFC exists, none of these technologies can be strategically used to send out specific location based data.

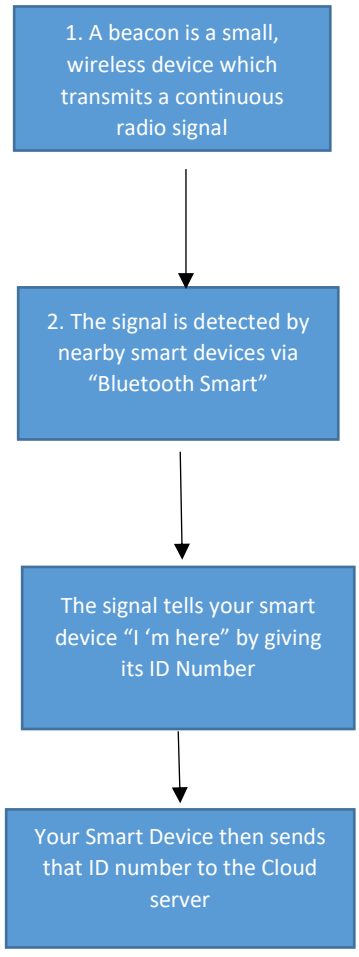

Fig 1. Basic Working of a Beacon

In today's world user profiling, user localization and tracking are vital to a broad range of services and applications. In the areas where GPS is not available, user localization achieved by utilizing several wireless communication technologies such as Wi Fi, Bluetooth, long-term evolution (LTE) etc. The existing basic Bluetooth positioning technology divided into three categories [1]: -
1) Fingerprint positioning
2) Triangulation positioning
3) Proximity positioning

Among all the fingerprint-based positioning, the most applied technique for indoor localization is REAL-TIME-LOCALIZATION SYSTEMS (RTLS). The main advantage of fingerprinting technique is that they utilize the existing wireless communication infrastructures without any need to deploy any additional, specialized equipment. The dataset of fingerprints called "radio map" are the basis of the positioning algorithms. These are generated rapidly and at relatively low cost. Fingerprinting is a two phase process: -
1) First one is OFFLINE phase. Radio maps are generated by recording the access points(AP) RSS (received Signal Strength length) values which are either measured or obtained through a simulator) for each location in the area of interest. In-order to improve the quality of radio-map, calibration and training techniques are used.
2) Second is the online phase, during this phase the Mobile Station (MS) performs network discovery as well as real-time RSS measurements. After this, Different positioning algorithms are then applied in order to identify the best match between the observed RSS fingerprint and the respective mean value of the fingerprint recorded during the first phase.

The triangular positioning is of comparatively lower cost and easier to realize. Bluetooth use signal strength to measure the distance between device and Bluetooth beacons, lower signal strength means the device is far from the beacon. The Bluetooth signal strength is inversely proportional to the beacon distance, and the distance between the signal acquisition point and the Bluetooth beacon can be estimated based on this characteristic. To get a suitable result, it is important to place Bluetooth beacons based on Bluetooth signal transmission characteristics.

Proximity methods create zones and assigns the users location when they enter that zone.

The positioning of Bluetooth are discrete points and inertial navigation is a technique to keep a continuous track of these points and the fusion of these two can result in better performance than single source positioning method. The general Bluetooth Beacon placement rules are:
1) No obstacle between the beacon and the terminal. After the penetration of walls and other obstacles, Bluetooth signal will have a sharp decline and the data could not support the positioning. Therefore, the positioning should consider avoiding the wall and other indoor obstacles and should increase the density of the Bluetooth beacon around the bearing columns.
2) The distance between terminal and beacons should be apposite, too far and the RSSI (received signal strength indication) lost the ability to measure distance. A spacing of 4 to 6m is an optimal Bluetooth placement plan.
3) The optimal positioning point is the triangular center, meaning the angle among terminal and the beacons is equal.

As many work is going on in this field so many new methods have proposed for improved indoor localization using Wi-Fi and Bluetooth beacon technologies.

The new hybrid method that combines Bluetooth low energy and 802.11 has transformed the previously used algorithm KNN (K-nearest-neighbor) into a new algorithm dubbed i-KNN. This new filters the initial fingerprint dataset (i.e., the radio map) after considering the proximity of RSS (received signal strength) fingerprints with respect to the BLE devices. In this way, i-KNN provides a small subset of user-locations, based on which it finally estimates the user position. Dubbed i-KNN method is better than the previously used algorithms such as KNN (K-nearest-neighbor), Maximum a because: -

1) It achieves fast positioning estimation due to utilization of a fragment of the initial fingerprint dataset.
2) Improves positioning accuracy by minimizing any calculation errors

As compared to the other user's localization and indoor positioning such as integrating body sensor networks and smart devices, The i-beacons which are made by combining existing well-established Wi-Fi positioning systems with Bluetooth Low Energy (BLE), is more favorable as localization accuracy can be achieved easily by just simply deploying small number of low-cost BLEs on top of existing Wi-Fi infrastructure.

Propagation modelling make the procedures more difficult and important when it comes to using the data in techniques to accurately calculate the location of user. Different methods have been proposed in order to filter the data and provide better results. The researches regarding the signal strength have raised the issues such as:

1) About the signal strength setting, which is simply the power the beacon uses to transmit each broadcast. This directly effects the battery life of beacon along with the maximum distance that a beacon can be detected at. In smaller area a stronger signal is able to bounce more before the signal dissipates but most importantly the signal strength is important while calculating a propagation model.
2) About the broadcast interval setting and it also has a direct effect on the battery life of beacon and also leaves less time for signal to dissipate and may increase multipath issues. At the same time having a higher interval allows for more continuous data readings. And hence, there is a trade-off to be made between multipath increasing and the speed of reading [6].

After experimenting in these issues the results were contrary to what had been expected. The result made clear that the size and the topology of the areas can vary greatly. The Long-distance path testing concluded that in the areas like cave the distribution values were smaller and overall values were lowered and in water area the propagation model introduced more noise. Also results concluded that indoor positioning is a difficult task as topology constraints in the indoor environments are much more complex than in outdoor environment. Due to this the propagation model needs to be more precise and even a small area can have large differences in how the signal bounces from position A to position B in indoor positioning [7].

The quality of the signals can be hence improved by: -

1) Implementing propagation models as they give general sense of the way a signal travels in a room and hence give an idea about how to distribute the beacons across a room...
2) Introducing advanced Kalman filters and statistical analysis can help to filter out the noise from bouncing signals and the fact that users cannot jump between locations is very helpful in this approach.
3)For multipath issues, it can be solved by the smartphones platforms providing more control over the hardware through more advanced APIs or by research into multipath countermeasures for smartphones.

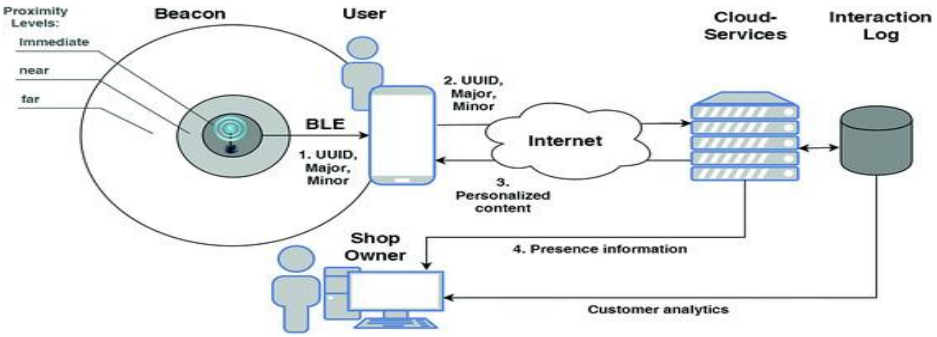

Fig2 System Architecture

Beacon technology follows the principle of contextual integrity to maintain user privacy. By the word contextual integrity, we mean that the people are not opting for outright privacy, rather they need some levels of privacy that ensures their goal. We produce a plausible approach for handling the privacy of the beacon technology by the method of crowdsourcing through the user provided labels and category. The effectiveness of crowdsourcing was astonishing as the results were accurate about 92% with an 84% acceptance rate of the crowd labels. So crowdsourcing is the first big step in the making of beacon technology [2].

BLE was basically introduced as part of Bluetooth 4.0 specifications which allows the devices to support both BLE and classic Bluetooth protocols simultaneously. This power efficiency of Bluetooth with low energy functionality is suitable specifically for IoT applications as it allows devices to run for long periods on extremely low power sources [3]. BLE operates at 2.4GHz and uses Gaussian frequency shift key(GFSK) modulation in 40 channels of 2MHz.3 of the 40 channels are called “advertising channels” and remaining 37 are called “data channels” which ensures connectivity with other nodes. BLE has a range of around 100m in an outdoor environment, a maximum data rate of 1 Mbit/s and an application throughput up to 305 Kbit/s. It supports point-to-point and mesh networks.

There are mainly 4 types of beacon protocol

1. iBeacon (Apple)
2. Eddystone (Google)
3. AltBeacon (Radius Networks)
4. GeoBeacon (Techno-World)

iBeacons is a cross platform technology for both Android and iOS devices that are able to support the BLE standard. Devices, acting as beacons, generate iBeacon advertisements through which they establish a region around them. Android and iOS devices receiving the advertisements can determine the entrance and exiting borders from each beacon’s region, can estimate the nearest beacon and can approximate the distance between the two devices [4]. The proximity can be set by the limiting the ranges of the beacons such as when a receiver encounters a beacon not only does it show the advertisements on the receiver’s phone through an installed app that detects beacons, it also supplies us with the distance of beacon from the receiver. A beacon provider or retailer can infer certain things from these techniques and can thus be secure and can know about a person given the frequency of visits to a certain place. The aforementioned advertisements contain three identifying fields:

1) UUID-universally unique identifier is a 128-bit integer used as an ID for all beacons in an application.
2) Major-is a 16-bit integer, used to differentiate beacons with the same UUID.
3) Minor-is a 16-bit integer used to further differentiate beacons that have same UUIDs and major values.

Eddy Stone:
Google released it in July 2015, and it also works for both android and iOS devices. If we talk about a single beacon then it can transmit either one, two or all the frame types, which are:

1. URL: to decrease the need of installing the app
2. UID: 16-digit string of characters, used for identification of a beacon.
3. TLM: all the sensor and administrative data is communicated through telemetry.

AltBeacon (Radius Network):
They announced it in July 2014, An open source beacon designed to overcome the issue of protocols favoring one vendor over the other.
GeoBeacon (Techno-World):
They announced it in July 2017. Also open source beacon designed to be used in GeoCaching applications.

With Various types of Beacons are available in market we should also know about the areas where they are expected to be implemented are few areas like Retail, Payments, Events, Content Delivery, Transportation, Homes [5].

Hence iBeacons are flexible in deployment and can be used in mobile objects or to temporarily define a region and sub-regions.

Future Scope

Beacons have a very bright future in the market as they are an emerging technology where we can find a solution to a problem with ease as technology is meant to ease our life and enhance the comfort as well as this technology is not only promising but also very cheap to implement. It can be implemented in various fields where we need to share the data to unknown people such as advertisements; e-commerce etc.

Conclusion

Beacon technology is quite promising to implement in the areas where we cannot provide internet facility mainly in developing countries on a cheaper rate. One of the major drawback of this technology is the range as the base is Bluetooth, which provides range up to specific limit otherwise counting the advantages this technology can bring a revolution in the market.

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