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Analyzing Collaborative Technology Wi-Fi Bluetooth for localization in Indoor Positioning System in indoor premises

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Abstract

For tracking people or object's Location in the indoor environments, a network device is suggested known as IPS.. This technology mainly used because of supervising the health, position, guidance in different sectors like Universities, museums, airports, hospitals and warehouses the main advantages of IPS with distinct feature like reduction of material and energy cost over time that has huge impact compared to other technology which are more costly. Among various technology like (UWB) Wireless Fidelity (Wi-Fi) Bluetooth Low Energy (BLE). (Wi-Fi)Technology is an outstanding approach for indoor navigation and positioning due to already available Wi-Fi Infrastructure Wireless IPS has categorized into two approaches :geometrical –calculation based and Scene –Analysis based former relies on measurement of geometrical parameter of Distance and angles by physical characteristics of Signal. RSS is the performance parameter used for achieving robustness and accuracy which is most concerned factor for current scenario

Most Recent Research has solved the problem of inconsistency on Received Signal Strength (RSS) using fingerprint method. But the RSSI that received may contain some noise. This paper mainly proposed a method to estimate or tracking the real position of dynamic user. With RSSI value as input to be processed and the result of it will be a location (x, y) value, repeat the process to create an estimate coordinate map of route taken. Our proposed method is based on fingerprinting with weighted sum of four nearest reference access point to estimate the position of dynamic user then using Extended Kalman Filter as a tracking algorithm. In this paper we try new ways to collect the data of RSS by dynamically collecting the data in many routes to see whether the proposed algorithm could estimate the position better. We achieve an average mean of error around 2cm using Weighted Sum using Extended Kalman Filter tested on dynamic data.

Key words: Indoor Positioning System, Dynamic User Localization, Fingerprinting Method, Weighted Sum Model, Extended Kalman Filter

1. INTRODUCTION

Location detection has been popular implemented in outdoor environments by the introduction of GPS technology. GPS has made many changes on our daily activities; to navigate to other places has been a very important factor of the success of GPS. Different from outdoor positioning, GPS technology can't be used for indoor positioning. GPS technology had limited access to indoor positioning because of many factors such as lack of line of sight and in indoor the signal of the GPS will be attenuated as they cross through walls [4].Building structure and in other case the indoor positioning system would behave differently. Also, in Indoor positioning there is many obstacle that need to be included as an obstruction. This cause the GPS could not applied intoIPS

Various indoor positioning technologies has been proposed based on the literature review such as Infrared, Ultrasound, WLAN/Wi-Fi, BLE and RFID to estimate the position of user in indoor position environment. Among them, Wi-Fi and BLE used similar bandwidth of 2.4 GHz radio wave frequency but based on [14,25] BLE has more advantage than Wi-Fi because of lower material cost and high availability of BLE because of shorter channel width and 3 dedicated advertisement channel also supported by most modern smartphones which made BLE more advantageous than Wi-Fi technology.
BLE is introduced as a new form of wireless communication that is designed for short range communication [25-27]. BLE act as a replacement for cable to transmit the data into another device. Most of the time BLE stays in sleep mode constantly except when connection is initiated [15]. In the previous research most of the experiments on other literature are based on static user, where positions of users are estimated while users are immobile. This is why we will do experiment on dynamic user with fingerprinting algorithm and implement tracking element on the position by Extended Kalman Filter to see the difference.
In the Fingerprinting method we can get the object's location based on the signal strength that are channel led from the BLE, it consists of 2 main phase that are Offline and Online phase. Offline phase used to store the experimental condition of radio wave on a grid based possible location with signal strength received from each transmitter as the reading value, mean while online step is the phase where positioning be done where measurement of signal strength from each transmitter will be used to match the condition stored from previous step

Fingerprinting in indoor positioning systems was also known as scene analysis method which was used to measure the condition of radio frequency signal on the test field. The measurement of radio frequency was taken not only to determine position on the online phase but also to avoid wrong measurement because of obstacle material, human cause, etc. Much research has been focused on removing the noise caused by other factors, but there are no exact methods to remove it.

There are two main proposed methods in this paper to solve our problem. First one, this paper intended to implement a tracking algorithm based on RSSI value of Bluetooth butwith the extended version because of the non-linearity of RSS measurement. I proposed this tracking algorithm because of the change from static user data collection to dynamic user data collection. Also, we proposed this filtering algorithm because in [13] we see an improved accuracy around 93% by using various filtering algorithm. The proposed method expected to improve the current accuracy by tracking the estimated position based on measured noise covariance, process noise covariance, and Kalman gain. We proposed to capture the data dynamically by walking in a route that we had created with some constraint and see whether the algorithm proposed could measure the distance or not.

2. RELATEDWORKS

Indoor Positioning System using BLE technology has been experimented on many known techniques from Wi-Fi technology [7,8] like trilateration is a method of position estimation using the distance between mobile target and the receiver with the received RSSI as the measuring unit. The position of an object can be measured with a minimum of 3 estimated distances which is why this method was called trilateration. The disadvantages of this method is the simplicity of the measurement only based on the placement of BLE or Wi-Fi access point location and current RSS information which can change depending on environmental change also due to multiple interference on other radio signal that will cause the distance estimated contain some noises.

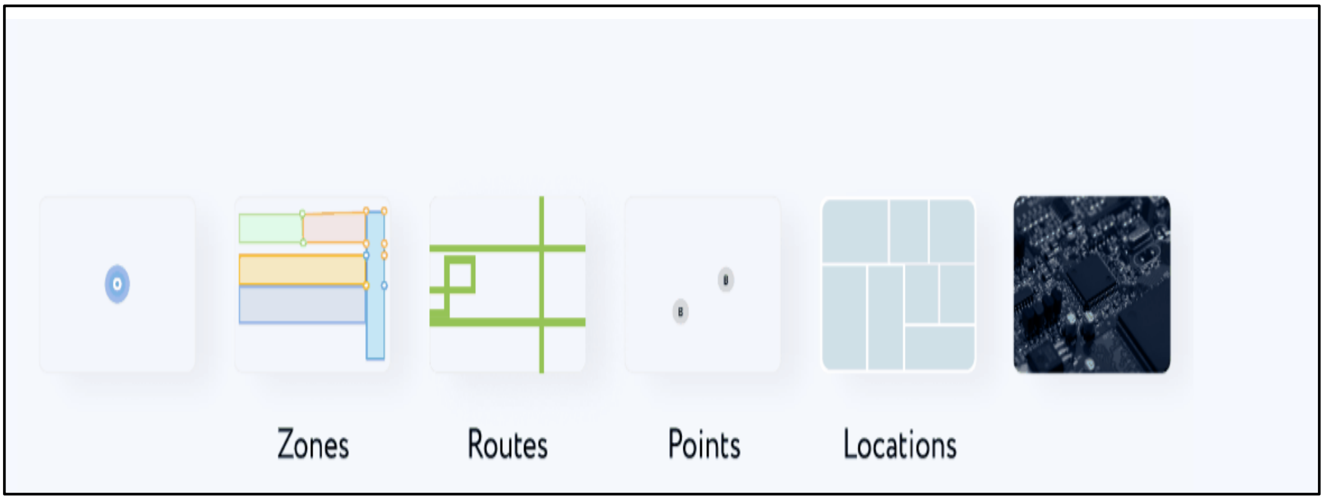

Figure 1: Elements of various collaborative roots for IPS using Hybrid Wi-fi system

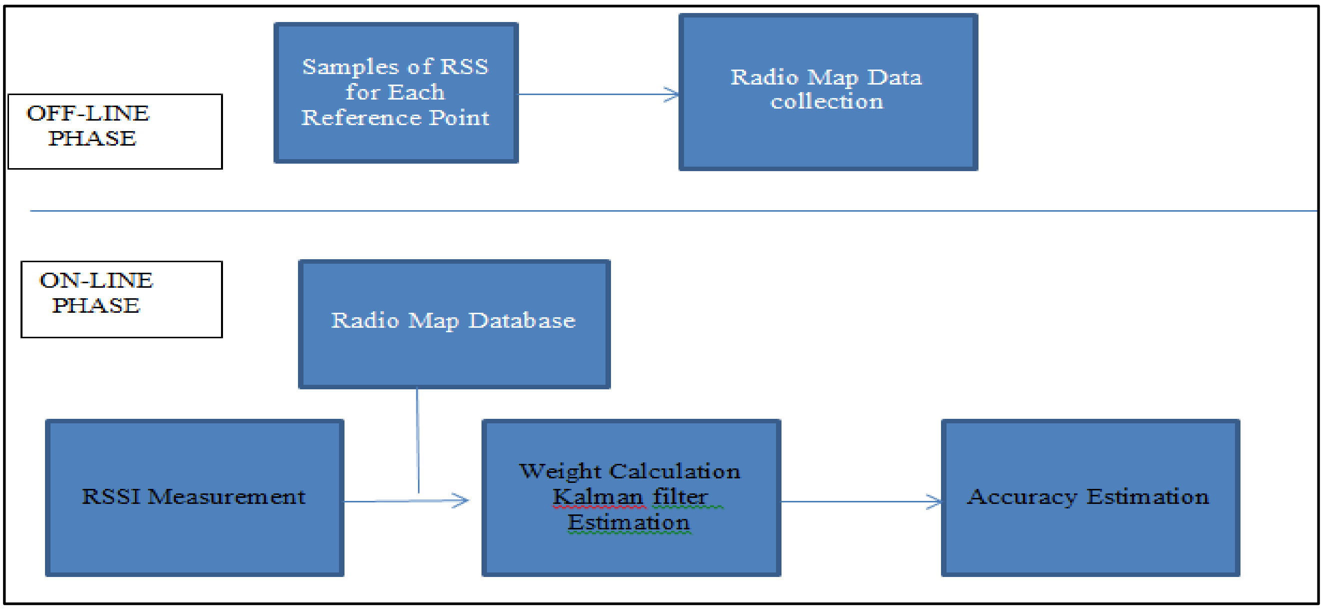

Figure 2: Outlines for online and offlinePhase of with RSSI values for IPS using Hybrid Wi-fi system

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Figure 3: Screenshot for Moving Blue dot denoted as outline room location with RSSI value at each Wi-Fi node

3. PROPOSEDMETHODS

Fingerprinting

In this paper we proposed an Indoor Positioning System by using BLE with fingerprinting method. There are two main phases of fingerprinting method proposed in this paper shown in Figure 1 Outlines for online and offlinePhase of with RSSI values for IPS using Hybrid Wi-fi system ,offline phase is designed for learning the RSS at each reference point (Figure 2). This method simply creates Radio Map Database by gathering on each of the reference points and started receiving RSS from all BLE beacon then send the representative data to database. One row of data on the radio map database consisting 2d coordinate value (x, y) where the Reference point (gathered point) are and each BLE beaconRSSreceived. Themaintaskofthisphaseistocollect fingerprint data to build a model[5].

In the Online phase, the measurements are taken based on every each route. The position will be estimated using localization algorithm and will be compared with the datathat is already stored in the database. In our research the sample will be taken with interval of 5 seconds. Then the sample data containing RSS value will be tracked by using Extended Kalman Filter and Weighted Sum that will measuredwith Euclidean distance and then ranked using the K-nearest Neighbor, resulting a single value consisting of their coordinate (x,y).

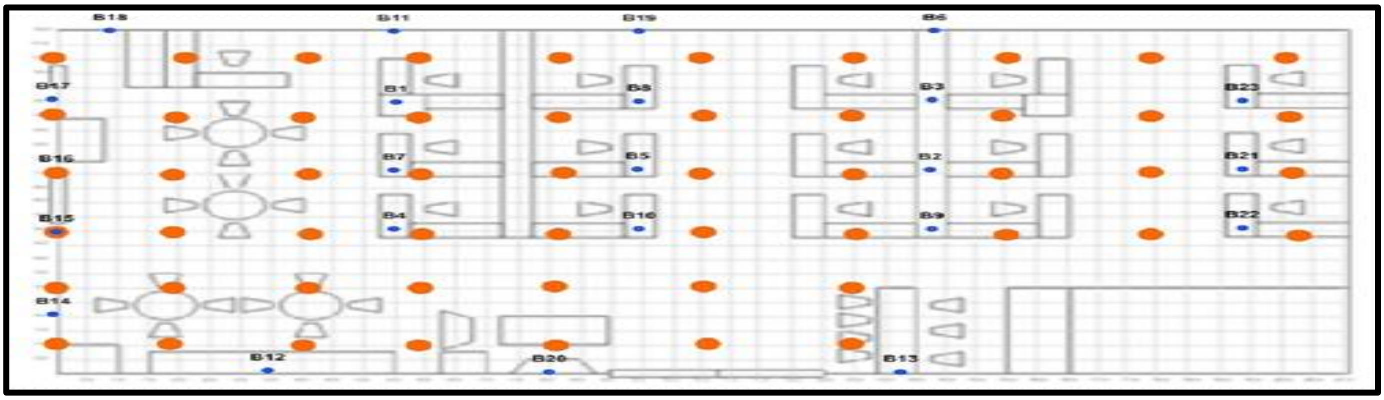

Figure 4: road map for Phase of Localization

The deterministic positioning algorithm is based on the measured signal strength on radio map creation phase to match the real-time measured signal strength to determinethe position of receiver While deterministic positioning algorithm is based on signal that matches the corresponding fingerprint data to determine receiver position, probabilistic positioning algorithm approaches this by calculating the probability distribution of radio wave signal strength during a certain time and stored in fingerprintdatabasetobeusedon onlinephasealsoduringthe online phase of positioning, the more static a user are on the position, the more accurate the result of position estimation will be which is why probabilistic positioning algorithms cannot be used to determine the position on a dynamic device

Ways of Determining Position Indoors:

Indoor positioning service can be provided both by using beacons and Wi-Fi. The use of Wi-Fi or beacons depends solely on the requirement. Beacons are basically preferred when we require very high accuracy but in huge university campus, beacons will not be a better option, for they have to be installed in proximity with each other making it's usage impractical and uneconomical. The drawback of using Wi-Fi is that the accuracy of location will solely depend on signal strength which may suffer sometimes but with recent developments in Wi-Fi speed and SDKs like android 9 and 10 it is a problem that can be tackled easily.

Process of Determining Users Position using Wi-Fi: When using WIFI our device requires the following information for calculation of distance.

1. The latitude and longitude
2. The relative position of our device to each Wi-Fi. It is calculated by making use of Wi-Fi frequency (usually 2.4GHZ) and signal strength as depicted in formula below. This is modified free-space path loss formula where the frequency is in dBm and signal strength in megahertz.
3. The absolute position of a WIFI tower is also calculated using the above information (point 1 and 2). This information is then integrated into a code created in the Android studio.

Suitable SDKS (with their features) for Indoor Navigation are listed below:Oreo (Android 8):

1. **Geofencing:** It helps in the creation of a virtual perimeter.
2. Provision of Cache.

Enables the APP to:

1. Run faster
2. Consume less power and memory
3. Provide a smooth in-app experience

Pie (Android 9):

1. Provides us platform support for indoor positioning services.
2. RTT (WIFI Round Trip Time) APIs to measure the distance to nearby WIFI access points (usually 3).
3. Its accuracy is between 1 to 2 meters.
4. With this accuracy, we can make in-building navigation quite easy.

Android 10:

1. Offers a high-quality multi-window support.
2. Manages the way your app is displayed on foldable screens.
3. Enables multi-tasking across apps and windows and provides screen continuity
4. It eliminates the navigation bar area and allows a user to use full screen to deliver a more rich and immersive experience.
5. More user control over location data.
6. Prevention of device tracking.
7. Blocking unwanted interruptions.
8. Offers suitable support for display so that high quality videos can be provided by using limited bandwidth.
9. Enables high performance and low latency modes.
10. Provides high end-user experience in real-time gaming, navigation, and active voice calls.
11. Reduces power consumption.

4 EXPERIMENTALDESIGN

First, we configured Wi-Fi module as Access point Bluetoothbeacon fromHC-05 shown in Figure 3 with transmit power of 20 dBm and transmit interval of 100 milliseconds. Then the RSSI value willbe deployed in this research as shown in Figure 2 represented by the blue dots as beacon deployed where on the site will be placed at 5m apart each other height from the floor

Due to the simplicity on basic idea of trilateration, many researcher[7, 8, 10] has proposed a new idea to include other parameters that can be taken as measurement such as Time of Arrival (TOA) and Time Difference of Arrival (TDOA). TOA is the time measured for a radio wave from transmitter to reach receiver and TDOA is the measurement taken by examining the difference of time between each radio signal interval. The most accurate usage of TOA/TDOA has been proposed by [10] where radio wave propagation was modeled as probabilistic model and determination of position will be based on time-delay estimation algorithms and this method has proven to solve the fading effect of radio wave propagation.

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To solve the problem of multipath radio wave phenomenon and more accurate measurement on positions, fingerprinting technique was developed. Fingerprinting on IPS uses Wi-Fi Access Point ID or BLE ID and RSSI where an experimental site with transmitter scattered then divides the space into small grids and collects the RSSI value on each grid to be saved into a database is called a radio map [1, 11]. From here, there are two approaches that have been known so far to determine the position of receiver deterministic positioning algorithm and probabilistic positioning algorithm.

The test field is built on the 6th floor of the Thakur Polytechnic campus as a specimen and the device used for Bluetooth receiver is a smartphone device with specifications of “one plus 6T” shown on Table

Test field used in this experimental design is an office room with size 12 m x 19 m shown at Figure 5. Reference point are placed with 2 meters gap each shown in Figure 4 and total of 54 reference point are used in the radio map. On each referencepoint100samplesweretakenbysmartphonedevice specified on Table 2 to log the RSS received while standing on the point around 3 minutes for the entire sample of a point to be taken.

$$(x+a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k}$$

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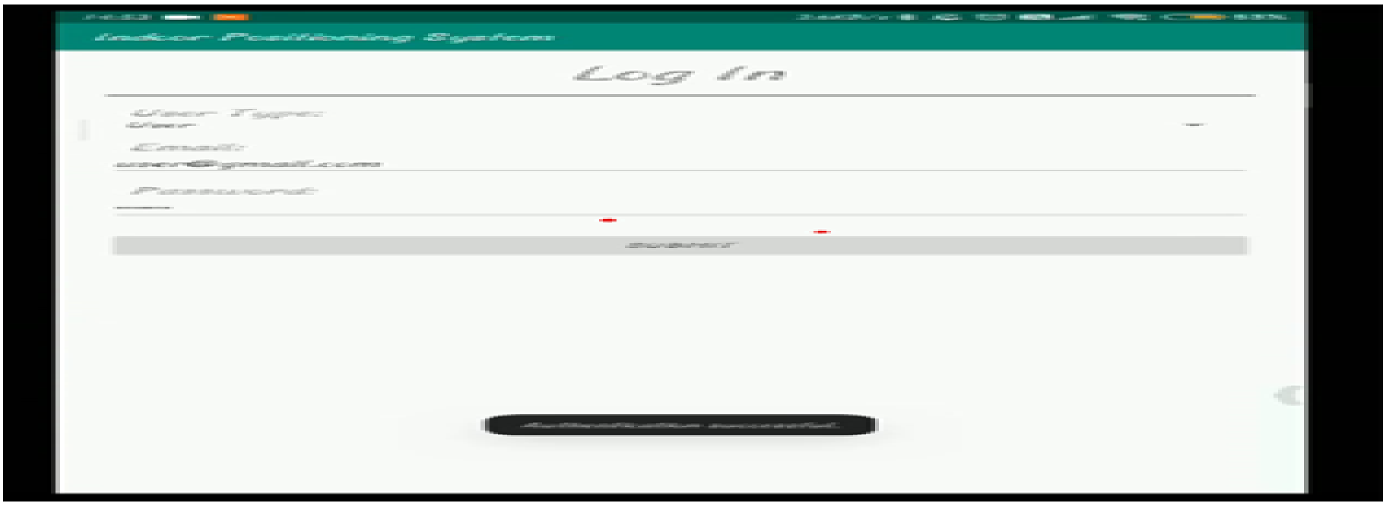

Figure 5 Log in with Authenticated user-id

The test field is built on the 6th floor of the xyzlocation campus as a specimen and the device used for Bluetooth receiver is a smartphone device with specifications of “one plus 6T” shown on Table 1

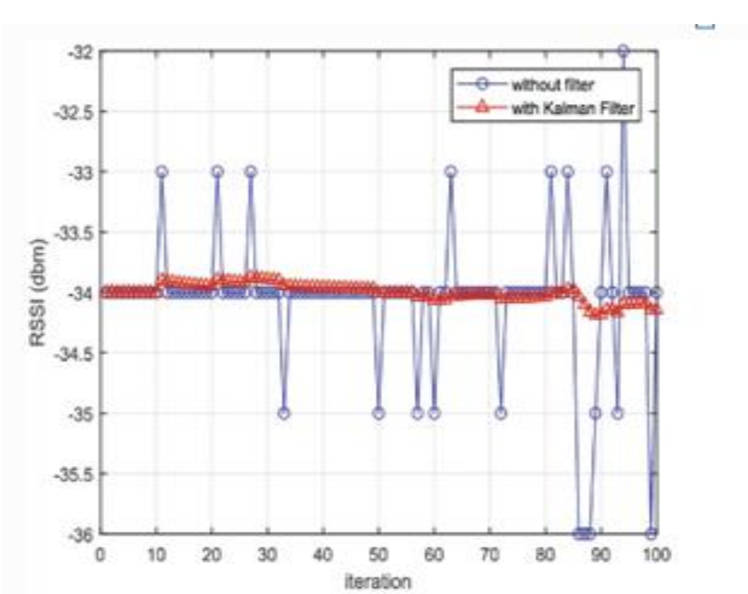

Figure 6(a) Sampling point from four Wifi module and Blue tooth signal with 1 Meter

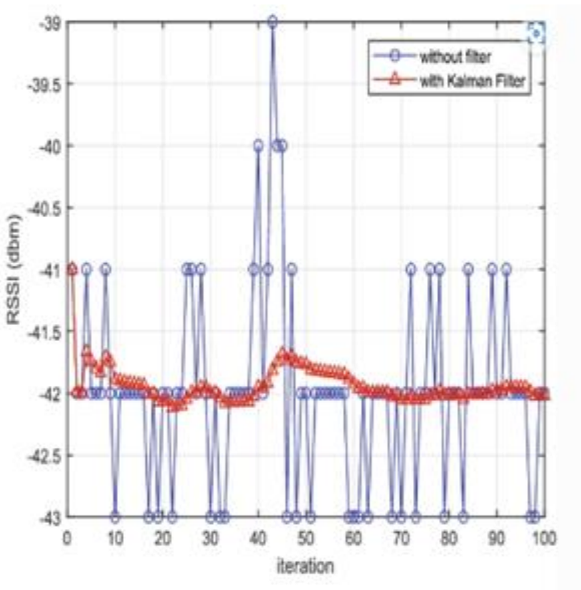

Figure6(b) Sampling point from four Wifi module and Blue tooth signal with 3 Meter

RSSI VALUE IN DB	WIFI-1	WIFI-2	WIFI-3	WIFI-4
RSSI1	**-30**	**-56**	**48**	-100
RSSI 2	**28**	**58**	**48**	100
RSSI 3	**27**	**60**	**47**	100
RSSI 4	**29**	**59**	**48**	100
RSSI 5	**21**	**-63**	**48**	99
RSSI 6	**25**	**55**	**47**	-100
RSSI 7	**-21**	**-59**	**48**	98
RSSI 8	**-22**	**60**	**46**	98

Table 1Sampling point from four Wifi module and Blue tooth signal with different Rssi values

5. Conclusion

WiFi describes a local wireless network that uses radio waves to communicate data. Typically from the internet. It uses the IEEE 802.1 standard to communicate. There are multiple versions of Wi-Fi as defined in the IEEE specifications, which include common ones such as 2.4 GHz and 5GHz frequency radio waves. Wi-Fi enables transferring large amounts of information, with speeds of up to several gigabits per second for certain versions.

With this in mind, Wi-Fi positioning is a positioning system that uses techniques to locate a connected object or device. Wi-Fi location uses already existing infrastructure and Wi-Fi access points (APs) to calculate where a device is located. The device needs to be able to listen to the Wi-Fi AP but does not need to connect to it. Localization in Wi-Fi positioning systems depends on multiple Wi-Fi signals and knowing where those APs are located.

Wi-Fi’s short-range can roughly be around 150 meters. The accuracy generally depends on the number of APs and the physical environment. Positioning and localization is more precise with more APs in a given area. Wi-Fi can provide about 20m accuracy using existing Wi-Fi infrastructure with no calibration. However, through calibration, surveying, and fine-tuning, Wi-Fi positioning can achieve 5-8 meter accuracy in indoor environments.

Wth the tested data provided to the system we received the RSSI values for different meter rang in the table mentioned above.and it can be more effective by applying different algorithm used for specific localization system

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