Wi-Fi Indoor Positioning System-Advanced Finger Printing Method

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Abstract—**The Wi-Fi-indoor positioning System is the major part to make the IOT real without using more expensive resources and external Hardware. This paper will give you brief introduction about the algorithms and method which can help us to achieve the position of an individual accurately, the main problem with majority of the methods is that they require the additional hardware to install or the complexity of the system is off the charts which will require more time and money .Later in the paper choose one of the method which is accurate and low cost but the only disadvantage is the labour cost or the amount of hard work it require.**

I. INTRODUCTION

Just Imagine that you can able to detect the position of a patient or the staff in the hospital, So you can give the orders to the nearest staff member to look after the patient who need them. The position of the patient can also be tracked in their homes also, now that's a little weird but to trace the health or the recommended exercise are being performed by the patient or not.

The very next interesting application is in the groceries stories, Now imagine that you are moving in the store and the automatically your phone give you a message that there is some discount on the item you are standing next, amazing right? How they come to know that I am standing besides this item shelf, that's power of smart shops which we can achieve through the Wi-Fi Indoor positioning system. The method is pretty simple you calculate the RSSI values at each and every point of the store with each and every router. Then deploy the system and use the values which you get in the database in the app of the store. When the customer comes he/she can connect to the store's Wi-Fi and it will give the exact location of themselves in the store. So the people at the back end will give the discount to the products which are not in sale.

The very next example of WIPS is of free Wi-Fi services given by the shopkeepers and the coffee house, suppose they only want to give this service to the people who are inside their region but the people are using it outside their premises.

So the WIPS technology provide the Wi-Fi access to the people inside the shop.

These are some major uses which we can use with the help of

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WIPS Technology. This technology can optimize the work in the big organization and make them profitable. Further in the research paper we discussed about the various technology which also provide the same features but not able to do it cheaply or very much complicated to implement .So we choose the best method among them and try to solve some problems. At last we use the database and server client technique to implement the procedure which we introduced and it gives us the good result.

II. LOCATION DETECTION TECHNIQUES AND LOCATION ALGORITHMS

A. Time Based Method

In this method position is determined by the distance measurement. It can calculate the distance from the fixed reference point that's why it is called Range Measurement Technique. This method says that minimum three fixed point should be present to determine the location. These systems are based on the same synchronization of the arrival as well as transmission time from a mobile device to fixed reference points. The distance is calculated from the transmission time delay and speed of light.

The Mobile device and the fixed Reference Point need the exact knowledge of the time and should be synchronized at a same time, But for doing so we need the additional server which can make this method expensive[1,2].

Pros:-Three Reference point using to detect the location. Cons:-The clock time should be in a synchronized way which is not that simple.

B. Signal Property Based Method

Till now the method uses the time information or the angle based information to detect the position of the device. But the main problem with those method are that they can be influenced by the multi-path effect, because of which the accuracy of detection can be decreased. This method uses the attenuation of the emitted signal strength as a measuring unit.so we uses the RSSI value which is (Received signal strength indicator).but this RSSI also can be affected by the environmental factors and they are also non-linear . The other plus point is that this method can be achieved using existing WIFI Routers[3,4].

Pros:-Using Received Signal strength.

Cons:-Affected by the environmental factors.

C. Dead Reckoning (DR)

This method uses the last known position to calculate the current position or increase the position based on the current speed during

the time interval. This method is used in the inertial navigation which gives the exact location and is widely popular. One of the major drawback in this method is that inaccuracy of this process is cumulative so the deviation in the position grows with time because it uses entirely the previous knowledge to determine the position [5,6].

Pros:-Uses the last known position.

Cons:-Deviation in the position grows with time.

D. Map Matching (MM)

The use of pattern recognition combine with electronic map to detect the real position of the vehicles in a road network. This method requires additional hardware and also some very complex algorithms to implement which increase the cost of the system [7,8,9].

Pros:- Using Pattern Recognition Technique to detect the real position.

Cons:- Require Additional Hardware and complex to implement

Method	Measurement type	Indoor accuracy	Coverage	Line of sight (LOS)/nonline-of sight (NLOS)	Affected by multipath	Cost	Notes
Proximity	Signal type	Low to high	Good	Both	No	Low	(1) Accuracy can be improved by using additional antenna. However, it will increase the cost. (2) Accuracy is on the order of the size of the cells
Direction (AoA)	Angle of arrival	Medium	Good (Multipath issues)	LOS	Yes	High	(1) Accuracy depends on the antenna's angular properties (2) Location of antenna must be specified.
Time (ToA, TDoA)	Time difference of arrival	High	Good (Multipath issues)	LOS	Yes	High	(1) Time synchronization needs. (2) Location of antenna must be specified
Fingerprinting	Received signal strength	High	Good	Both	No	Medium	(1) Need heavy calibration. (2) Location of antenna is not necessary
Dead reckoning	Acceleration, velocity	Low to medium	Good	NLOS	Yes	Low	Inaccuracy of the process is cumulative, so the deviation in the position fix grows with time.
Map matching	An algorithm based on algorithms based on projection and pattern recognition	Medium	Medium (indoor) Good (outdoor)	NLOS	Yes	Medium	(1) Map matching purely focus on algorithms and not fully on position methods, coordinate transformation, and geocoding (2) Using pattern recognition, high computing complex and poor real time issue occur.

Fig. 1. Comparison of different Methods

III. FINGER PRINTING

This method does not require any special hardware in either the mobile device or the receiving end [10].

Consist of two phases offline and online phase.

Offline phase:-A Database is made by calculating the Received signal strength indicator at each station by using the Device and Reference point.

Online phase:-At online phase the device calculate only the Received signal strength and send it to the Server ,server match value from the database and show the location.

Example:-First of all the station have already being measured with their RSSI value. When the system goes online it calculate the RSSI value at unknown spot and measure it the Database (Radio Map).

We can also use some extra characteristics of the radio waves to determine the more specific location.

Not every system is perfect. This system is also have some Draw-Backs which are described below.

DrawBack1-The Method is very laborious and time consuming.

DrawBack2- Extra station need calliberation again.

DrawBack3-The Number of devices connected to the Router may also deviate the value.

DrawBack4- The problem of same RSSI values at the same coverage.

DrawBack5-The Environmental Factors which can also affect the system entirely.

The accuracy of FingerPrinting Method depends on the number of base stations and the density of Recorded points where the fingerprints are taken. Recorded Received signal strength Indicator varies in time, even if there are no changes to the environment or locality. In order to eliminate the deviation of attenuation in the signal, the Received Signal Strength values are to be averaged over a certain time interval up to several minutes at each Base Station.

A. Solution to the Drawback

So till now we come to know that the Finger Printing is the Best Method But with some Drawbacks which we try to reduce by applying different methods.

DrawBack1- This Method is Time consuming and Laborious. We tried to come up with some method so that there should be no recording of data again and again. But we couldn't find the Solution of it.

DrawBack2-Suppose if we get the new chambers or any architectural change in the office building, we have to record the data again and update the database.

DrawBack3-Now there were no mention about the number of devices connected to the Wi-Fi which can alter the Received Signal Strength Indicator values at different places. We use the MAC airport tool for measuring the RSSI values at different position with different number of devices connected. The following Measurement is shown in the Fig-2,3,4,5,6,7,8.

The Next step is to take the values at each and every point and note down the values when different number of devices were connected to Router.

We get the values and start plotting them into the graphs. Each place got it's own graph with all the readings plotted, which shows the deviation because of the Number of devices connected.

This is the actual deviation which we found during our Measurements, We uses MAC Airport Tool which gives us the RSSI and Noise values and we add both the values to get the SNR Number.
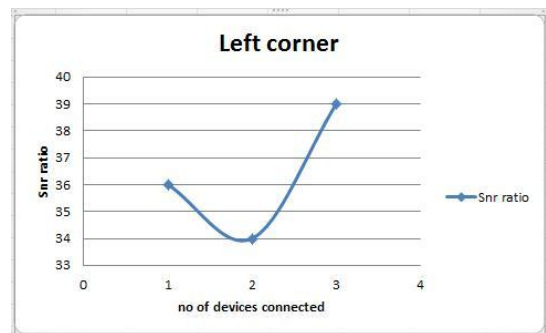

Fig. 2. Deviation of RSSI value at Left Corner of the Router

DrawBack4-This problem can be solved by using the techniques in the time based method which is Using three fixed

points at least. We calculate the value from the each router for a device at each and every location
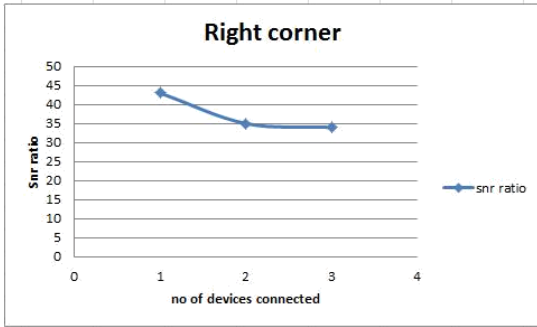

Fig. 3. Deviation of RSSI value at Right Corner of the Router
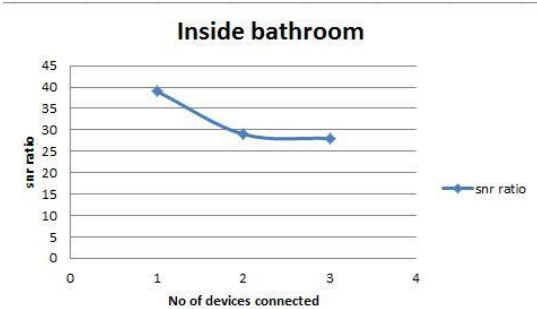

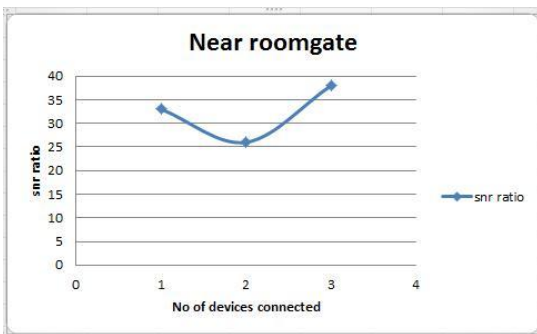Fig. 4. Deviation of RSSI value inside the Bathroom
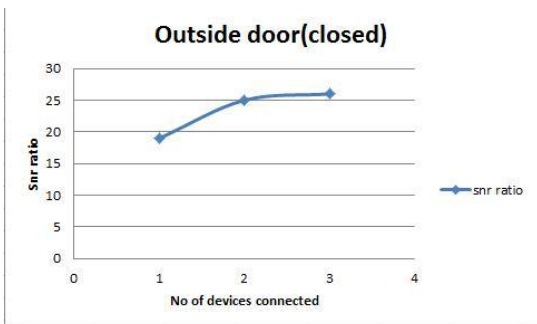

Fig. 5. Deviation of RSSI value

Fig. 6. Deviation of RSSI value

because of which our accuracy is increased. The above process is shown inn below figure9.
DrawBack5- To include the environmental factors in our system we have to include the one more factor which
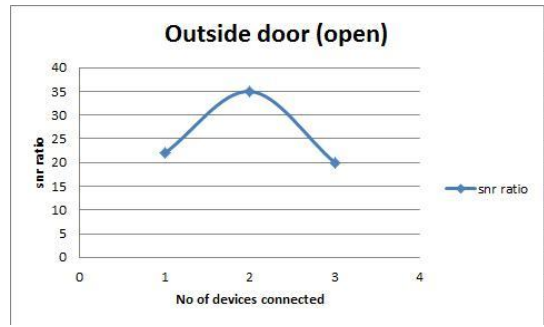

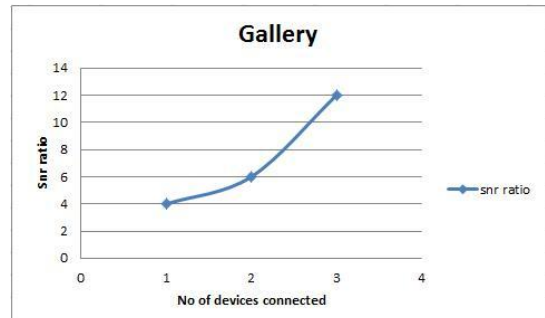Fig. 7. Deviation of RSSI value Outside Door When opened

Fig. 8. Deviation of RSSI value at Gallery
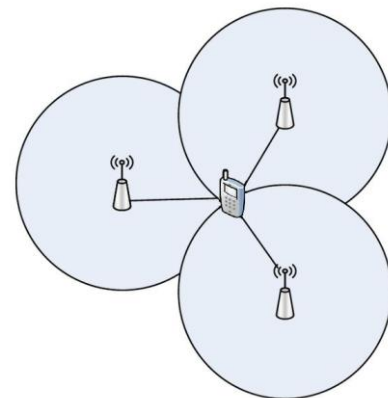
Fig. 9. Locate the Exact location using three reference point

is time .What we have to do is that we have to calculate the RSSI value for each Hour for one day for every number odd devices connected and to every router.
Final Solution- The Final solution will look like this as a use case diagram in fig-10 . The solution to eradicate most of the drawbacks is to consider the number of router(NOR),Number of devices Connected(NOD),Time, Place and RSSI value.
Final Table- The Final which looks like this Table1.

B. Work with Simulation

The Next step in this method is to implement the database and the fingerprinting method into the simulation which can prove whether the given method can give the result we desire or not. Till now the solving of the drawbacks with

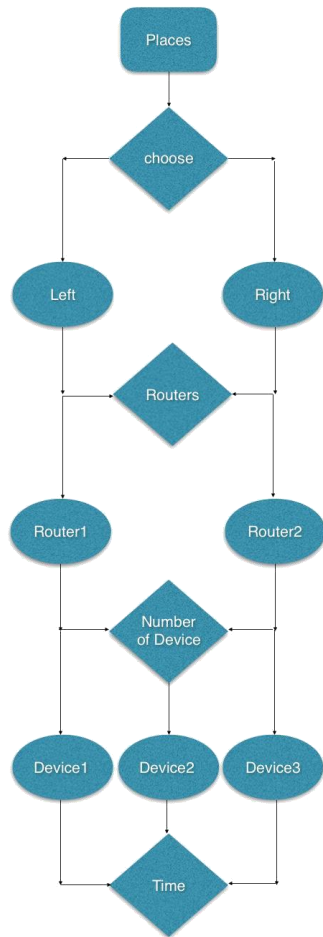Fig. 10. An Overview of a DataBase

TABLE I

DATA BASE TABLE

Id	NOR	NDC	Time	Places	RSSI

Measurement and different methods is done theory wise, But the further part is totally depend on the simulation and experimental result the following figure11 will give you better insight
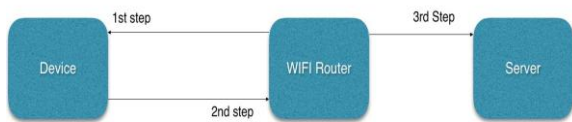

Fig. 11. Experimental Method

1st step:-Wi-Fi router connected to the device

2nd step:-device send the RSSI value back to the Wi-Fi 3rd step:-Wi-Fi sent the RSSI ,nod, nor, time to the server(database),to provide the location of the device.

IV. EXPERIMENTAL RESULTS

The Fig.11 is used to test the above suggestion which we used in our papers, So first of all getting the value of RSSI We used the airport tool in the mac which gives us the RSSI value [Fig12] and then we use the server and client program with the help of the python which connect the two system and we transfer the values of the Received signal strength. Then the server uses the database and compare the values and gives the location of the user.

```
[Siddharths-MacBook-Pro:bin Siddharth$ while x=1; do /System/Library/PrivateFrame]
works/Apple80211.framework/Versions/Current/Resources/airport -I | grep CtlRSSI
| sed -e 's/^.*://g' | xargs -I SIGNAL printf "\rRSSI dBm: SIGNAL"; sleep 0.5; d
one
RSSI dBm: -76
```

Fig.12 Calculation of RSSI Value

The second part is to transfer the file and compare with table which we made with help of the MySQL shown in the Fig13

```
+------+---------+--------+------+------+------+
|    1 | A_phone | S_room |    0 |   12 |  -77 |
|    2 | A_phone | S_room |    1 |   12 |  -77 |
|    3 | S_phone | S_room |    0 |   12 |  -31 |
|    4 | S_phone | S_room |    1 |   12 |  -32 |
|    5 | V_phone | S_room |    0 |   12 |  -40 |
|    6 | V_phone | S_room |    1 |   12 |  -40 |
|    7 | A_phone | S_room |    0 |    1 |  -79 |
|    8 | A_phone | S_room |    1 |    1 |  -68 |
|    9 | S_phone | S_room |    0 |    1 |  -25 |
|   10 | S_phone | S_room |    1 |    1 |  -26 |
|   11 | V_phone | S_room |    0 |    1 |  -40 |
|   12 | V_phone | S_room |    1 |    1 |  -41 |
|   13 | A_phone | S_room |    0 |    2 |  -69 |
|   14 | A_phone | S_room |    1 |    2 |  -70 |
|   15 | S_phone | S_room |    0 |    2 |  -35 |
|   16 | S_phone | S_room |    1 |    2 |  -36 |
|   17 | V_phone | S_room |    0 |    2 |  -43 |
|   18 | V_phone | S_room |    1 |    2 |  -44 |
|   19 | A_phone | S_room |    0 |    3 |  -75 |
|   20 | A_phone | S_room |    1 |    3 |  -76 |
|   21 | S_phone | S_room |    0 |    3 |  -25 |
|   22 | S_phone | S_room |    1 |    3 |  -25 |
|   23 | V_phone | S_room |    0 |    3 |  -47 |
|   24 | V_phone | S_room |    1 |    3 |  -46 |
|   25 | A_phone | S_room |    0 |    4 |  -70 |
|   26 | A_phone | S_room |    1 |    4 |  -70 |
|   27 | S_phone | S_room |    0 |    4 |  -35 |
|   28 | S_phone | S_room |    1 |    4 |  -33 |
|   29 | V_phone | S_room |    0 |    4 |  -52 |
|   30 | V_phone | S_room |    1 |    4 |  -50 |
|   31 | A_phone | S_room |    0 |    5 |  -69 |
|   32 | A_phone | S_room |    1 |    5 |  -70 |
|   33 | S_phone | S_room |    0 |    5 |  -25 |
|   34 | S_phone | S_room |    1 |    5 |  -26 |
|   35 | V_phone | S_room |    0 |    5 |  -45 |
|   36 | V_phone | S_room |    1 |    5 |  -50 |
|   37 | A_phone | S_room |    0 |    6 |  -67 |
|   38 | A_phone | S_room |    1 |    6 |  -68 |
|   39 | S_phone | S_room |    0 |    6 |  -29 |
|   40 | S_phone | S_room |    1 |    6 |  -30 |
|   41 | V_phone | S_room |    0 |    6 |  -36 |
|   42 | V_phone | S_room |    1 |    6 |  -34 |
+------+---------+--------+------+------+------+
```

Fig. 13. Table with all the RSSI values from Three Routers and time lapse of 6 hours

Now the last part is to use the query from the file which we receive from the sender's side and compare the values which include time ,RSSI, NOD(Number of devices), with the help of the query and gives us the location of the User (Fig14).

V. FUTURE WORK

The Future Work in this field can be done by using some advanced methods to calculate the received the signal

```
mysql> select id,place from wifi where
    -> NOD=0 and Time=12 and RSSI=-77;
+------+--------+
| id   | place  |
+------+--------+
|    1 | S_room |
+------+--------+
1 row in set (0.00 sec)
```

Fig. 14. Query used to detect the location.

strength at different places and continuously record the values according to their time and Number of devices connected. The main focus is to improve this method by making it autonomous. A Brief idea about applying is to record the mobile RSSI value regularly and then the server will make use of some method(Machine learning, Big Data) to segregate the useful RSSI values and fill them in the database accordingly. There is some new method also developed by the MIT researcher named CHRONOS. Which uses only one reference point to know the location of the devices. At last the application of this idea is magnificent if someday we able to make this better and useful the application of this method makes our life very much easy.

VI. CONCLUSIONS

So the conclusion is that the number of devices connected to the Wi-Fi affect the RSSI values at the different places which is not consider by anyone, and also the technique to take the environment factors into account which was resolved by measuring the values at each interval of time. This method makes fingerprinting more accurate but more laborious and tiresome. The future Work in this topic is to make fingerprinting method autonomous

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