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DETERMINING THE POSITIONING ALGORITHM FOR FINGERPRINTING USING WLAN

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1. ABSTRACT

The effectiveness of Location Based Systems depends on the correct location of users and mobile devices the outdoor location can be easily calculated, while using technologies such as GPS (Global Positioning System), it is more difficult to obtain when the location scenario is an indoor environment. Several technologies and location techniques can be used in this field. One of these techniques is FINGERPRINTING which consists in two different phases:
the first phase is the :

CALIBRATION PHASE: when data is collected and the Fingerprint Map is generated.

the second phase is the :

ON-LINE PHASE: where data collected by the mobile device and the data collected in the calibration phase are used to estimate the location of the mobile node.

From the several wireless communications technologies IEEE802.11 is probably the most used in Wireless Local Area Networks.

Keywords----- Client-server model, Existing WLAN methods ,IEEE 802.11b, Location determination technique,
Positioning algorithm for location estimation, Triangulation and KNN algorithm,

2. INTRODUCTION

All the Location Based Services (LBS) depends on the correct estimation of the users' location. While in outdoor environments technologies such as GPS (Global Positioning System) can be successfully used, the same is not true when the operating scenario is indoor environments. In such scenarios alternative location technologies and methodologies must therefore be used, making this a very challenging research area where in the last years several different types of solutions have been developed.

Some of the most used technologies used for indoor location include the use of infra-red, ultrasonic waves Pressure sensors, RFI (Radiofrequency Identification) and wireless communications networks.
In what concerns to the methodologies used to obtain the location, they can be divided into three main areas:

Triangulation, Proximity, Scene Analysis: Here, we focused on a particular location technique, which uses wireless communications networks as location technology, methodology based on scene analysis. Location using fingerprinting:

Location Estimation Algorithms will be used, and their performance was analyzed. The following LEA were considered to do this analysis:

- Nearest Neighbour – which considers the coordinates of the nearest reference as coordinates of the actual location
- k-Nearest Neighbour – which uses the average of the coordinates of the k nearest neighbors.
- Weighted k-Nearest Neighbour – which uses a weighted average of the coordinates of the k nearest neighbours.

IEEE 802.11b:

IEEE802.11b supports data rates up to 11Mbps, much higher than what IEEE 802.11 supports, increasing the variety of application that were feasible as compared to the previous IEEE 802.11 protocol. A number of different rates were defined; these can be used in different situations. These rates are: 11 Mbps, 5.5Mbps, 2Mbps, and 1Mbps. The actual user data throughput which users experience is usually around 5Mbps, similar to the actual throughput of an IEEE 802.3 10Base-T wired local network. IEEE802.11b uses the 2.4GHz Industrial, Scientific, and Medical (ISM) frequency band, which does not require a license for the user – but does require that the manufacturers meet the requirements for wireless local area network devices for their products. IEEE 802.11b WLANs can be used as a supplement to LANs or as an independent network. Today most laptop computers have a built-in IEEE 802.11b WLAN interface in addition to a IEEE 802.3 1000 base T interface. This WLAN interface helps users to avoid having to carry and connect cables. Today, most corporate and academic sites provide (legitimate) users with WLAN connectivity.

While IEEE 802.3 (Ethernet) utilizes a carrier sense multiple access (CMSA) mechanism to control when packets are sent. Specifically, IEEE 802.3 employs Carrier Sense Multiple Access with Collision Detect (CSMA/CD). With this media access protocol all stations that wish to send messages listen for when the channel is idle. As only one station can be allowed to send at a time, the others need to wait until the channel is free. If two or more stations send messages at the same time, then a collision occurs, in this case all of the messages which were being set are lost and all of the stations attempting to transmit will stop trying to send and will wait for a random amount of time

Before listening to see if the channel is idle – at which time they will attempt to transmit their message again. Because in a wired network it is possible to determine if someone else is attempting to transmit at the same time as you are, this method works quite well. Unfortunately, this is not easy to do in the case of a WLAN interface, thus IEEE802.11b uses another technique CSMA with collision avoid (CSMA-CA). Collision avoidance is necessary because the radio transmitter cannot detect a collision (unlike the wired LAN case). To avoid collisions each interface that wishes to transmit waits for a random time after detecting that the channel is idle before attempting to transmit. This period of time can be divided into different ranges of time in order to enable a mix of higher priority traffic and lower priority traffic.

Application:

WLANs provide additional features. For example, in many historic sites, it is quite hard and expensive to run new wires or cables; additionally it is better to avoid cables in order to protect the historic building's appearance, construction, and so on. The most important feature of a wireless network is their flexibility. In many indoor scenarios, the network configuration must be changed frequently, which for a wired network would require an expensive (re-)deployment; where as in a wireless network there is little wiring (as only the access points are attached to the LAN) significantly reducing the installation cost. Furthermore, WLANs also support other desirable features, such as roaming. Roaming enables users to move between APs; while retaining the ability to communicate, despite attaching to a new subnet via a new AP(access point).

3. LOCATION DETERMINATION TECHNIQUE

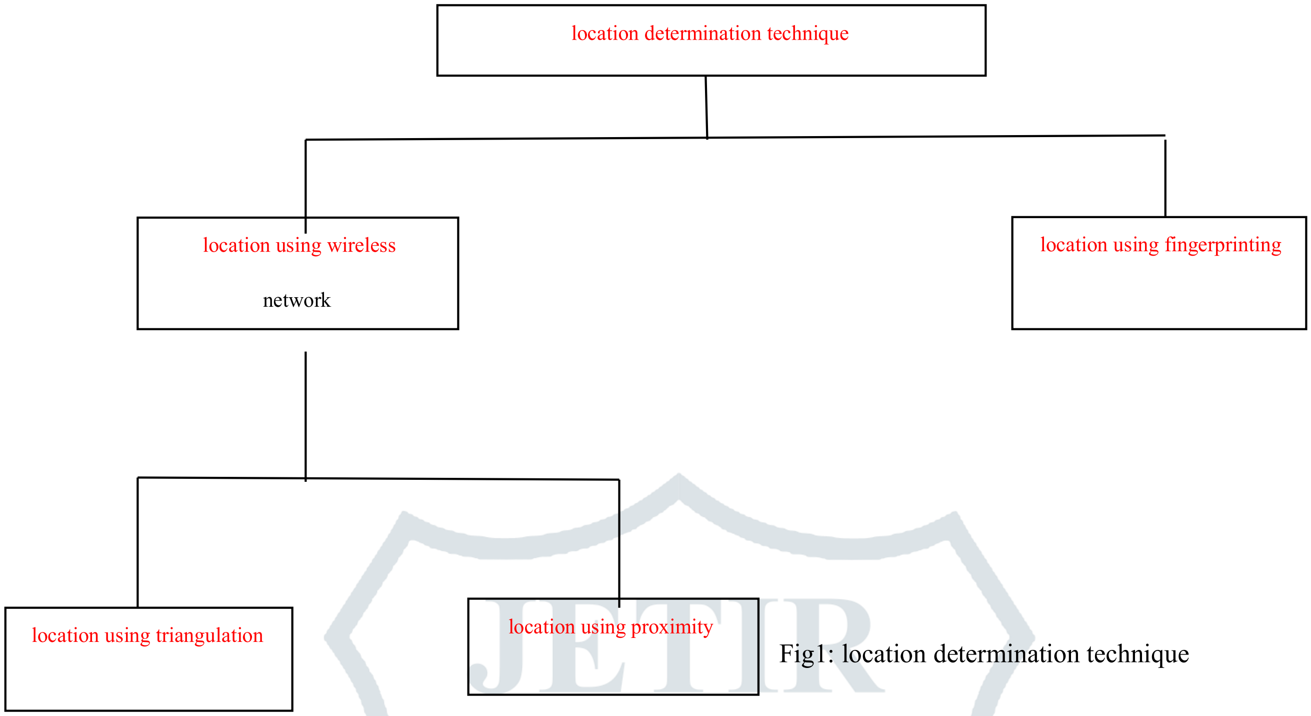


Fig1: location determination technique

3.1. LOCATION USING WIRELESS NETWORKS

Location using wireless networks is based on the properties of wireless signals. Any property of a wireless signal can be used in location systems, as long as there is a relation between it and the current location of the mobile terminal. The signal properties that usually are used in location systems are:-

Time-of-Flight – the time needed by the information to travel from the transmitter to the receiver.

Received Signal Strength (RSS) – which indicates the power received by the wireless networks.

Technique comes under location using wireless network

3.1.1 Location using Triangulation

Triangulation uses the geometric properties of triangles to determine the location of the mobile node.

It can be divided into Lateration and Angulation.

1. Lateration uses the distances to determine the location. It takes into account the distances between the mobile node to be located and the references.

2. Angulation the angle of incidence of a signal must be known. By analyzing the Angle of Arrival of a wireless signal relatively to a given reference, it is possible to determine the location of the mobile node.

3.1.2 Localization using Proximity

Location using this methodology consists in discovering the nearest reference to the mobile terminal; therefore its spatial resolution is dependent on the number of used references.

3.2. LOCATION USING FINGERPRINTING

Fingerprinting is a scene analysis technique. In scene analysis a scene is observed and its patterns and variations along the time are observed. The information about a scene in the case of fingerprinting is obtained from one or more properties of electromagnetic signals from the references.

4 . EXISTING WLAN LOCATION METHOD

4.1. Cell-ID

In this method the serving cell identifier (cell-ID) is used to locate the user. The accuracy in this method depends upon the radius of the cell. For urban areas, e.g. in a large city, this may be a few hundred meters; in rural areas it could be up to 30km.

4.2. Cell-ID and RxPowerLevels

This information is used to locate the mobile subscriber with good accuracy and high speed. The mobile terminal gathers information concerning the serving cell and the power level received from it. Along with the same information about other cells in the locality, this data is passed back to a server within the network operator's network. The network server then calculates the position of the user based on the positions of the cell base stations and the power at which they are transmitting.

4.3. Global Positioning System (GPS)

The GPS positioning method measures the distance from the satellites to the receiver by determining the pseudo ranges (code phases). The system extracts the time of arrival of the signal from the contents of the satellite transmitted message. It then computes the position of the satellites by evaluating the ephemeris data at the indicated time of arrival. Finally it is possible to calculate the position of the receiving antenna and the clock bias of the receiver by using this information.

4.4. Angle of Arrival (AOA)

This requires a minimum of two base stations with directional antenna. It measure the angle of arrival of signals, coming from a particular mobile subscriber, at the two base stations, and from this can calculate the users position.

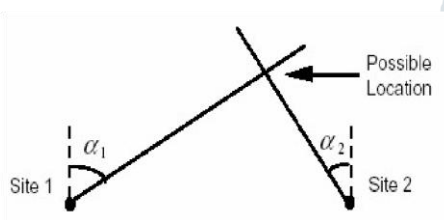


fig2: AOA

4.5. Time of Arrival (TOA)

The Time of Arrival method locates the mobile terminal by triangulation from a minimum of three base stations. Because the speed of electromagnetic waves is known, it is possible to calculate the distance from each base station by observing the time taken to arrive. This method assumes that all transmitters and receivers are perfectly synchronized and ignores reflections or interference that will affect the position accuracy.

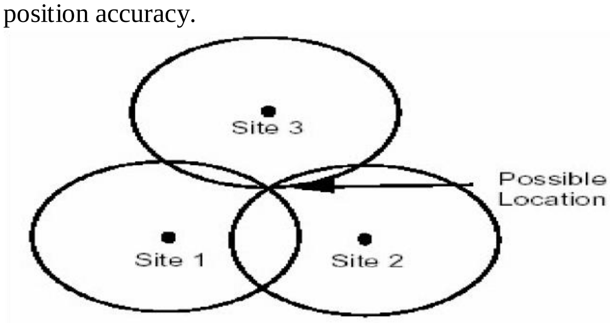


Fig3: TOA

4. 6.Time difference of arrival

Time difference of arrival (TDOA) is an algorithm based on TOA, which determines the position by measuring the time difference of signal arrival. This significantly decreases the requirement for time synchronization. This technique is used in a wide range of applications ranging from wireless communication to electronic warfare. Receivers are located at known fixed positions; the transmitter's position can then be determined by a hyperbolic function.

4.7. RSS (Received signal strength)

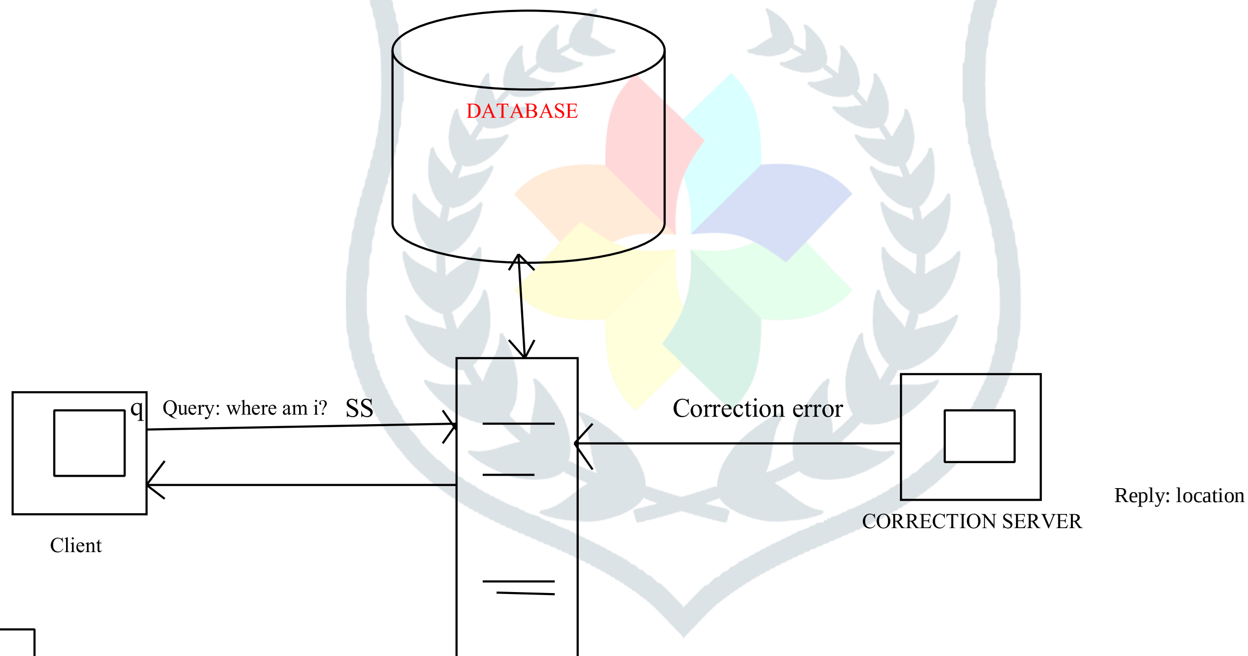
The power density of an electromagnetic wave is proportional to transmitted power and inversely proportional to the square of the distance to the source. This physical law as well as the vectorial combination of waves that reach a receiver over different paths is the basis for estimating distance and location from signal strength measurements.

4.8. Time of flight (TOF)

The distance between a transmitter and receiver equals the time of flight, or electromagnetic propagation time, of the transmitted signal times the speed of propagation, which is the speed of light. Distance can be determined from measurement of time of arrival (TOA) of a signal at a receiver when transmission time is known, or from differences of reception time at different locations (time difference of arrival—TDOA).Another expression of time of flight is the phase of the received signal, which may be referred to as phase of arrival (POA), since phase may be related to time and distance through the signal wavelength and speed of light.

5. CLIENT-SERVER MODEL

5.1. Locate Self



Tracking and positioning server
Fig4: Client-server model (locate self)

1) The client sends query "where am I" to the positioning server. Along with the query the client sends its direction and signal strength from access point.

2) The server receives the query and signal strength information, compares the information with the signal strength database using specific positioning algorithm and estimate the location of client.

3) The server replies to the client with the location information.

5.2. Locate other

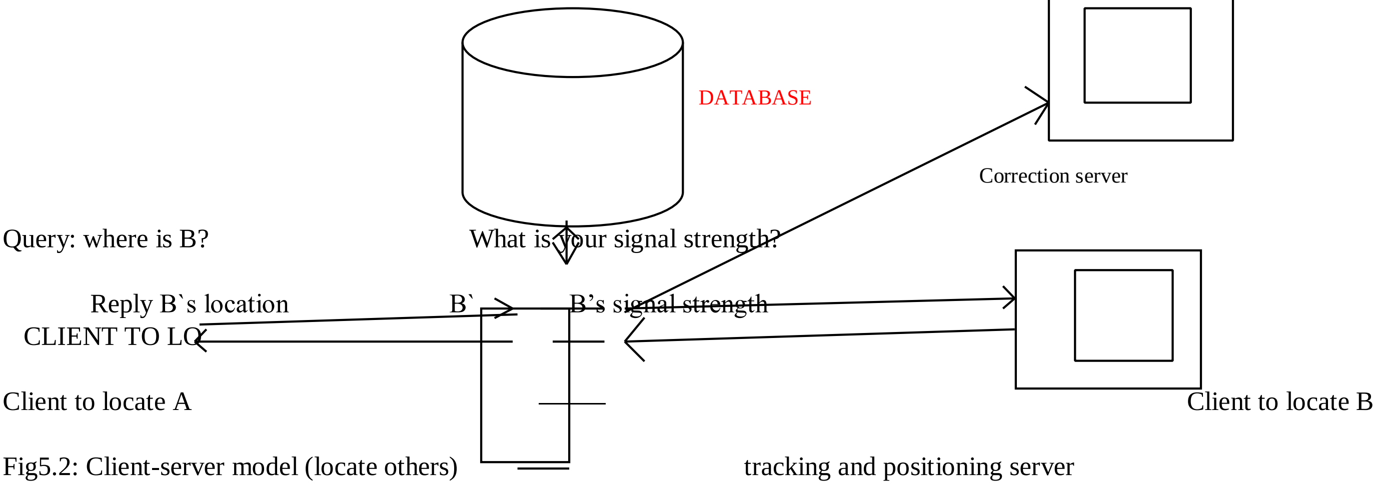


Fig5.2: Client-server model (locate others)

1) The client A sends query "where is B" to the positioning server.
2) The positioning server sends query "what is your signal strength" to client B.
3) Client B sends reply to positioning server with its signal value.
4) Positioning server receives signal strength values from B, compare it with signal strength database and estimate the location of B.
5) Positioning server sends reply to A with location of B.

In client-server model, it is a mobile device which retrieves signal strength from its access point and reports it to the location determination server, which means estimates the location of mobile device using proper mathematical algorithm. It does not require any positioning component to be included in the wireless system. Therefore can work with normal IEEE802.11 access point. The location determination server matches the RSS with the RSS radio map and estimates the current location of mobile device using tracking and positioning algorithm. Mobile device collects RSS from access point at specific position (RPs) and transmit these data to the server. After the fingerprint collection is done by the device, the server creates the radio map database.

6 . INTERACTION BETWEEN MOBILE DEVICE AND LOCATION DETERMINATION SERVER

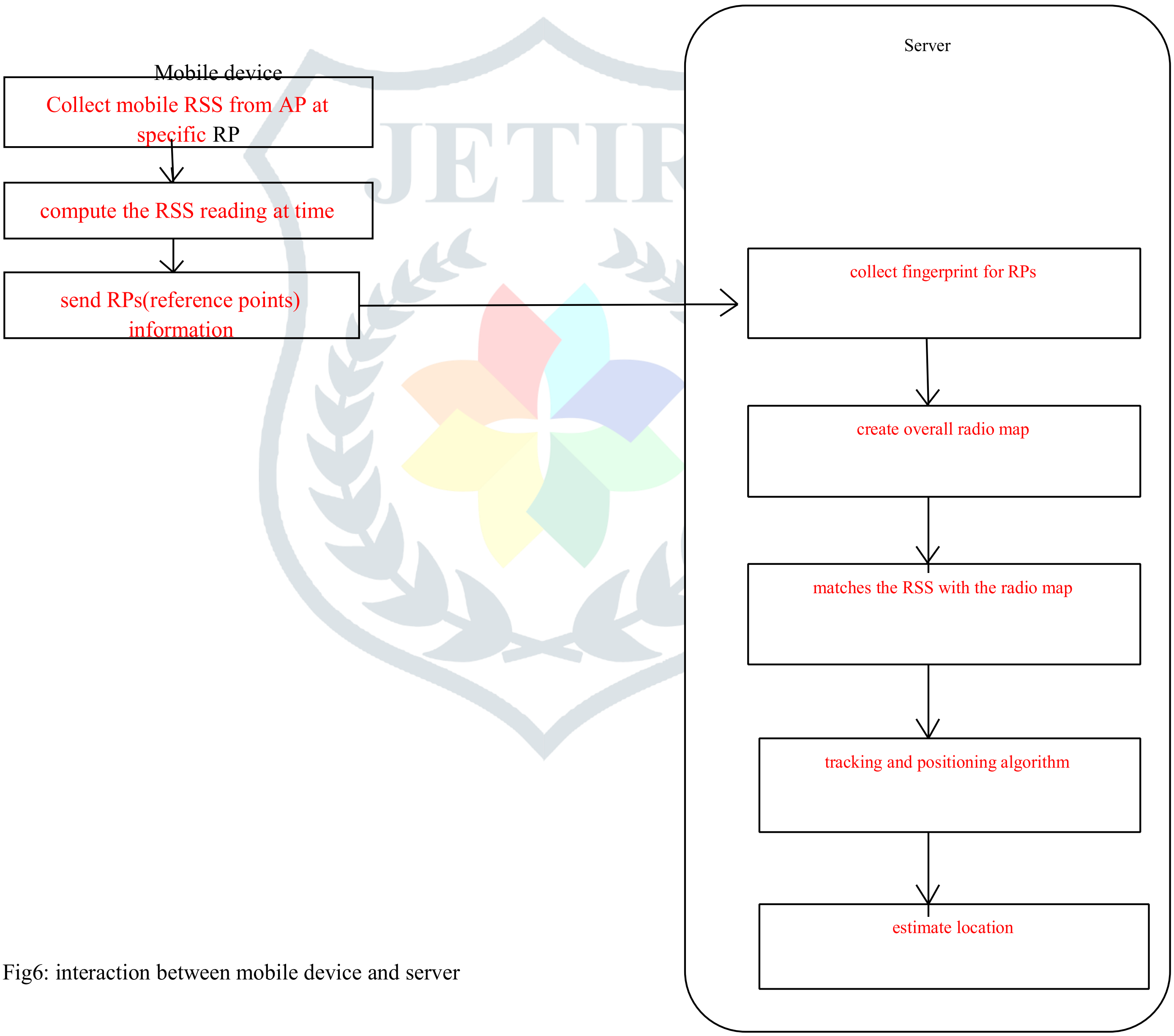


Fig6: interaction between mobile device and server

7 . RELATED WORK

A system works in client-server model and a dynamic KNN algorithm is used, which uses triangulation and a KNN as a mathematical model and a positioning algorithm for location estimation is designed by merging the triangulation and knn approach to estimate the location of mobile devices and to improve accuracy.

7.1. LOCATION ESTIMATION USING TRIANGULATION: The transmitted signal (Tx) and the received signal (Rx) are two of the most important parameters used for location prediction of wireless node. Tx is used to calculate Available Signal Strength (ASS) and Rx is used to calculate Receive Signal Strength (RSS). These ASS and RSS are used to calculate the distance between the sending node and the receiving node. If there are three or more access point in a room or in an area then it is possible to build a triangulation positioning technique. Signal level drops when the distance between the antenna and the mobile device increases. Under ideal conditions the contours of signal level around the antenna are circles. If we know the relation between signal level and distance, from the signal level measured we can get the distance from the mobile device to the antenna. The mobile device is on the circle around the antenna with the distance as semi-diameter. Once the signal levels of the mobile device from three antennas are measured, using triangulation we can estimate the location of the mobile device. The distance can be calculated using Euclidean distance----

$$d = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}$$

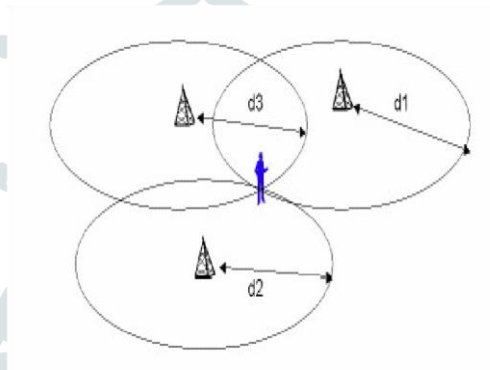


Fig7.1: location estimation using triangulation

7.2.LOCATION ESTIMATION USING KNN ALGORITHM: In the knn algorithm the mobile device measures the signal strength of each of the access point within range,then searches through the radio map database to determine the signal strength tuple that best matches the signal strength,it has measured.The system estimates the location associated with the best matching signal strength tuple(i.e nearest neighbour) to be the location of mobile.We use the following Euclidean distance to measure----

$$Sd = \sqrt{\Sigma (si - si')2}$$

Using this measure,we investigate the signal space to find the position in the physical space.In this formula--- k = no. of access point in the physical space.

Si is signal matches in the database for APi and Si' is the measured signal strength in the real-time operation for APi.
This technique basically calculates the Euclidean distance(sd) in the signal space and pick the signal tuple that minimize this distance in signal space and declares the corresponding physical coordinates as its estimate of the mobile location.

8 . POSITIONING ALGORITHM FOR LOCATION ESTIMATION

Step1: Begin

Step2: Input: Real-time signal strength information.

Step3: Open signal strength strength database

Step4: Read a first record from signal strength database

Step5: If direction of current record = direction of real-time signal information

Step6: Then calculate Euclidean distance of current record and signal strength information, otherwise Loop: next record in the signal strength database and go to step4.

Step7: After calculating Euclidean distance compare that current Euclidean distance < minimum distance

Step8: If this condition holds then minimum distance = current Euclidean distance, otherwise Loop: next record in the signal strength database and go to step4.

Step9: estimated location = location of current record

Step10: Close the signal strength database

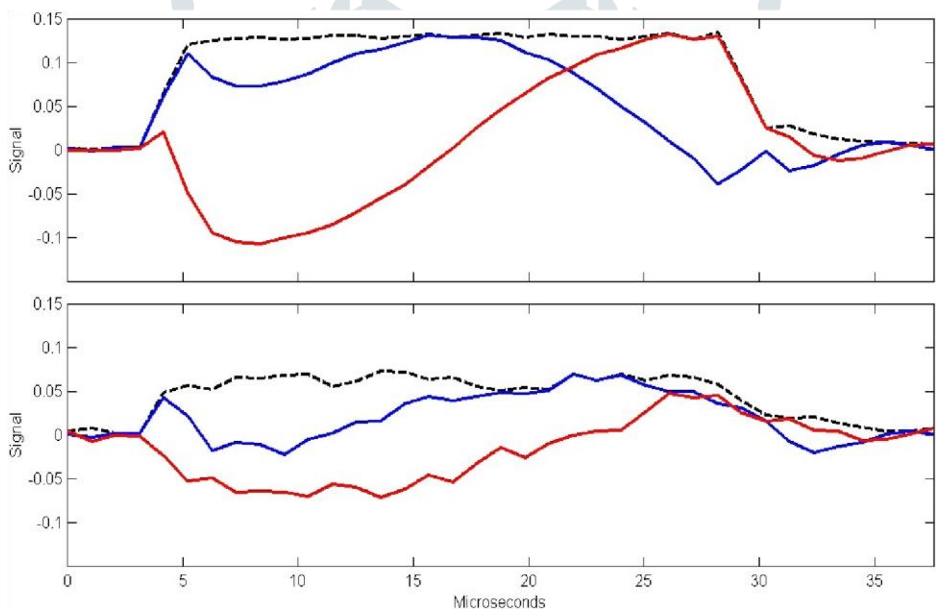
Step11: Output: estimated location

Step12: End

Algo1: positioning algorithm for location estimation

9. RESULT ANALYSIS

The number of access points is very important. With three or more access points installed, aliasing is reduced, and the positioning accuracy are improved a lot. The number of access points is a vital factor for positioning accuracy. We are using MATLAB for simulation and simulate the positioning algorithm for location estimation we see that accuracy is increased and we get position near to accurate.



10. CONCLUSION AND FUTURE WORK

The best candidate to determine a user location in indoor environment is by using ieee802.11 (Wi-Fi) signals, since it is most widely available installed on most mobile devices used by users. Unfortunately, the signal strength, signal quality and noise of Wi-Fi in worst scenario, fluctuate up to 33% because of the reflection, reflaction, temperature, humidity and dynamic environment etc .This makes problem in determining a user location indoor. This study present our current development on a light-weighted algorithm, which is designed to be easy, simply but robust in producing the determination of user location. We study determination of estimated location and improve accuracy. A system works in client-server model and a dynamic KNN algorithm is used, which uses triangulation and a KNN as a mathematical model and a positioning algorithm for location estimation is designed by merging the triangulation and knn approach to estimate the location of mobile devices and to improve accuracy. Using this approach the accuracy is achieved near to accurate. As a future work it is possible to consider the issues that how many access points are required to provide a more accuracy with a granularity of the grid in the database, how the database should be organized for better searching speed, whether matching distributions of RSS in locations that are severely obstructed from APs is preferable to simply matching the average RSS, etc.

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