Localization of Indoor Mobile Networking

Priya Darshini
MTech Student
Department of Electronics and Telecommunication
Siddaganga Institute of Technology
Tumkur, India.

Mrs. Suchitra V
Assistant professor
Department of Electronics and Telecommunication
Siddaganga Institute of Technology
Tumkur, India.

Abstract - Reliable indoor location techniques are essential for the development of advanced location-conscious applications. Most of the previously proposed solutions to this problem assume that the nodes can use some ranging technology to obtain pair distances to other nearby nodes. These techniques for indoor localization fix the inadequacy of the global positioning system within a closed setting, such as houses. This research describes and evaluates a method for locating devices that use a wireless network to communicate. The distances between a blind node, unable to decide its position, and a group of anchor nodes, recognizing its localization, are calculated using the signal attenuation (Relative Received Signal Strength Indicator) obtained while capturing International Mobile Subscriber Identity numbers. The position is calculated using the triangulation method.

Keywords - IMSI (International Mobile Subscriber Identity Number), RSSI (Relative Received Signal Strength Indicator), GPS, IPS (Indoor Positioning System), GSM, indoor mapping.

I. INTRODUCTION

With the exponential development of mobile connectivity and the pervasive computing technologies, the need to provide location-aware service is growing. While the Global Positioning System (GPS) may provide location services with accurate and reliable position information, indoor environments cannot be used effectively [5], [6]. Researchers have introduced various innovative technologies for localization, such as sensor network [3], RFID, and Wi-Fi [2] to solve this constraint. Wi-Fi positioning systems appealed considerable interest among them because it is focused on cell phones which are widely used around the world [2]. The crowded areas, such as highways, office buildings, shopping centres, hotels, and airports, typically have a lot of access-point (AP) hot-spots, providing a large coverage of Wi-Fi network. Thus, it is practical and feasible to follow the Wi-Fi network and cell phone [3] to incorporate indoor staff positioning. An important and novel emerging technology is precise indoor localization [4], [6], [7].

The former utilizes the signal propagation model to translate measured signal intensity to distance data. We will then calculate the target location using a known location, based on the distance between target in motion and the various access points. The actual installation of Wi-Fi access points is unusual for an ordinary multilevel house, as it is seriously affected by certain variables such as the building layout. Therefore, fulfillment is very complicated for defining and calculating the AP coordinates. Hence the signal propagation model cannot accurately describe the relationship between real distance and signal strength with complex structures in the indoor environment [6]. The ability to access the exact location contributes to substantial context-conscious computing and a wide range of useful Location Based Services (LBS). Examples of such applications include asset tracking, context-conscious computing, omnipresent computing, security for wireless access, mobile advertising and various personal robotics applications. This project uses Universal Software Radio Peripheral (USRP) to collect IMSI numbers for users nearby. With the support of GNU's Not Unix (GNU) radio software and python programming, USRP is used to obtain an IMSI number of different users.

A. IMSI (International Mobile Subscriber Identity):

The international mobile subscriber identity or IMSI is used to identify subscribers of the cellular network and is a specific identifier used with all cellular networks. It is located as a bit field and is sent over the mobile device to the network. An IMSI would usually appear as a number of 15 digits but may be shorter. The first three digits indicates Mobile Country Code (MCC), preceded by Mobile Network Code (MNC) in 2- or 3-digit formats. The length of the MNC depends upon the importance of the MCC. The remaining numbers are the Mobile Subscriber Identification Number (MSIN) within the client base of the network, typically 9 to 10 digits long depending on the MNC's length.

Fig 1: IMSI number description.

IMSI catcher is an eavesdropping tool that is used to capture cell phone traffic and monitor mobile phone users' location data. A fake cell tower that operates between a target mobile phone and the real tower of the service provider, which is called a "man-in-the-middle "attack, IMSI catchers can distinguish cell phone IMSI numbers in its vicinity. When the licensed network operator has more than one base station available, they should always pick the one with the strongest signal. As a base station, an IMSI-catcher masks and causes all cell phones of the simulated network operator to log in within a given radius.

B. IPS (Indoor Positioning System):

Indoor Positioning Systems (IPS) allow the location of objects or individuals within buildings. Due to the absence of visual contact within the GPS satellites [5], [7], GPS is inadequate in enclosed environments, an IPS (Indoor Positioning System) may use other forms of positioning. These include common consumer technologies such as Wi-Fi or Bluetooth Low Energy (BEL), but also ultra-wideband (UWB), or wireless solutions based on RFIDs. Infsoft's devices are ideal for indoor and outdoor applications. The first and most critical step in applying localization programs is to select the method [4] and positioning technologies [1]. IPS technologies allow for a variety of location-based solutions, which include real-time location systems (RTLS), navigation, inventory management, as well as first responder location systems. There is a wide variety of different technology which can be used for indoor positioning [6], some of which may be proximity-based systems [4], Wi-Fi systems [2], ultra-wideband systems, acoustic systems and infrared systems.

II. METHODOLOGY

Indoor positioning systems (IPS) allow to locate objects or people within buildings. Provided that GPS is ineffective in enclosed spaces due to lack of visual communication with GPS satellites and lack of accuracy, an IPS wants to use other positioning methods. These include common consumer standards such as WiFi or Bluetooth Low Energy (BEL), but also Ultra-Wideband (UWB) or passive RFID based solutions. The selection of the positioning approach and technologies is the first and most important step in the implementation of locating systems. Base-station is places in the defined area in a certain position for precise localization. Base-stations are linked and the information is shared. Base-station is used by users in the specified area to collect basic information parameters (IMSI number, MCC, MNC, RSSI). Therefore, using triangulation procedure, these parameters can help to determine the distance and position of particular users. Coordinates for specific locations can be identified using 2D mapping process.

Fig 2: 2D mapping of the interior indoor area.

Trilateration positioning uses measured distances to measure the latter's location between multiple emitters and receivers. Distances are determined either by algorithms RSSI or ToF. RSSI stands for Relative received Signal Strength Indicator. RSSI refers for measure of signal intensity obtained by relative. It makes distance measuring based on radio wave attenuation that fulfills the inverse-square physical theorem.

Fig.3, where the base stations eat connected to a master processing unit, indicates a model of a traditional indoor positioning system, and a reference tag is necessary to put the cell node into the regional 3-D coordinate network. Using the arrival time difference (TDOA) for 3-D triangulation in tandem with the leading-edge detection at the UWB receiver allows reduce the strict synchronization criteria of the base station and the susceptibility to thick multipath indoor interruption. Although the network architecture shown in Fig.3 is well known and has been integrated into wireless positioning systems like Global Positioning Systems (GPS), this concept for high precision indoor 3-D positioning has proven to be deceptively difficult to achieve.

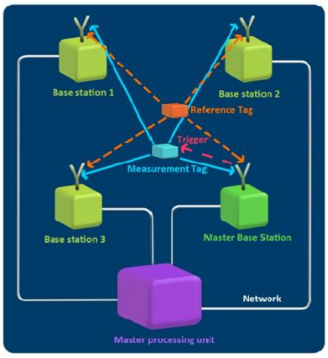


Fig 3: A standard indoor positioning system, with four or more base stations triangulating a mobile's 3-D location.

In this project, USRP is acting as a base station in the mobile network to collect the user data. USRP will gather the user's basic information parameters such as IMSI number, MCC, MNC, RSSI in a given region. Using triangulation method certain parameters can be used to measure a given consumer's distance and location. Method direction for the determined position can be identified by using 2D mapping method.

III. RESULTS AND DISCUSSION

This chapter discusses how the radio parameters are collected, users' distance and the 2-D mapping detected. This will explain the process for obtaining certain criteria and measures to be taken. As well as the results obtained after the above measure.

A. Radio parameters collected using USRP:

USRP acts as a base station, and attempts to connect to the users in the specified area. This sends powerful signals to communicate with users than the other base station. User network can scan for the strongest base station transmitting signal and request the temporary USRP-user link. The mobile device sends its protection capabilities, but this can be overlooked by the USRP as of experimental purpose. It responds to the phone with a request for an ID (sent identifier). The user mobile phone will send IMSI'/TMSI back in plain text, finally. The law enforcement will use this IMSI number to establish the IMSI's phone number and user.

GSM traffic captured must be decoded before it is fed to Wireshark. Decoding here means converting radio signals into data, and this can be done using the grgsm method. Gr-gsm application scanning GSM bands and printing information of base transceiver stations transmitted in the area and interactive single channel monitor. Grgsm uses GNU Radio Companion method for processing GSM signal. A Grgsm scanner is the application which scans GSM bands and prints information on transmitting base transceiver stations in that area. A Gr-gsm folder contains programs for scanning and monitoring. Export uhd image files and debug scanner software. The output of the scanner is shown in figure 4 below.

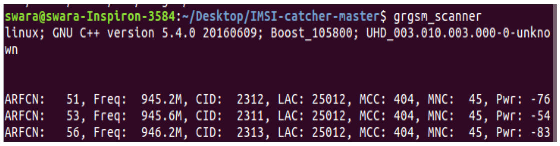


Fig 4: The output of scanning GSM band.

From the GSM frequencies scanning above, one of the frequencies with the highest receiving power. The highest receiving power means the user is closest to the fake base station and is simple to connect. From the above, we chose the frequency 945.6MHz with a maximum receiving power of -54 Watts. Grgsm offers a series of GRC blocks and scripts to interpret GSM signals. Live monitoring of the GSM signal opens an interface where one can set their GSM frequency. Through another terminal window, when a decoder detects a simple GSM signal, one can see the received I/Q values. The completely decoded network traffic of the GSM is sent over the interface of the localhost where the data can be analyzed. Figure 5 shows they process of decoding.

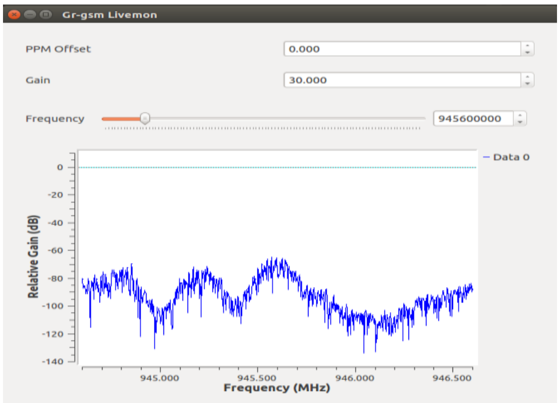


Fig 5: Relative gain obtained while live monitoring

Start the script which is a simple IMSI catching program that can collect the IMSI numbers which are in that particular band. It resolves all the various types of packets that live monitoring passes to it. From there it attempts to overcome any values of TMSI or IMSI. Starting there it can save data for further processing of the data in sqlite database. Figure 6 describes the results obtained after live monitoring, the GSM band which contains IMSI, TMSI, the country, brand, operator, MCC, MNC, LAC and Cellid.

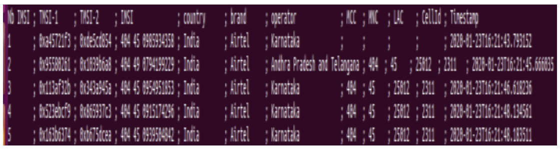


Fig 6: Results after live monitoring.

B. DISTANCE AND LOCATION CALCULATION:

Taking 3 reference points is determined using the triangulation method, position and distance of the unknown. Three points are divided as 2 base-station reference and the other is a current location. It calculates the distance between each point. The distance calculation formula is given below which took earth radius as the reference.

$$Dist = \cos^{-1}((\sin(lat0)\sin(lat1)) + (\cos(lat0)\cos(lat1)\cos(lon1 - lon0))) \times earthR$$

They ate translated into cartesian (x, y, z) co-ordinates of 3 points, P0, P1 and P2 using the latitude and longitude of the reference points taken. An array of triangulation point ECEF (acronym for earth-centered, earth-fixed) x, y, z is measured using cartesian-shaped reference points. Convert cartesian back from ECEF to latitude/longitude and convert to degrees. And we measure the distance. The figure 7 shows the calculation results that got after running the program which is for calculating location and distance of a unknown point.

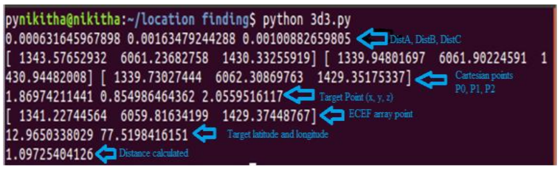


Fig 7: Location and distance of a unknown point.

C. GENERATION OF A 2-D MAP:

The blue points in the graph are all static, and the target point is red. Because it depends on multiple nodes from USRP, two static points are assumed, and their RSSI values are constant. Having one varied RSSI to the target node, using the triangulation method, achieves the cartesian view as below. Any changes to the target point, changes to its RSSI depend on RSSI of the static points and consideration of the static point node, the variation on the graph will be seen. The output of the results obtained is plotted on graph, figure 8, and the position is determined using the method of trilateration.

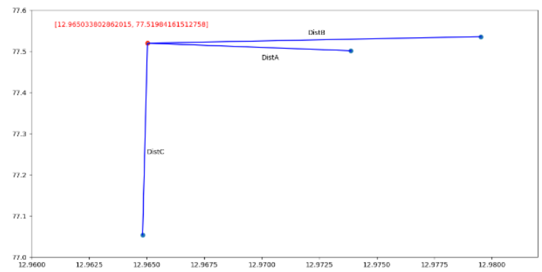


Fig 8: Location and distance of an unknown single point graphically.

The below figure 9 explains the location and distance of two target points. In the below graph, points A and B are used as static points and the other two points are variable points. While evaluating points A, B and C the target point is found between them, where C is a reference point that can be varies as the consumer wishes. When we consider A, B and D points, another target point is detected, where a D point is also a variable point. Usage of the two-reference points C and D to identify the two target points. Many points that require more valuable points can also be found by taking two static points.

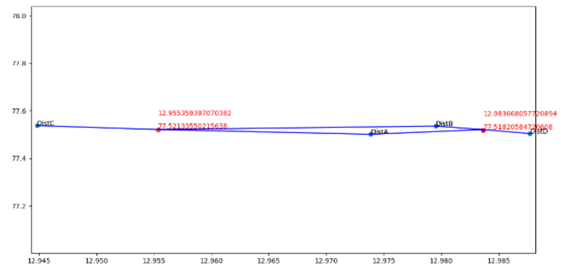


Fig 9: Location and distance of a undefined 2 point graphically.

If 5 nodes which are A, B, C, D and E are considered, the target nodes obtained will be extracted if we take A as reference node. The combinations of the target nodes are ABC, ABD and ABE respectively. The below figure 10 describes the output of the first three combinations by taking node A as reference node. The graph shows the target points in the form of red dots with the location values that is latitude and longitude. The output values of the target points calculated using node A as a reference are shown in figure 11. The values calculated using the basic triangulation method are shown below. The location is firstly calculated in cartesian form is then to the latitude and longitude form. The latitude and longitude information is supplied to the position of the target points, and the distance is also determined by taking node A as reference.

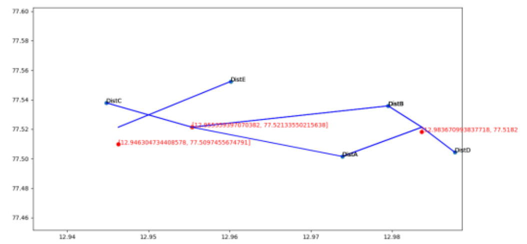
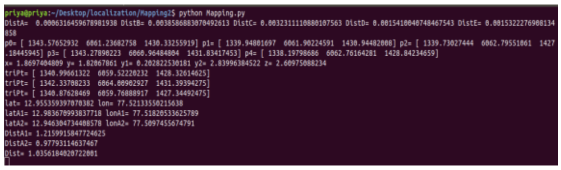


Fig 10: The location of three target points using node A as reference.



```
priya@priya:~/Desktop/localization/Mapping2$ python Mapping.py
DistA=  0.0006316459678981938 DistB= 0.0038586883070492613 DistC= 0.003231110880107563 DistD= 0.0015410040748467543 DistE= 0.0015322276908134
858
p0= [ 1343.57652932  6061.23682758  1430.33255919] p1= [ 1339.94801697  6061.90224591  1430.94482008] p2= [ 1339.73027444  6062.79551061  1427
.18445945] p3= [ 1343.27890223  6060.96484804  1431.83417453] p4= [ 1338.19798686  6062.76164281  1428.84234659]
x= 1.8697404809 y= 1.82067861 y1= 0.202822530181 y2= 2.83996384522 z= 2.60975088234
triPt= [ 1340.99661322  6059.52220232  1428.32614625]
triPt= [ 1342.33708233  6064.00902927  1431.39394275]
triPt= [ 1340.87628469  6059.76888917  1427.34492475]
lat= 12.955359397070382 lon= 77.52133550215638
latA1= 12.983670993837718 lonA1= 77.51820533625789
latA2= 12.946304734408578 lonA2= 77.5097455674791
DistA1= 1.2159915847724625
DistA2= 0.97793114637467
Dist= 1.0356184020722001
```

Fig 11: The location and distance calculation results using node A as reference.

Obtain the target nodes by taking B as reference node for the other four nodes along with the older output with the node A as reference. BCA, BCD and BCE are the various combinations of the goal sites, respectively. The below figure 12 explains the output of the first three combinations by taking node B as their reference nodes. Figure 5.13 displays the output values for the target points determined using the nodes A and B as references. The information on latitude and longitude is given to the target points location, and the distance is also calculated by taking nodes A and B as reference points.

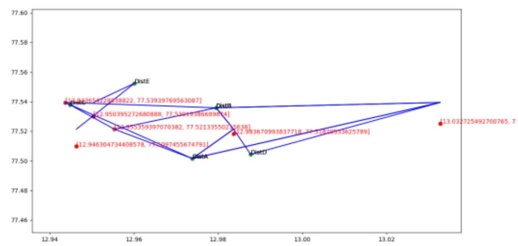
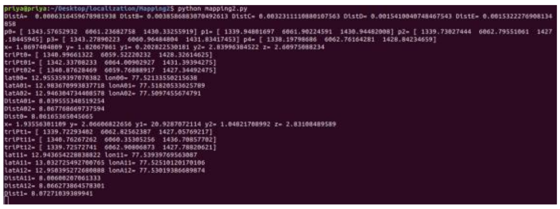


Fig 12: The location of the target points using both node A and B as reference.



```
priya@priya:~/Desktop/localization/Mapping2$ python mapping2.py
DistA=  0.0006316459678981938 DistB= 0.0038586883070492613 DistC= 0.003231110880107563 DistD= 0.0015410040748467543 DistE= 0.0015322276908134
858
p0= [ 1343.57652932  6061.23682758  1430.33255919] p1= [ 1339.94801697  6061.90224591  1430.94482008] p2= [ 1339.73027444  6062.79551061  1427
.18445945] p3= [ 1343.27890223  6060.96484804  1431.83417453] p4= [ 1338.19798686  6062.76164281  1428.84234659]
x= 1.8697404809 y= 1.82067861 y1= 0.202822530181 y2= 2.83996384522 z= 2.60975088234
triPt0= [ 1340.99661322  6059.52220232  1428.32614625]
triPt01= [ 1342.33708233  6064.00902927  1431.39394275]
triPt02= [ 1340.87628469  6059.76888917  1427.34492475]
lat00= 12.955359397070382 lon00= 77.52133550215638
latA01= 12.983670993837718 lonA01= 77.51820533625789
latA02= 12.946304734408578 lonA02= 77.5097455674791
DistA01= 0.039555348519254
DistA02= 0.067768669737594
Dist0= 0.06165365045665
x= 1.93556301109 y= 2.06606822656 y1= 20.9287072114 y2= 1.04821708992 z= 2.83108489589
triPt1= [ 1339.72293402  6062.82562387  1427.05769217]
triPt11= [ 1340.76267262  6060.35305256  1436.70857702]
triPt12= [ 1339.72572741  6062.90806873  1427.78820621]
lat11= 12.943654228838822 lon11= 77.53939769563087
latA11= 13.032725492700765 lonA11= 77.52510120170106
latA12= 12.950395272680088 lonA12= 77.53019386689874
DistA11= 0.00600207061333
DistA12= 0.066273864578301
Dist1= 0.07271039389941
```

Fig 13: Location and distance calculation results using both node A and B as reference.

IV. CONCLUSION

Indoor positioning is a very complex matter and cannot be addressed with different technology like the way GPS does outdoors. The successful providers rely on a method called sensor fusion, based on using a mix of sensors to provide the highest possible precision. Much of the time, they use trilateration to get an absolute location, often to improve accuracy in combination with fingerprinting. We then use motion control to shift the blue points until sufficient variance of the radio signal occurs to determine another absolute location. That way they will spare mobile batteries, because operation monitoring radio signals comes along with high energy costs. The proximity positioning is a low-cost and low-tech way of getting a position. Also, if it is really simple, it could be appropriate depending on the situation, since not every project necessarily requires high precision; without specifying the budget you need to do it. This project relates to indoor mapping using the parameters of the mobile network. The target point is determined using the RSSI values of the static and moving system and is pointed precisely at the spot. Calculated using a triangulation method, the distance between static and target is then.

REFERENCES

[1] S.Alraih; A.Alhammadi ; I.Shayea ; Ahmed M. Al-Samman, “Improving accuracy in indoor localization system using fingerprinting technique”, 2017 IEEE International Conference on Information and Communication Technology Convergence (ICTC).

[2] Xiang He, Shirin Badiei, Daniel Aloi, Jia Li, “WiFi iLocate: WiFi based indoor localization for smartphone, Conference Paper, 2014.

[3] Han Zou, Zhenghua Chen, Hao Jiang, Lihua Xie and Costas Spanos, “Accurate Indoor Localization and Tracking Using Mobile Phone Inertial Sensors, WiFi and iBeacon”, March 2017.

[4] M.Usman, M.Rizwan ,Imran Shafique Ansari, Fabrizio, Khalid A. Qaraqe, “Technologies and Solutions for Location-Based Services in Smart Cities: Past, Present, and Future”, volume 6, 2018.

[5] Xinrong Li, Kaveh Pahlavan, Mika Ylianttila, Ranvir Chana, and Matti Latvaaho,” An Overview of Wireless Indoor Geolocation Techniques and Systems”, Conference Paper, January 2000.

[6] Eladio Martin, Oriol Vinyals, Gerald Friedland, Ruzena Bajcsy, “Precise indoor localization using smart phones”, conference paper, October, 2010.

[7] Katsuyuki Haneda, Lei Tian, Henrik Asplund, Jian Li, Yi Wang, “Indoor 5G 3GPP-like Channel Models for Office and Shopping Mall Environments” IEEE International Conference on Communications, May, 2016.