Localization Using GSM Network in Indian Scenario

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Localization Using GSM Network in Indian Scenario

Major Project

Submitted in partial fulfillment of the requirements

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Master of Technology in Computer Science and Engineering

By

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Undertaking for Originality of the Work

I, **Dheeraj Dadhich**, Roll. No.**12MCEI06**, give undertaking that the Major Project entitled **"Localization Using GSM Network in Indian Scenario**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Information and Network Security** of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

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This is to certify that the Major Project entitled **"Localization Using GSM Network in Indian Scenario**" submitted by **Dheeraj Dadhich (12MCEI06)**, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Information and Network Security** of Nirma University, Ahmedabad is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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Abstract

GPS(Global Positioning System) is always considered as a best localization technique. GPS technology uses multiple satellites for finding the exact location. But there are some problems with GPS technology. GPS technology doesn't work in indoor scenario and in similar areas with limited line of sight with GPS satellite. For GPS we need line of sight with the device. Another issue with GPS is specific hardware needed to connect with satellite, which increases the cost. In our project we are trying to get alternative of GPS localization. To achive this we are using cellular network which is more stable and robust network. We are using GSM network to find the location as it has multiple advantages over GPS technology. Using GSM over GPS is beneficial because we don't need any specific hardware basic mobile phones will work. GSM signals will work even in indoor scenario.GPS devices even consume more battery as compare to GSM mobile phones.

In our project we are using GSM fingerprinting algorithm which works in two phase learning phase and prediction phase. In learning phase environment is studied and based on that database is created. In prediction phase based on the database prediction regarding location is done. It works on a simple concept that whenever our GPS is on the algorithm will work in learning phase and will prepare learning database. When our GPS is off and we need to find some location, algorithm will work as prediction phase. It will look into learned database and give best possible matched location.

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Dheeraj Dadhich
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Chapter 1

Introduction

1.1 Project Definition

Localization is to track the device, to achive this the best option is to use GPS(Global Postioning System) technology. GPS has some problems as it adds the extra cost to the device and its poor coverage inside the building. The best possible alternative we can use for localization is cellular network which provide better coverage and resonable accuracies. Cellular network i.e. GSM network is well stablished network and can be used effciently. In our Project we are trying to use GSM network for localization.[1] GSM network can replace GPS technology because cellular network is available within the building. Thus we can achive indoor localization.

There are different technology other than GPS and GSM which can be used for localization. Infrared, ultrasound, Wi-Fi and Bluetooth localization systems work well indoors, but deploying these technologies to the wide area is either cost prohibitive or not technically possible.

1.2 Motivation

GPS technology is well stablished localization technique but when we use this technology we found some problems. When we constantly use GPS the main problem is power it consumes. GPS hardware requires more power and thus consumes more battery. Other problem with GPS is it doesn't work where line of sight is not available with satellite. Thus it will not work for indoor scenario. All these problems motivated us to find an alternative approach where we can overcome these issues.

1.3 Advantage of GSM localization

GSM localization has specific advantages over Wi-Fi localization [1]:
(a) GSM network operates in licensed band. Thus has no interference from microwave ovens and other electronics equipments.
(b) GSM network is a well managed network, meaning no interference from neighboring access points that are tuned to the same channel.
(c) GSM networks is a stable network therfore requires significant installtion cost.
(d) GSM network coverage is greater than other communication networks.

1.4 Problems with GPS technology

GPS is always considered as best localization techniques but there are some issues with GPS [2]
(a) Line of sight is required for localization in GPS
(b) GPS device drains more battery
(c) GPS satellite signals are weak

1.5 Scope

Localization using GSM network is an approach to provide an alternative to GPS technology. GSM signals works well for indoor scenario. Thus, we can use GSM based scheme for indoor localization. For outdoor localization it will be an addon to the GPS technology. We will no longer always depend on GPS for localization.GSM localization can be used anywhere any time but prior training database is required. Therefore we cannot use this scheme without traing database.

Chapter 2

Literature Survey

GSM stands for Global System for Mobile Communication. GSM is open, digital cellular technology used for transmitting mobile voice and data services. GSM network is a worldwide standard with deployment in more than 210 countries. In India it works on 900 MHz and 1800 MHz bands. GSM network is cell based where cell are hexagonal shaped. GSM uses base station to transmit data. These base station are placed in center of cell. Each physical location is divided into multiple hexagonal cells. Each cell has unique ID and frequency upon which it works. These values are constant for particular cell. We can use different feature of GSM network for localization. Different approaches available for localization is explained below

2.1 Different Approach

2.1.1 Cell-Identity

This is the most basic location finding technique available in GSM network. In this technique the GSM cell which is registered to handset is used for localization. As GSM network uses hexagonal cell for communication. Each cell has its unique ID which is used to identify the cell. The cell-Id is converted to geographic location. The accuracy of this scheme depends on cell size and type of cell i.e. Omni-directional or sectored antenna. We can get more accurate location if GSM cells are sectored. A sectored cell will use number of antenna which will provide sector information. Thus accuracy will increase. The accuracy of this scheme also depend on location i.e. rural, sub urban and urban areas. The benefit of this scheme is we don't need any assistance from service provider [2].

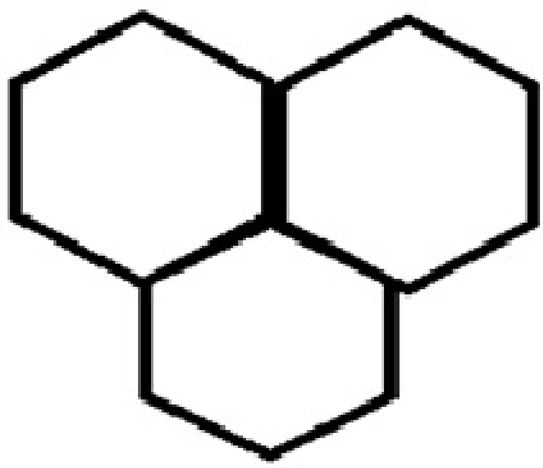

Figure 2.1: GSM Cell Structure

2.1.2 Enhanced cell-ID

In this handset makes measurement for its operating condition and send that information to the base station for handover related decision. This report uses both main and neighbour cell information to determine the handset power level. This power level is used to determine the estimation of location basd on network planning tools.

2.1.3 Angle of Arrival

It uses directional antenna for finding line of bearing between handset and base station. The relative angle is calculated by phase difference across the antenna. The angle from at least three base stations is measured and then using triangulation algorithm location is calculated. In this scheme the line of sight between handset and base station is required to find the location[2].

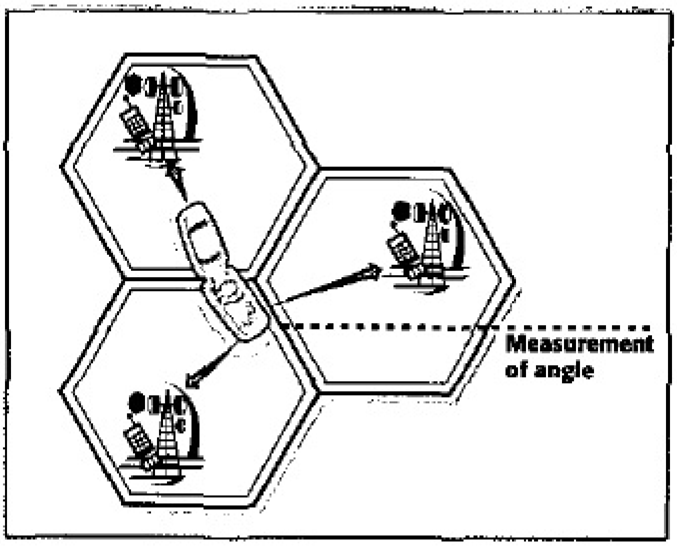

Figure 2.2: Angle Of Arrival [2]

2.1.4 Time of arrival

Time of arrival works by measuring signal strength to and from the base station. Since radio waves travel at the speed of light, the distance between the handset and the base station can be estimated from the transmission delay. This, places the handset on a circle, with the basestation at the centre of the circle.[2] Thus more accurate location is not found. But if the estimate were made from three basestations, there would be three base station that would intersect at the exact location of the handset. In this scheme precise syncronization is required between handset and base station.

2.1.5 Enhanced observed time difference

In this time-based technique the handset measures the arrival time of signals transmitted from at least three base stations. In handset assisted mode, timing measurements

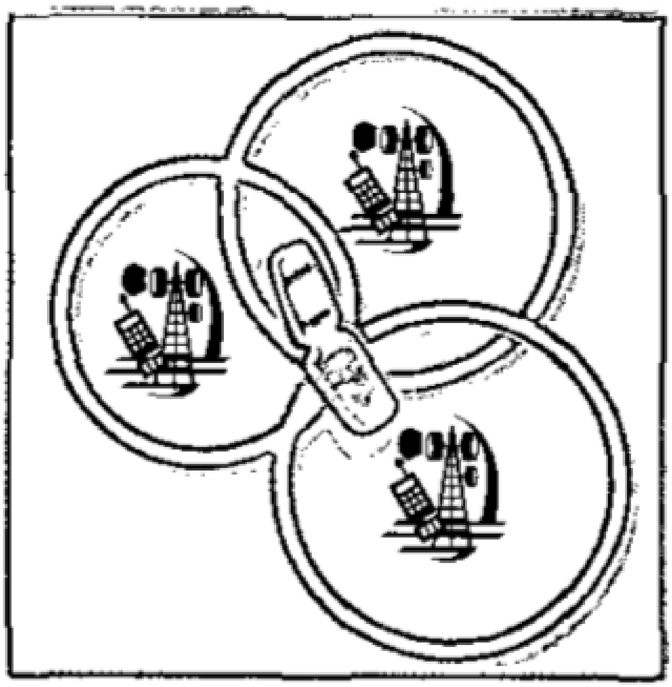

Figure 2.3: Time Of Arrival [2]

made by handset are transferred to serving base station. These measurements are related to the distance between each base station and handset.[2] Thus we can find the location using triangulation algorithm. Its accuracy depends on cell density, cell plan, multi path, interference, noise, cell site position accuracy. Its performance is degraded in areas with low density of basestations.

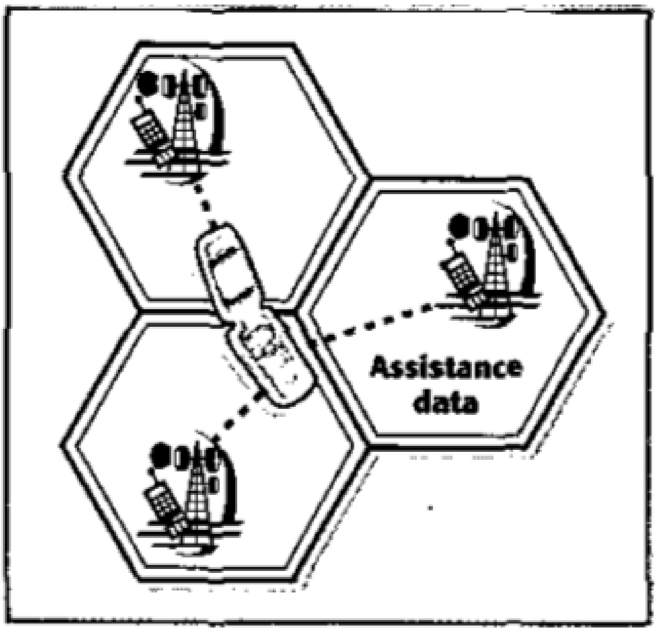

Figure 2.4: Enhanced observed time difference [2]

2.1.6 Assisted Global positioning system

Assisted GPS is also a time based technique in which the handset measures the arrival time of three or more signals, transmitted from GPS satellite. The information decoded by GPS receiver is transmitted to the handset.Thus hanset does not need to decode signals from each satellite. Assisted GPS also provides good accuracy and velocity estimates.

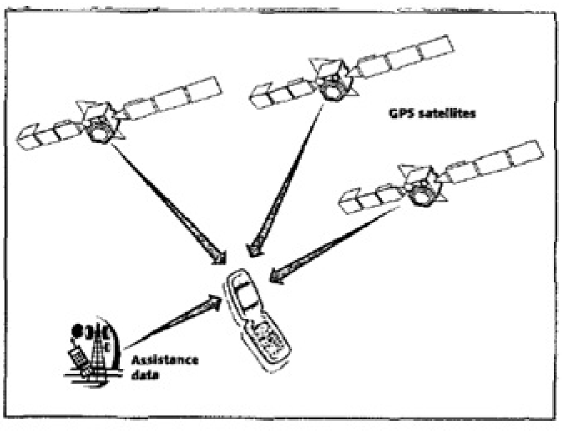

Figure 2.5: Assisted GPS Satellites [2]

2.1.7 Signal Strength

This is the most basic technique to implement localization. This scheme uses signal strength information received by handset to estimate the location. If both the transmitting power at the basestation and receiving power at the handset are known, the distance from each other can easily be calculated using a path loss equation.If we use three base station to measure the distance will produce three circle. A handset location can then be easily calculated by the approximate intersection of these circles with known radius, by using least squares to minimize error.

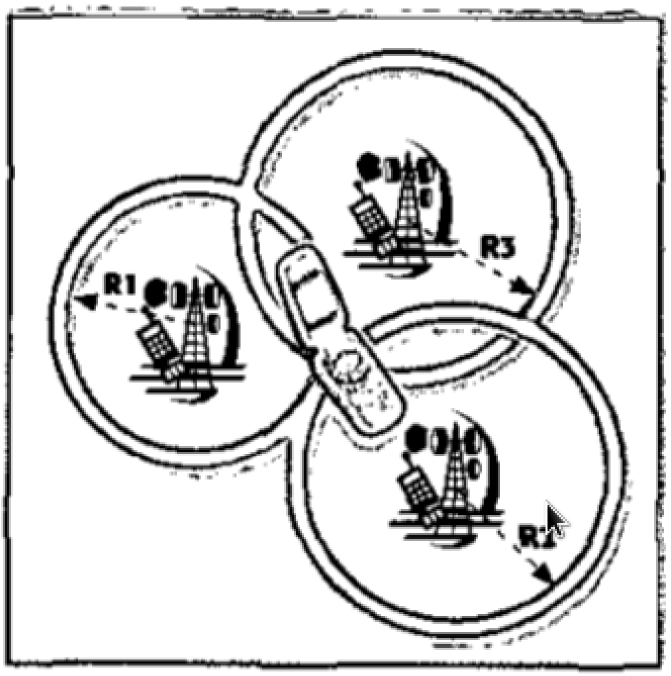

Figure 2.6: Signal Strength [2]

2.1.8 Hybrid

This technique uses two or more techniques combined for example: cell-id and signal strength based.

Note: Cell-Id and signal based technique doesn't need processing at base station. Thus they can be implemented directly in handset.

2.2 Position Algorithm

There are many radio based location algorithm but we studied these three algorithm: Centroid algorithm which does not model radio propagation, Monte Carlo localization with learned Gaussian process signal propagation model and fingerprinting algorithm. For our purpose we are using fingerprinting algorithm.

2.2.1 Centroid Algorithm

This algorithm is very fast to compute but doesn't use radio propagation model. This algorithm works on lookup table which contain Cell id, latitude, longitude fields. [3] The Cell id information can be get from network parameters of handset. Then corresponding cell id is searched in lookup table, to get latitude and longitude information. This algorithm depends on cell tower position. Therefore the phone's position can be determined by geometric center of all the cells. The problem with this algorithm is cell tower position information is not given by service provider and we cannot get the exact position within the cell.

2.2.2 Fingerprinting Algorithm

This algorithm constructs a search index and maps radio fingerprints to location. This algorithm works in two phase learning phase and prediction phase. In learning phase we take network information like cell id and signal strength at different locations [3]. Then we map that information to the physical location. The more efficient learning data will help in getting more accurate position. In prediction phase, the algorithm uses the index and calculates the difference in signal strength between the current trace and all available traces in the database. It then selects those traces that have smallest distance as possible current location. The location of the device is estimated as an average of the latitude and longitude coordinates of the best matches.

2.2.3 Monte Carlo localization with Gaussian process signal model

This algorithm uses radio propagation model and Markov localization to predict the phone's position. It builds a sensor model to predict the signal strength at each location. [4]. The phone's position is estimated using a Bayesian particle filter. This approach is like fingerprinting, except it uses an abstract parametric model of the signal environment instead of building a direct search index of the calibration data itself as is done with fingerprinting. In Monte- Carlo localization, the belief about the phone's position is represented by a set of random samples. Each sample consists of a state vector of the underlying system, which is the position of the mobile phone.

2.3 GPS Technology

GPS is a space based satellite navigation system used for navigation on or near to earth. GPS receivers can determine their current location, time and velocity. GPS uses minimum 3 satellites to calculate the location. Location is calculated in terms of latitude and longitude.The accuracy of GPS is from 10m to 100m. Degree of latitude and longitude measure the angle between location and the reference line(Equator and Greenwich England). Minutes and seconds are fraction of degree. There are 60 seconds in a minute, 60 minutes in a degree, and 360 degrees is full circle. We are using DMS format of latitude and longitude.

2.3.1 Displacement in latitude and longitude

During Study we find out that there is slite displacement in latitude and longitude. This displacement is caused by geographical effects i.e. polar tides and atmospheric pressure. The tides give periodic loads on the earth's surface which cause a certain kind of site displacement. The tidal deformation of the earth, resulting from the tidal forces of the moon and sun, has been shown to introduce associated horizontal and vertical displacements of the order of 40 cm over 6 hours.[9]

2.3.2 Conversion Decimal- Degree format

The latitude and longitude values we are getting from GPS device are in decimal format but for processing and comparision we need to convert these values in degree format. We will use following conversion formula.

D = trunc(DD)

M = trunc(|DD| * 60) mod 60

S = (|DD| * 3600) mod 60

2.4 Noise Removal Techniques

As GSM traces we captured from our device contain some unneccessary information. We need to remove this noise and extract information which is important to us. For this process we used statistical methods.

2.4.1 Kalman Filter 1-D

The Kalman filter is an algorithm that uses a series of measurements taken over time. These observations contains noise and other inaccuracies.This algorithm then produces estimates of unknown variables that are more precise than those based on a single measurement[7]. Kalman filter operates recursively on streams of noisy input data to produce a statistically optimal estimate of the system. In our project kalman filter is used to estimate the position from the noisy data. Kalman filter works in a two-step: prediction step and . In the prediction step, the Kalman filter produces estimates of the current state variables, along with their uncertainties. Once the outcome of the next measurement which contain some noisy error is observed, these estimates are updated using a weighted average, with more weight being given to estimates with higher certainty. Because of the algorithm's recursive nature, it can run in real time using only the present input measurements and the previously calculated state.

2.4.2 Regression

Regression analysis is a statistical process in which we estimates the relationships among variables. It is a technique in which we model and analyze several variables. The focus is on the relationship between a dependent variable and independent variables. Regression analysis explains how the value of the dependent variable changes when any one of the independent variables is changed, while the other independent variables are constant. [8]. Regression analysis is widely used for prediction and forecasting. Regression analysis use has substantial overlap with the field of machine learning. Regression analysis is also used to understand which among the independent variables are related to the dependent variable, and to explore the forms of these relationships. In our scenario regression is usefull to understand the dependency of signal strength and other GSM fields. How location varies when GSM fields changes.

Chapter 3

Experimental Setup

Our project is an expriment with real life scenario where we are trying to get location using GSM signals. Its an approach where we are working with GSM network and using its unique features to track the location. For this experiment we had done some prerequisite setup.

3.1 Data Collection

The first phase requires a learning data. We need to take traces from different locations. For our experimental purpose we are taking traces from two different locations of Ahmedabad city. These two locations are Ashram Road and SG highway. Ashram road is dense area thus have small GSM cells and strong signal strength. Whereas SG highway is sparse area having large GSM cell and signal strength varies highly. For taking traces we are using Wavecom Q2303 USB GSM modem with Airtel SIM card, GPS enabled Micromax A116 handset (as shown in figure), HP pavilion g6 laptop with i3 processor.

GSM modem is a specfic type of modem which accepts sim card [11]. It is similar to mobile phone which works for subscribed operator. For taking this data we traveled for 3 consecutive days. We will find GSM traces by running AT commands in GSM modem. For running AT commands we are using minicom tool for fedora

Figure 3.1: GPS enabled handset and GSM modem used for data collection

OS. AT commands are known as Attention Commands. These commands are used to communicate with GSM modem. Our focus is on a specific command which give us GSM cell related information.

3.2 Training Area

Initially, training area we were considering was for indoor localization. For this purpose we selected Post Graduate Block of Nirma University campus. Then, we tried for outdoor localization. For this purpose we selected different locations of the Ahmedabad city. We had taken traces from two different locations i.e. Ashram road and SG highway. Ashram road is dense area having strong GSM traces where as SG highway is sparse area where GSM signal varies highly.

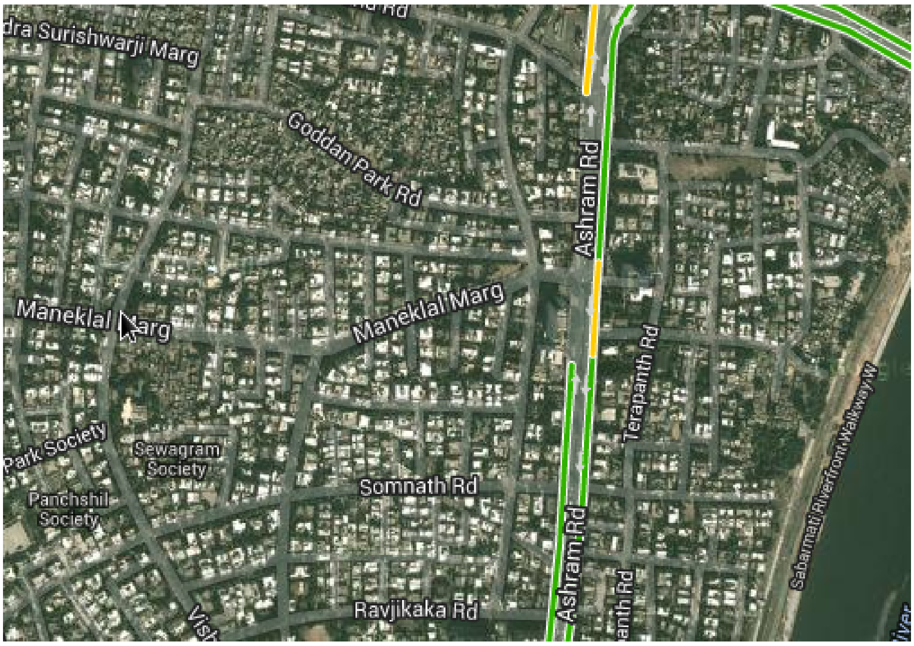

Figure 3.2: Google map of Ashram road showing the density of the area.

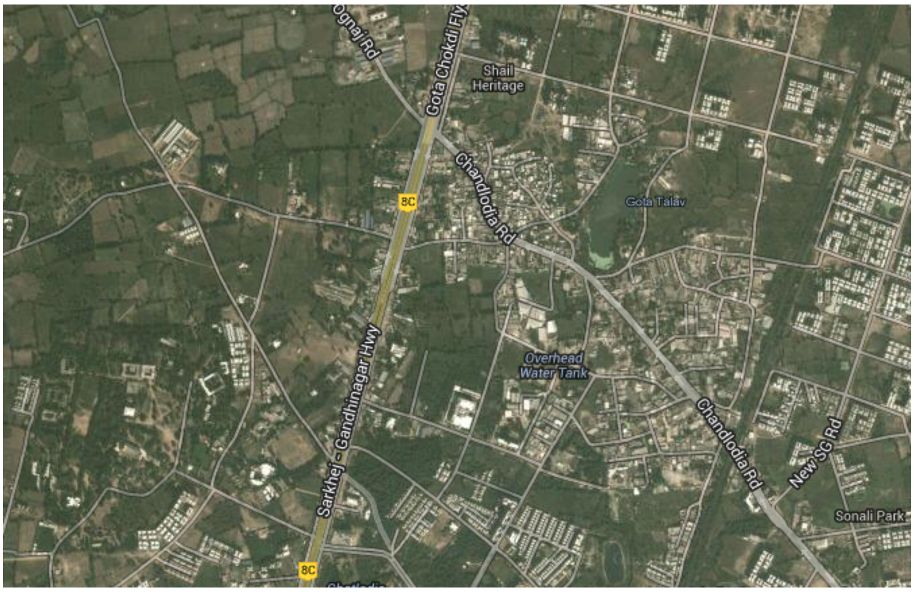

Figure 3.3: Google map of SG highway showing the density of the area.

3.3 AT Commands

AT commands are instructions used to comunicate with modem. AT is the abbreviation of ATtention. That's why modem commands are called AT commands. GSM modems and even mobile phones support AT command set that is specific to their purpose, which includes SMS-related commands like AT+CMGS (Send SMS message), AT+CMSS (Send SMS message from storage), AT+CMGL (List SMS messages) and AT+CMGR (Read SMS messages)[10]. Here are some of the tasks that can be done using AT commands with a GSM/GPRS modem:

- We can get basic information of mobile phone using AT commands. Information like name of manufacturer, model number, IMEI number and etc.
- We can get basic information about the subscriber. For example, MSISDN and IMSI number (International Mobile Subscriber Identity).
- We can get the current status of the mobile phone. For example, mobile phone activity status, mobile network registration status, radio signal strength, battery charge level and many more.
- We can establish a data connection or voice connection to a remote modem.
- We can send and receive fax.

There are many other tasks that can be accomplished by AT commands. For our purpose we will use only one AT command which provide GSM cell related information. For running AT commands we use a tool minicom. Minicom provide serial port communication with the device. Shown in the figure AT command and its response from GSM modem.

Let us study the response in detail.

- MCC : Mobile Country Code
- MNC : Mobile Network Code
- LAC : Location Area Code
- CI : Carrier to interference ratio

- BSIC : Base Station Identity Code
- BCCH Frequency : Transmitted Frequency
- Rx Level : Recieved signal level
- Rx Quality : Recieved signal Quality

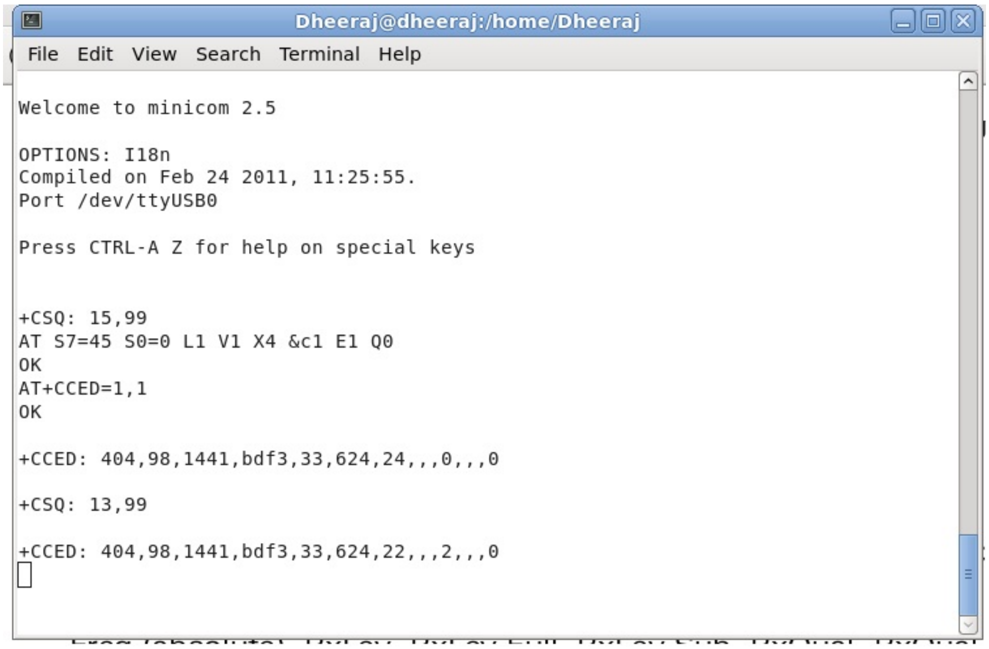

Figure 3.4: AT commands with response

Figure 3.5: Response of AT command related to cell information

Chapter 4

Implementation Methodology

Localization using GSM network works in two phase. First phase is learning phase where our algorithm learns the GSM scenario. In this phase GSM environment is studied and based on that our learning database is created. Other phase is prediction phase. In prediction phase we use database created in previous phase and tries to predict the location. Thus for more accurate prediction learning database should be more accurate.

In learning phase, we are taking traces from Ashram road and SG highway. We had taken traces for every 100m distance. Instead of just taking GSM traces we had also taken GPS values of the location. These GPS values will be required to map with GSM traces. When we have these values for consecutive days we will process GSM values so that only required information will be entered in database.

In prediction phase, we will take sample GSM trace as input and tries to predict the maped location from database. In this phase algorithm tries to find the maximum match of input and GSM values of database. When algorithm finds the maximum match it will give the mapped location ID.

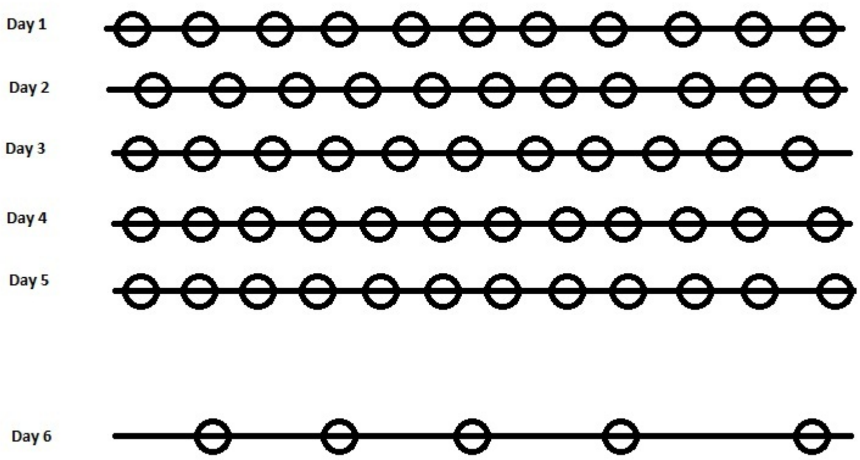

Figure 4.1: Methodology for outdoor localization

4.1 Implementation Algorithm

There are two phases to analyzing the positioning accuracy. First, a training trace containing time-stamped GSM and GPS measurements is used to build a model that is specific to that algorithm. In the second phase, the algorithm uses the GSM measurements in an independent testing trace to estimate its position, and outputs latitude/longitude values in its position estimate.

4.1.1 learning phase algorithm

In learning phase, we are taking GSM traces generated from GSM modem. We had taken GSM trace for every 100m. For taking traces we had taken two different location of Ahmedabad city. First location was Ashram road as it is dense area with heavy traffic. Other location was SG highway, it is sparse area. The GSM traces we are getting from AT commands contains various fields. While taking GSM traces at every location we will also take GPS values of the location. This GPS value will be used at later stage for mapping with GSM traces. Some fields out of this is not important or redundant. We are interested in only main cell-id, signal strength and neighbour cell id. We will filter out all other information. Then for a particular location find main cell-id, minimum signal strength, maximum signal strength and neighbour cell-id. We have this data for consecutive three days. Now compare signal strength values for consecutive days. If minimum and maximum signal strength doesnot matches significantly we will take union of consecutive traces. This process is repeated till signal strength range matches significantly. This process will increase the location distance from 100m to 200m and so on if needed. This processing will finally give us learning database for our training area. we will store these traces and use them in next phase i.e. prediction phase. Flow chart of the algorithm is shown in figure.

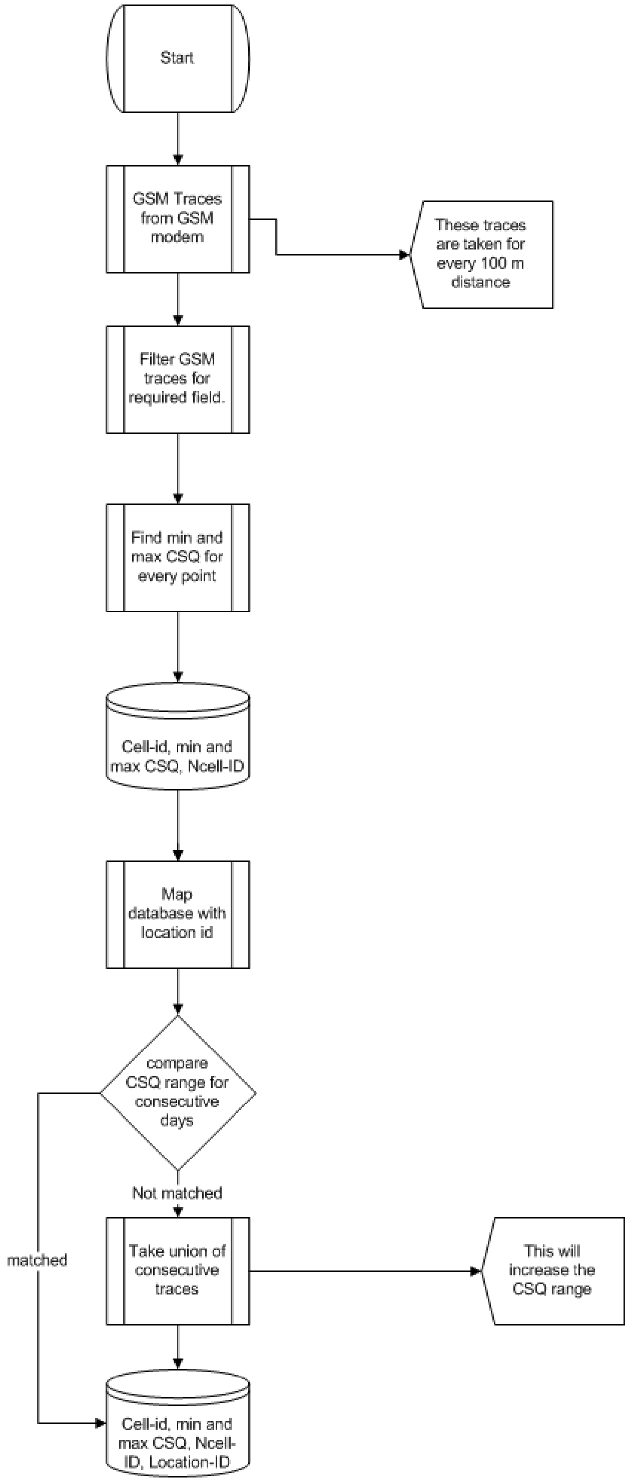

Figure 4.2: Learning Phase Algorithm

4.1.2 Prediction phase algorithm

Second phase is prediction phase. In this phase we will predict the location just by taking GSM traces as input. For the prediction we are using the database created during learning phase. As in learning phase we have database of main cell id, minimum signal strength, maximum signal strength and neighbour cell id. All these information is mapped with latitude and longitude values of the location. This database is created during learning process thus more precise learning process will be required for more precise database. To this database we will give main cell id, minimum signal strength, maximum signal strength and neighbour cell id as input.These values will be matched with database fields. When the maximum match is found algorithm will give the mapped latitude and longitude values as output.

We have raw data of three consecutive days. So we will use this data to give input to our prediction phase algorithm. We will take day 1 traces and give input to our algorithm. similarly for day 2 and so on. We will first compare input cell id with cell id from database. Based on cell id we will filter the database. From all the data, possible locations can be found where cell id matches. Then in next phase we will compare minimum and maximum signal strength. We will check input signal strength with stored value. As exact match is difficult to find we will match these values with threshold. If minimum and maximum signal strength matches with a threshold value we will filter the database. Thus step by step we will get filtered database. Now lastly we will match the neighbour cell id. we will compare the neighbour cell id and find the maximum match string. After counting the maximum match of N-cell id the trace with maximum count will be declared as possible match. It may possible that there are more then one trace with equal and maximum count then both the tace will be declared as possible location. After getting the possible traces algorithm will give mapped latitude and longitude values as output.

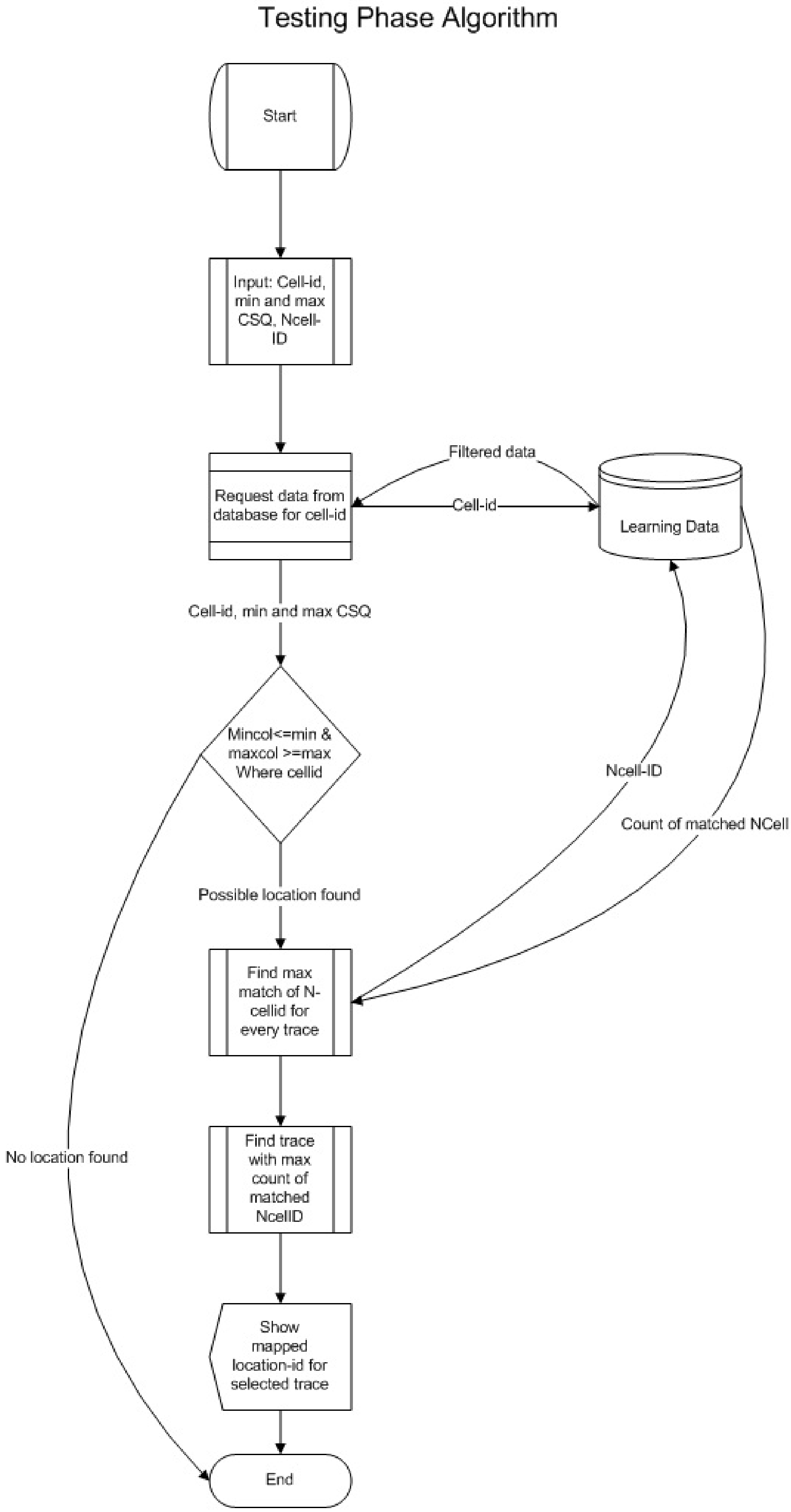

Figure 4.3: Prediction Phase Algorithm

Chapter 5

Result

We worked for both indoor and outdoor scenario. We tried to trace back the location using GSM signals. Initially we studied for indoor scenario and for this purpose we selected PG block of Nirma University. We done this exercise to study the variation of GSM signals for indoor scenario. We selected different locations in the building and taken GSM traces. After mannual processing the GSM data, we figured out that for every floor of the building there is sufficient variation in GSM signals. Thus we can easily locate between floors on the basis of GSM traces. This is important because GPS doesnot work for indoor applications.

For outdoor scenario we studied two locations of Ahmedabad city. Both the location have different scenario Ashram road is dense area and SG highway is sparse area. We performed our analysis for both the locations. We had taken reading for every 100m for both the locations and see the variations of GSM features. Ashram road has healthy GSM traces as it is very populated area. We figured out that GSM cell size is small in Ashram road area with good signal strength. On the other hand cell area in SG highway is large and signal strength varies from lowest to highest.

We run our algorithm for SG highway and tried to find the location. We get the set of location for given input GSM trace. For each trace our prediction algorithm will give a set of predicted location. To get the more accurate location we will assign weight to each trace. These weight is based on the matched neighbour cell-id. Then using these weight we will find the average weighed location. Table shows the actual location and predicted location by the algorithm. Then we find the location error by finding the distance between actual location and weighed average location. This location error is the distance from the predicted location to actual location. We have shown our results in table.

	Output Location			Average Output Location		Average weighed output location		Location Error
Actual Location	Latitude	longitude	Weight	Avg Latitude	Avg Longitude	Avg(weight) latitude	Avg(weight) longitude	
23.12885,72.54065995	23.12885	72.54065995	0.73	23.12885	72.54065995	23.12885	72.54065995	
	23.12885	72.54065995	0.27					
23.12801165,72.5403908	23.12885	72.54065995	0.64	23.12885	72.54065995	23.12885	72.54065995	97 m
	23.12885	72.54065995	0.36					
23.1269841,72.54008165	23.1259141	72.5397683	1.00	23.1259141	72.5397683	23.1259141	72.5397683	120 m
23.1259141,72.5397683	23.1259141	72.5397683	0.50	23.1259141	72.5397683	23.1259141	72.5397683	
	23.1259141	72.5397683	0.21					
	23.1259141	72.5397683	0.29					
23.1249358,72.5394533	23.1259141	72.5397683	1.00	23.1259141	72.5397683	23.1259141	72.5397683	110 m
23.1239133,72.53916245	23.1259141	72.5397683	0.40	23.1259141	72.5397683	23.1259141	72.5397683	230 m
	23.1259141	72.5397683	0.60					
23.12277995,72.53885245	23.1218983	72.5386408	1.00	23.1218983	72.5386408	23.1218983	72.5386408	120 m
23.1218983,72.5386408	23.1218983	72.5386408	0.56	23.1218983	72.5386408	23.1218983	72.5386408	
	23.1218983	72.5386408	0.44					
23.1212908,72.53847245	23.1218983	72.5386408	0.25	23.1218983	72.5386408	23.1218983	72.5386408	80 m
	23.1218983	72.5386408	0.45					
	23.1218983	72.5386408	0.30					
23.1204666,72.5382091	23.1218983	72.5386408	0.40	23.1218983	72.5386408	23.1218983	72.5386408	180 m
	23.1218983	72.5386408	0.60					
23.11956075,72.5379658	23.1218983	72.5386408	1.00	23.1218983	72.5386408	23.1218983	72.5386408	280 m
23.11865995,72.537725	23.1218983	72.5386408	0.38	23.1218983	72.5386408	23.1218983	72.5386408	400 m
	23.1218983	72.5386408	0.63					
23.117765,72.5374783	23.11865995	72.537725	1.00	23.11865995	72.537725	23.11865995	72.537725	100 m
23.11698,47.82711955	23.1212908	72.53847245	0.57	23.1212908	72.53847245	23.1212908	72.53847245	
	23.1212908	72.53847245	0.43					
23.11613995,72.5369958	23.11865995	72.537725	0.40	23.118212475	72.53760165	23.11812298	72.53757698	230 m
	23.117765	72.5374783	0.60					
23.11518075,72.5367308	23.11518075	72.5367308	0.33	23.1137974375	72.53630955	30.8184974167	96.7151118056	
	23.11418245	72.5364283	0.44					
	23.11327495	72.53613665	0.22					
	23.1125516	72.53594245	0.33					
23.11418245,72.5364283	23.11518075	72.5367308	0.33	23.113866175	72.536336625	23.1134279833	72.5362052333	87 m
	23.1125516	72.53594245	0.67					
23.11327495,72.53613665	23.11518075	72.5367308	0.33	23.1137974375	72.53630955	53.9317329167	169.2512485333	
	23.11418245	72.5364283	0.67					
	23.11327495	72.53613665	0.67					
	23.1125516	72.53594245	0.67					
	23.11518075	72.5367308	0.33					

Full Screen
Full Screer

Figure 5.1: Location Result of Algorithm

Results of Ashram Road

Actual Location	Output Location	Average Location	Location Error(in meters)
23.0552016,72.5717616	23.0552016,72.5717616	23.0552016,72.5717616	
23.0539549,72.5716816	23.05352,72.571615 23.0521066,72.5714933	23.0528133, 72.57155415	130 m
23.05352,72.571615	23.05352,72.571615 23.0521066,72.5714933	23.0528133, 72.57155415	79 m
23.0521066,72.5714933	23.05352,72.571615 23.0521066,72.5714933	23.0528133, 72.57155415	79 m
23.0514666,72.5714566	23.0514666,72.5714566	23.0514666,72.5714566	
23.0504,72.5714266	23.0504,72.5714266 23.0493233,72.5712883 23.0487066,72.571225 23.0464616,72.5703949 23.0455566,72.5702133	23.04808962, 72.57090962	550 m
23.0493233,72.5712883	23.0504,72.5714266 23.0493233,72.5712883 23.0487066,72.571225 23.0464616,72.5703949 23.0455566,72.5702133	23.04808962, 72.57090962	400 m
23.0487066,72.571225	23.0504,72.5714266 23.0487066,72.571225 23.0464616,72.5703949 23.0455566,72.5702133	23.0477812, 72.57081495	300 m
23.04754,72.5709733	23.04754,72.5709733	23.04754,72.5709733	

Figure 5.2: Location Result of Algorithm

Chapter 6

Conclusion and Future Work

6.1 Conclusion

We started our experiment to get the alternative of GPS technology. For that we developed the algorithm which works in two phase. During the experiment we worked with GSM traces and uses its unique featues to get the location. We developed the algorithm which give us location error ranging from 100 m to 250 m. We are still working to develop the more complex algorithm which give us less location error. So that we can use this approach widely.

6.2 Future Work

In future, our focus is on the algorithm which give us more precise location. We are working on the algorithm which give us less the location error. In future we will also work on an android application that uses this technique for localization.

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