# Finger printing localization in WIMAX network based on RSS and modulation

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**Abstract:**
Among techniques based on power, fingerprinting method has the highest level of accuracy. In this method,error caused by the none line of sight (NLoS) between base station and user is compensable. However, some problems of the technique for implementation are: need to gather high-capacity database and necessity of update and computational complexity to estimate the position. In this paper, The similar BCCH and Cell-ID and the used modulation and received signal strength (RSS) employed for filtering existing point in database to reduce computational complexity which is a novel technique. By executing the proposed algorithm in a part of Isfahan metropolis, the calculated average error of the suggested technique is 21 meters which its error is less than other techniques.

**Keywords:** Wimax, Fingerprinting, Received Signal Strength(RSS), Base Station(BS), Angel of Arrival(AoA)

## 1. Introduction

There are several ways to positioning a wimax network user. GPS is the most popular method, because its positioning accuracy is very high. The main problem with GPS are the battery high consumption and the limited coverage and the latency. Also GPS performs poorly in urbon areas with rising buildings and inside tunnels[1,2]. There are another ways to positioning a wimax network user. The most convenient and application way is Cell-ID which has been used in mobile communication systems despite its accuracy is very low. The advantage of using this method is the low cost[3]. Another network parameters which use in positioning are received signal strength and angel of signals arrival and time of signals sent and received which measured in wimax network[4,5]. Some of these measurements are hard to obtain and need to extra devices in wimax network.

## 2. Positioning Possibilities in WIMAX Networks

The topology of WiMAX network is similar to GSM one; the two of them use base stations to establish a wireless connection with subscriber stations (GSM terminal or WiMAX enabled computer for example). And almost the same quantities can be measured using both networks.

Following a brief explain about some of the ways of wimax network user positioning:

### 2.1. Location Based on Cell-ID

This technique is the most basic method of cellular positioning and is easily applied by detecting base station in which the user has been registered. At any time, MS in a BTS which is the nearest base is registered, of course, this assumption is not always reliable due to effects of broadcasting environment between sender and receiver [1,7]. Therefore, one can estimate position of MS by specifying base stations in the network as shown in figure 1.

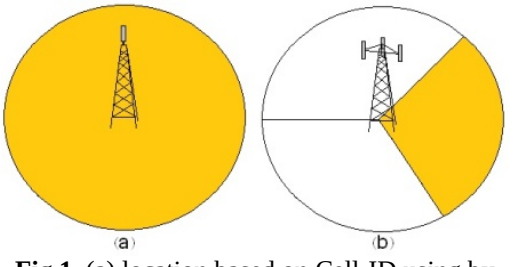


**Fig.1.** (a) location based on Cell-ID using by omnidirectional antennas.
(b) location based on Cell-ID using by directional antenna[2]

### 2.2. Location Based on Time of Arrival (ToA):

This method acts based on term of radio signal broadcasting between sender and receiver. By determining this term, distance between sender and receiver can be calculated. Therefore, one can consider

locus of common position on the circular circumference with center of BTS and with radius equivalent to distance between MS and BTS. For common positioning in two dimensional spaces, it is necessary to use at least three BTSs in case of absence of measurement error [9].

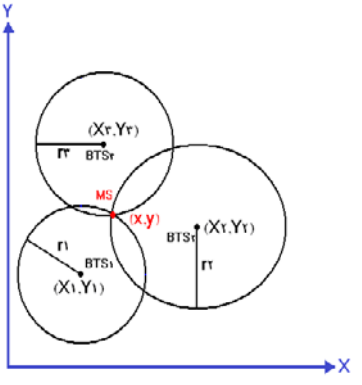


**Fig.2.** Location based on ToA using by 3 Base Station[10]

### 2.3. Location based on Time Difference of Arrival (TDoA):

This technique is based on calculation of time difference of signal broadcasting between MS and two BTSs. In case of assuming any pair of BTS as hyperbolic focus and calculating distance difference between MS and these two BTSs, one can imagine locus of a user as a hyperbole. By considering three BTSs and calculating distance difference between MS and both pairs of theirs and then drawing locus of the user as hyperbole; estimated position of MS is obtained by obtaining intersection of hyperboles [11].

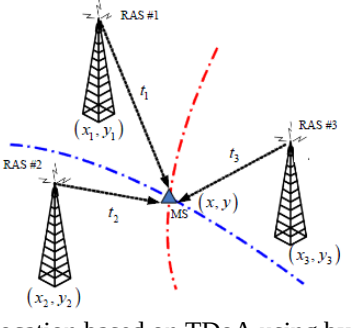


**Fig.3.** Location based on TDoA using by 3 Base Station[12]

### 2.4. Location Based on Angel of Arrival (AoA):

In order to implement such method in cellular networks, it is necessary to use array antennas [11]. According to figure (4), angle of signal is calculated at least in two BTSs in order to estimate common position [13]. The present WiMAX networks use directional antenna which allows BS to determine angle of a terminal. The thinner the beam of antennas, the more accurate the positioning will be [14].

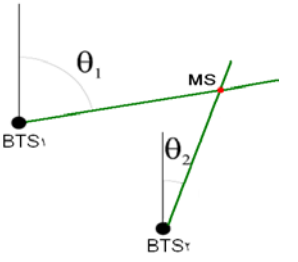


**Fig.4.** Location based on AoA[13]

### 3. The Proposed Positioning Algorithm for WIMAX Network User:

Fingerprinting positioning method includes two main stages of making database and positioning mobile terminal. In the first stage, one should prepare location-sensitive information samples from the desired zone in order to provide service along with geographical coordinates of each sample. In the second stage, location of mobile terminal should be calculated by adjusting information received from mobile station to inputs of database [15, 16]. Generally, database can be made by field measurement [16]. Results obtained from field measurements by USB dongle modem, greenpacket type in a part of Esfahan city are shown below:

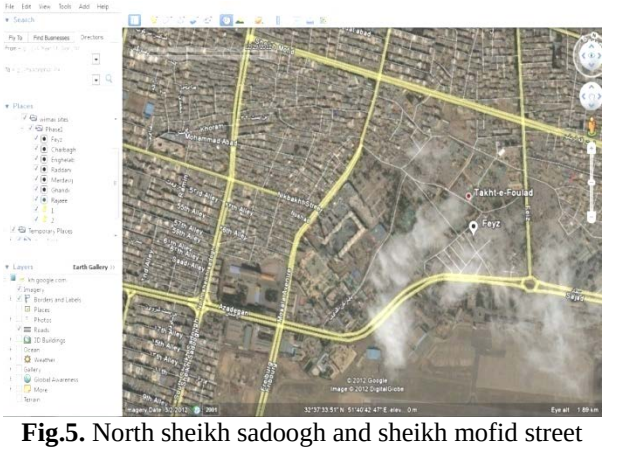


**Fig.5.** North sheikh sadoogh and sheikh mofid street

The obtained results show that reflects available in the network make the highest changes in the obtained powers due to the presence of long buildings, trees and metals.

In the second stage, we perform user poisoning process in WiMAX network by relying on the data obtained from the previous stage and applying data processing techniques.

Generally, each poisoning process includes main stages of filtering the reference points, adjustment to reference points and estimation of position. In positioning stage, one should search the entire database in order to select the nearest reference points to mobile terminal which imposes high processing load on the network. For this reason, it is recommended to filter the reference points as one of the most important stages of positioning process due to increase of accuracy of estimating position and reducing computation load.

### 3.1. Similar Modulation Filter

In WiMAX network, the used modulation changes by getting far from BS. Using this filter, we separate all points which use similar modulation.

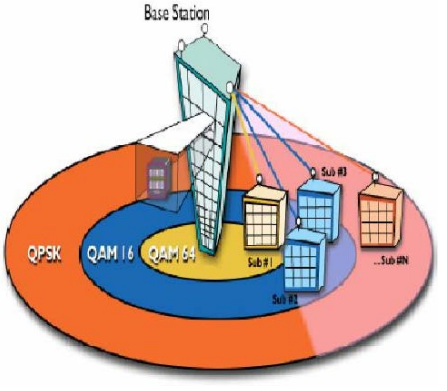


**Fig.6.** Different modulation WiMAX[17]

### 3.2. Similar BCCH Filter

The conducted studies on the real values obtained from the network show that the nearer the two locations, the more the number of common BCCH channels. Considering the received data, we filter the points which have at least 5 common BCCH channels.

### 3.3. Similar Cell-ID Filter

At the end, we separate the points which are located in similar cell.

In the third stage, a strategy should be determined for determining nearness of reference points extracted from the previous stage to mobile terminal. For this purpose, one should calculate difference between RSS values measured by terminal and each input of the database and then identify the nearest reference points to the terminal based on this difference. The most common method of measuring this difference based on Manhattan relations is as follows:

$$d(k) = \frac{\sum_i MS_i - RP_i(k)}{m} \quad (1)$$

Where $MS_i$ is power of the signal measured by terminal from i-th audible BCCH channel and $RP_i(k)$ is power of the signal received from the same channel in k-th reference point of database. Inputs of database with the lowest value of d(k) refers to the nearest reference points to termina [8,6]. In this relation, m is the number of common BCCH channel between RSS vector of reference pointy and mobile terminal.

In this paper, we replace them in the following relations considering the d(k)s which are obtained and obtain the estimated point:

$$w_k = \frac{\frac{1}{c(k)}}{\sum_k \frac{1}{c(k)}} \quad (2)$$

$$c(k) = exp\big(l * d(k)\big) \quad (3)$$

$$\widehat{X_{MS}} = \sum_k w_k X_k \quad (4)$$

$$\widehat{Y_{MS}} = \sum_k w_k Y_k \quad (5)$$

Where $W_k$ is corresponding to k-th nearest neighbor,$(x_k,y_k)$ is geographical coordinates of k-th reference point and L is considered 1 in this paper.

## 4. Conclusion

Considering the operations which have been performed in this paper, the following diagram indicates cumulative error distribution function for the methods which we have obtained without weighting the filtered points and also weighting the obtained points after filtering points available in database for 3&4 smaller d(k) and also showed mean error with diagram which is equal to 37.86, 24.81 and 21,08 meters respectively . error value in 67% of the estimations is equal to 44.8, 33.7 and 27.3 meters,respectively and error value in 95% of the estimations is equal to 86.1, 64.8 and 49.8 meters, respectively. According to FCC standard, error value should be below 100m in 67% of estimations and below 300 m in 95% of the estimations. As a result, the mentioned method is accepted by this standard.

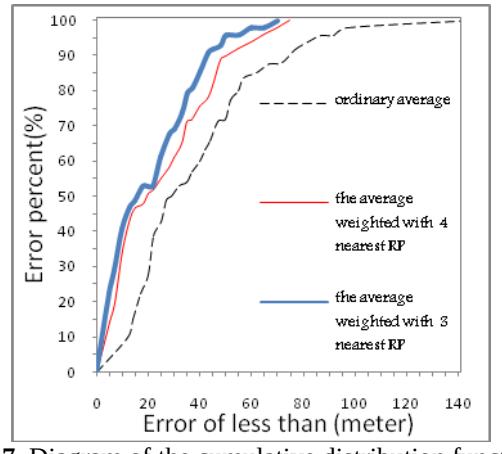


**Fig.7.** Diagram of the cumulative distribution function (CDF) error

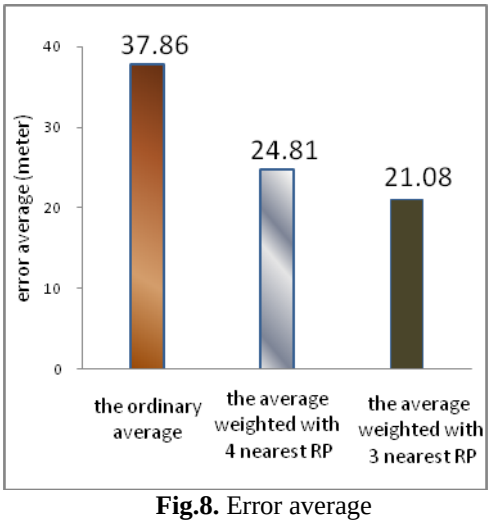


**Fig.8.** Error average

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