U-TDOA Position Location Technique for WCDMA

Marwan Mahmood Shakir **Dr. Sami Abdul-Mawjoud**

Assistant Professor

Department of Electrical Engineering, Mosul University

Abstract

Position location in cellular networks has become increasingly important in recent years due to emerging of location-based services. Numerous applications use position location such as emergency calls, network optimization to resource management and improve the performance of handover in cellular network .Uplink Time Difference of Arrival (U-TDOA) technique in cellular networks is dealt with this technique based on estimating the time difference between the received signal to the base stations of a certain subscriber using the Generalized Cross Correlation method. Chan's method is used in solving the resulting hyperbolic equations for finding the Position Location (PL) of a certain subscriber. Chan's method give accurate results, compared with other techniques .in this paper we concern on the some factors (increase sample, increase power without and with interference cancellation) for improved U-TDOA Accuracy.

Keywords: WCDMA; U-TDOA technique; U-TDOA accuracy

تقنية U-TDOA لتخمين الموقع في نظام WCDMA

الخلاصة

إن تحديد الموقع في الشبكات الخلوية أصبح مهم جدا في السنوات الأخيرة بسبب ظهور خدمات تعتمد على تخمين الموقع . هنالك العديد من التطبيقات تستخدم تخمين الموقع مثل مكالمات الطوارئ ، تحقيق الأمثلية في إدارة مصادر الشبكة وتحسين إداء المناقلة في الشبكة الخلوية. إن تخمين الموقع يتم بإستخدام تقنية الفرق في زمن الوصول_الاتصال الصاعد وهي تقنية معتمدة على قياسات الشبكة للفرق في زمن وصول الإشارة الى المحطات الأساسية باستخدام طريقة الترابط المختلف. ان طريقة تشان تستخدم لحل معادلات القطع الزائد لتخمين لموقع مستخدم معين . طريقة تشان تعطي نتائج دقيقة، مقارنة مع التقنيات الاخرى. في هذا البحث تم التركيز على بعض العوامل مثل (زيادة النمذجة، زيادة القدرة مع وبدون إلغاء التداخل) لتحسين دقة تقنية الفرق في زمن الوصول–الاتصال الصاعد.

الكلمات الدالة– الوصول المتعدد بتقسيم الشفرة عريض، تقنية الفرق في زمن الوصول–الاتصال الصاعد، دقة الفرق في زمن الوصول–الاتصال الصاعد.

Introduction

Recently, there has been a great deal of interest in developing mobile location systems for cellular telephones. The motivation is a series of regulations passed by the Federal Communications Commission (FCC) in 1996 .The purpose of these regulations is to improve the 911 service provided to mobile phone users. The new FCC regulations will require all cellular service providers to implement a new level of emergency call service called Enhanced 911 (E911) [1]. In October 1999, The FCC revised its phase II requirements, offering two alternative methods for position determination. In October 1, 2000 FCC declared whether they will offer a network based or handset based solution to the position determination problem. For offering network based solutions , an accuracy requirement specifies that,67% of E-911 calls must be located within 100 meters, and 95% of E-911 calls must be located within 300 meters. For handset-based approach, accuracy requirements are 50 meters for 67% of the calls and 150 meters for 95% of the calls[2]. Currently there are some major location modes based on network: Cell-ID,TOA, U-TDOA. Time Difference of Arrival (TDOA) is realized by estimating the position of signal source after detecting time difference which signals arrive at different base stations (BS)[3]. U-TDOA positioning method is reliable, new, and they give minimum estimation error compared with other positioning methods requires less alteration but achieves high accuracy[4].

Wideband Code Division Multiple Access

1- WCDMA is a wideband DS-CDMA system.
2- The chip rate 3.84Mcps leads to a carrier bandwidth approximately 5 MHZ.
3- WCDMA supports highly variable user data.
4- WCDMA supports two basic modes of operation FDD and TDD: in FDD mode, uplink and downlink are separated by 5 MHz carrier frequency, while in TDD only one 5 MHz carrier frequency is time shared between uplink and downlink.
5- WCDMA uses RAKE receiver to adopt the multipath of the transmitted signal.
6- WCDMA is designed to be coexisting with GSM; therefore, handover between GSM and WCDMA is supported.

Uplink Time Difference of Arrival (U-TDOA) Technique

U-TDOA techniques are based on estimating the difference in the arrival times of the signal from the source at multiple receivers. This is usually accomplished by taking snapshot of the signal at a synchronized time period at multiple receivers. The cross-correlation of the two versions of the signal at pairs of base stations is done and the peak of the cross correlation output gives the time difference for the signal arrival at those two base stations. A particular value of the time difference estimate defines a hyperbola between the two receivers on which the mobile may exist, assuming that the source and the receivers are coplanar. If this procedure is done again with another receiver in combination with any of the previously used receivers, another hyperbola is defined and the intersection of the two hyperbolas results in the position location estimate of the source. This method is also sometimes called a hyperbolic position location method.

This method offers many advantages over other competing techniques. Since all the processing takes place at the infrastructure level, no modifications are needed in the existing handsets. In this respect, this solution would be more cost effective than a GPS-based solution. It also does not require knowledge of the absolute time of the transmission from the handset like a modified handset TOA method needs. Since this technique does not require any special type of antennas, it is cheaper to put in place than the DOA _finding methods. It can also provide some immunity against timing errors if the source of major signal reflections is near the mobile. If a major reflector effects the signal components going to all the receivers, the timing error may get cancelled or reduced in the time difference operation. Hence, U-TDOA methods may work accurately in some situations where there is no LOS signal component. In this respect, it is superior to the DOA method or the TOA method. The required changes to incorporate the U-TDOA method are only to be in the software of the system. However, dedicated lines for position location data may be used between the base stations and the switching center, if the position location technique is to be used often enough, to avoid a toll on the revenue generating voice traffic in the regular connection between the base stations and the switch [6][7]. Figure 1 shown U-TDOA method

U-TDOA Estimation Techniques

The uplink time difference of arrival U-TDOA of a signal can be estimated by two general methods: subtracting TOA measurements from two base stations to produce a relative U-TDOA, or through the use of cross-correlation techniques , in which the received signal at one base station is correlated with the received signal at another base station. The former method requires knowledge of the transmit timing, and thus, strict clock synchronization between the base stations and source. To eliminate the need for knowledge of the source transmit timing, differencing of arrival times at the receivers is commonly employed. Differencing the observed time of arrival eliminates some of the errors in TOA estimates common to all receivers and reduces other errors because of spatial and temporal coherence. While determining the U-TDOA from TOA estimates is a feasible method, cross-correlation techniques dominate the field of U-TDOA estimation techniques. As such, the discussion of U-TDOA estimation is limited to cross-correlation estimation techniques. In the following section, a general model for U-TDOA estimation is developed and the techniques for U-TDOA estimation are presented[7].

U-TDOA Estimation

For a signal, s(t), radiating from a remote source through a channel with interference and noise, the general model for the time-delay estimation between received signals at two base stations, $x_1(t)$ and $x_2(t)$, is given by

$$x1(t) = A1s(t-d1) + n1(t) \quad \ldots\ldots\ldots\ldots(1)$$
$$x2(t) = A2s(t-d2) + n2(t)$$

where A1 and A2 are the amplitude scaling of the signal, n1(t) and n2(t) consist of noise and interfering signals and d1 and d2 are the signal delay times, or arrival times. This model assumes that s(t) , n1(t) and n2(t) are real and jointly stationary, zero mean (time average) random processes and that s(t) is uncorrelated with noise n1(t) and n2(t). Referring the delay time and scaling amplitudes to the receiver with the shortest time of arrival, assuming $d1 < d2$, the model of (1) can be rewritten as

$$x1(t) = s(t) + n1(t) \quad \ldots\ldots\ldots\ldots(2)$$
$$x2(t) = As(t - D) + n2(t)$$

Where A is the amplitude ratio and D = d2 − d1. It is desired to estimate D, the uplink time difference of arrival (U-TDOA) of s(t) between the two receivers. It may also be desirable to estimate the scaling amplitude A. By estimating the amplitude scaling, selection of the appropriate receivers can be made. It follows that the limit cyclic cross-correlation and autocorrelations are given by

$$R^{\propto}_{x2x1}(\tau) = AR^{\propto}_{s}(\tau - D)e^{-j\pi\alpha D} + R^{\propto}_{n2n1}(\tau) \ldots(3)$$

$$R^{\propto}_{x1}(\tau) = R^{\propto}_{s}(\tau) + R^{\propto}_{n1}(\tau) \ldots\ldots(4)$$

$$R^{\propto}_{x2}(\tau) = |A|^2 R^{\propto}_{s}(\tau)e^{-j\pi\alpha D} + R^{\propto}_{n2}(\tau) \ldots(5)$$

Where the parameter $\propto$ is called the cycle frequency . If $\propto$ = 0, the above equations are the conventional limit cross-correlation and autocorrelations. If s(t) exhibits a cycle frequency $\propto$ not shared by n1(t) and n2(t), then by using this values of $\propto$ in the measurements in (3)-(5),we obtain through infinite time averaging

$$R^{\propto}_{n1}(\tau) = R^{\propto}_{n2}(\tau) = R^{\propto}_{n2n1}(\tau) = 0 \ldots\ldots(6)$$

and the general model for time delay estimation between base stations is

$$R^{\propto}_{x2x1}(\tau) = AR^{\propto}_{s}(\tau - D)e^{-j\pi\alpha D} \ldots\ldots(7)$$

$$R^{\propto}_{x1}(\tau) = R^{\propto}_{s}(\tau) \ldots\ldots(8)$$

$$R^{\propto}_{x2}(\tau) = |A|^2 R^{\propto}_{s}(\tau)e^{-j\pi\alpha D} \ldots\ldots(9)$$

Accurate TDOA estimation requires the use of time delay estimation techniques that have immunity against noise and interference also the ability to resolve multipath signal components .Many techniques have been developed to estimate D with varying degrees of accuracy and robustness .These include the Generalized Cross-Correlation (GCC) and other types of cross-correlation methods, but these do not offer an advantage over GCC methods in CDMA system. As such, only generalized cross-correlation methods for TDOA estimation are presented [7][8][9].

U-TDOA Equation Solving Algorithms

Once the U-TDOA estimates have been obtained, they are converted into range difference measurements and these measurements can be converted into nonlinear hyperbolic equations. As these equations are non-linear, solving them is not a trivial operation. Several algorithms have been proposed for this purpose having different complexities and accuracies. Here, we will first discuss the mathematical model that is used by these algorithms, which is then followed by a survey of the algorithms that can be used for solving hyperbolic equations[6].

Mathematical Model for U-TDOA Equations

A general model for the two dimensional (2-D) PL estimation of a source using M base stations is developed. Referring all U-TDOAs to the first base station, which is assumed to be the base station controlling the call and the first to receive the transmitted signal, let the index i = 2…..,M, unless otherwise specified, (x,y) be the source location and (Xi,Yi) be the known location of the ith receiver. The squared range distance between the source and the ith receiver is given as[6]

$$R_i = \sqrt{(X_i - x)^2 + (Y_i - y)^2} \ldots\ldots(10)$$

$$= \sqrt{X_i^2 + Y_i^2 - 2X_i x - 2X_i x + x^2 + y^2}$$

The range difference between base stations with respect to the base station where the signal arrives first, is

$$R_{i,1} = cd_{i,1} = R_i - R_1 \ldots\ldots\ldots\ldots\ldots\ldots(11)$$

$$= \sqrt{(X_i - x)^2 + (Y_i - y)^2} - \sqrt{(X_1 - x)^2 + (Y_1 - y)^2}$$

Where c is the signal propagation speed, $R_{i,1}$ is the range difference distance between the first base station and the ith base station, R_1 is the distance between the first base station and the source, and di,1 is the estimated U-TDOA between the first base station and the ith base station. This defines the set of nonlinear hyperbolic equations whose solution gives the 2-D coordinates of the source. Solving the nonlinear equations of (11) is difficult. Consequently, linearizing this set of equations is commonly performed. One way of linearizing these equations is through the use of Chan's Method and retaining the first two terms. A commonly used alternative method to the Taylor-series expansion method, presented is to first transform the set of nonlinear equations in (11) into another set of equations. Rearranging the form of (11) into

$$R_i^2 = (R_{i,1} + R_1)^2 \ldots\ldots\ldots\ldots\ldots\ldots(12)$$

Equation (10) can now be rewritten as

$$R_{i,1}^2 + 2R_{i,1}R_1 + R_1^2 = X_i^2 + Y_i^2 - 2X_i x - 2Y_i y + x^2 + y^2 \;..\; (13)$$

Subtracting (10) at i = 1 from (13) results in

$$R_{i,1}^2 + 2R_{i,1}R_1 = X_i^2 + Y_i^2 - 2X_{i,1}x - 2Y_{i,1}y - X_1^2 - Y_1^2 \;..(14)$$

where $X_{i,1}$ and $Y_{i,1}$ are equal to $X_i - X_1$ and $Y_i - Y_1$ respectively. The set of equations in (14) are now linear with the source location (x,y) and the range of the first receiver to the source R1 as the unknowns, and are more easily handled.

Practical Methods for Solving U-TDOA Equations

The methods that can be practically used for solving hyperbolic equations are the Taylor-series method, Fang's method and Chan's method. Among these, Fang's and Chan's methods provide a closed form exact solution which is not available with the Taylor-series method and also are computationally less intensive. The Taylor-series method also carries the risk of converging to a local minimum if given a bad starting `seed'. On the other hand, the Taylor-series and Chan's method can make use of any redundant measurements, if occasionally available. It will be shown later in this section that the ambiguities in Fang's and Chan's algorithms are not a problem in cellular-type systems. Focusing in this paper on the Chan's method[6]. The mathematical procedures for this algorithm are as follow.

Mathematical procedures for Chan's Method

Following Chan's method [8], for a three base station system (M=3), producing two TDOA's, x and y can be solved in terms of R1 from (14). The solution is in the form of

$$\begin{pmatrix} x \\ y \end{pmatrix} = -\begin{bmatrix} X_{2,1} & Y_{2,1} \\ X_{3,1} & Y_{3,1} \end{bmatrix}^{-1} * \left\{ \begin{pmatrix} R_{2,1} \\ R_{3,1} \end{pmatrix} R_1 + \frac{1}{2} \begin{pmatrix} R_{2,1}^2 - K_2 + K_1 \\ R_{3,1}^2 - K_3 + K_1 \end{pmatrix} \right\} .(15)$$

Where

$$K_1 = X_1^2 + Y_1^2$$
$$K_2 = X_2^2 + Y_2^2$$
$$K_3 = X_3^2 + Y_3^2$$

When (15) is inserted into (10) , with i = 1 , a quadratic equation in terms of R_1 is produced. Substituting the positive root back into (15) results in the final solution. There may pass two positive roots from the quadratic equation that can produce two different solutions, resulting in an ambiguity. This problem has to be resolved by using a priori information. As was seen for Fang's algorithm, simulations in this work have shown that one of the roots of the quadratic equation in R_1 almost always gives negative values for R_1, which is not possible. In some rare cases when that root does give positive numbers, the numbers are too large and are well above the cell radius, which is again not possible. Hence, when the quadratic equation in R_1 is obtained in the form

$$aR_1^2 + bR_1 + c = 0 \quad \text{……………..(16)}$$

only the following root should be considered for cellular PL.

$$R_1 = \frac{-b-\sqrt{b^2-4ac}}{2a} \quad \text{……………...(17)}$$

An interesting observation that was made while studying the ambiguities in the Fang's and Chan's algorithms was that both these ambiguities are essentially the same. It was seen that if we make wrong choices in both algorithms for a given case then the wrong results given by both algorithms are identical.

Measures of Position Location Accuracy

A set of background is required to evaluate the accuracy of the hyperbolic position location technique .A commonly used measure of PL accuracy is the Root Mean Square (RMS)[9] ,this is because of the fact that this measure makes it easy to visualize the amount of inaccuracy in PL.

The root mean square (RMS) position location error is as follows[6].

$$RMS = \sqrt{\varepsilon} = \sqrt{E[(x-\hat{x})^2 + (y-\hat{y})^2]} \quad \text{……...(18)}$$

Where:

$\hat{x}$ and $\hat{y}$ are the estimated values of x and y coordinate of MS PL.

Assumptions, policies and metrics of interest :

- ❖ The system used in this simulation is WCDMA
- ❖ In U-TDOA method our concern is with the uplink
- ❖ The base station configuration used for simulation is based on a hexagonal cellular layout with 7 cells cluster as shown in figure (2)
- ❖ Macrocell radius equal to (5000) meter and Microcell radius equal to (1000) meter
- ❖ Number of users in the cell equal to (20) users
- ❖ Bandwidth equal to 5MHz
- ❖ Snap shot length equal to (12) bits
- ❖ Sample rate used in this simulation equal to (8) sample per chip
- ❖ Processing gain equal to (60)
- ❖ Signal noise ratio equal to (5)dB
- ❖ Number of rake receiver fingers equal to (4) fingers

General Structure of the Simulations

The general flow chart of the simulation program is

- ❖ Random binary data is generated for different users.
- ❖ Spread using the spreading codes (Gold Code and kasami) then sampling this data
- ❖ The length of the data is set according to the desired length of the snap shot (12 bit).
- ❖ calculating the signal delays and attenuations experienced by each

user's signal for each base station, depending on the distance of the user and the path loss model being used.

- ❖ Additive White Gaussian Noise (AWGN) is added to the signals depending on the desired Eb/N0(5dB).
- ❖ Received signal at each base station are incoherently added from all the users
- ❖ The data bits for the desired user are despread to form the snap shot so that it contains only the desired user spread Signal
- ❖ The cross-correlation is done to get the hyperbolic equations
- ❖ Chan's algorithm is used to solve the hyperbolic equation to get the PL estimate of the desired user
- ❖ Measures of Position Location Accuracy by using Root Mean Square (RMS)

Figure (3) shown the flow chart for general structure of the simulation

Simulation Models

Path Loss Model

The path loss model used in the simulation, is Personal Communication systems (PCS) Model [10]. This model is an Extension to Hata-Okumura Model and it is an empirical formula. The European Co-operative for Scientific and Technical research (EUROCOST) formed the COST-231 working committee to develop an extended version of the Hata- Okumura model to make it suitable for Personal Communication Systems (PCS) which has radius of no more than 1 km. The modified model extend Hata-Okumura model to 2 GHz and valid for cell radius of less than 1 km.

$$L(urban) = 46.3 + 33.9 \log(f_c) - 13.82 \log(h_{te}) - a(h_{re}) + (44.9 - 6.55 \log(h_{te})) \log(d) + C_M \quad \text{.......(19)}$$

Where:

(fc) is the frequency in MHz, ht is the height of the base station antenna in m, (hr) is the height of the mobile antenna in m, (d) is the T-R separation distance in km and a(hr) is the correction factor for effective mobile antenna height:

$$a(h_{re}) = (1.1 \log(f_c) - 0.7)\, h_{re} - (1.56 \log(f_c) - 0.8) \quad \text{.......(20)}$$

As mentioned previously, our value for (fc) is 1900MHz. We are assuming the base station antenna height , ht, to be 10 m and the mobile antenna height , hr, to be 1 m.

Additive White Gaussian Noise Channel

A zero-mean additive white Gaussian noise channel is used in all simulations. The noise n(t) is added to the transmitted signal s(t). so that the received signal r(t) is represented as [8].

$$r(t) = s(t) + n(t) \quad \text{.......(21)}$$

Rayleigh Fading Channel

Rayleigh fading refers to the dramatic changes in signal amplitude and phase that can be experienced as a result of small changes in distance (a small fraction of half-wavelength) in this spatial separation between a receiver and transmitter. The received signal consists of large number of multiple paths and there is no line- of –sight signal component[9][11].

Interference Cancellation

The challenging problem in position location using U-TDOA is to obtain a good signal for the require user in neighboring cells. One feasible method to solve this problem is to use multiuser receivers that have the ability to reduce the Multiple Access Interference (MAI) to increase the SNR of the required signal at those base stations. The effect of using and not using the interference cancellation at the neighboring base stations has been discussed in section (III). In this simulation one stage of parallel interference cancellation has been used to reduce MAI for the desired user's signal at the base stations other than the controlling BS[9].

An expression that approximately gives us the optimal value for this Interference Reduction Factor (IRF), depending on the number of users and the spreading gain which is:

IRF = 0.95 – 0.48 (k/N)……………(22)

Where (k) is the number of users and (N) is the spreading gain of the WCDMA system. In most of our simulations, we are assuming up to (20) users in each cell and the (WCDMA) spreading gain is (60), Hence (0.79) for the interference reduction factor [6].

Power Control Problem

The power control required of WCDMA systems presents a major problem for PL systems. In general, as the mobile moves closer to the base station handling the call, and consequently farther away from neighboring base stations, the received signal power from the mobile unit increases at the base station. Under a closed-loop power control scheme, the base station instructs the unit to reduce power to limit the amount of interference. However, this effectively reduces the signal power at the neighboring base stations. This can severely degrade the accuracy of the position location estimate and possibly eliminate the ability to geolocate the mobile unit. The first way to solve this problem is to instruct the desired user to transmit at a higher power to increase signal quality at other base stations. That if the mobile is instructed to transmit at maximum power, then the coverage area for position location can be considerably increased. However, initially we see two interference related problems with this solution. The second way for improved reception of desired user's signal at the neighboring base stations is the application of interference rejection at the neighboring base stations to reduce MAI for the desired signal. When the desired mobile is closer to its home cell site, its signal at the neighboring cell sites is very weak as compared to the signals from the users of those cells. This causes bit errors in the received version of desired user's signal at those base stations. Hence, if at those cell sites, we cancel their own users' signals and then detect the desired user's signal, this results in improved reception for the signal of interest[6,7].

Simulation Results and Discussion

The results presented in this section evaluate the performance of the Uplink-TDOA PL technique by effect the overlapping between the signals of all users in Wideband Code Division Multiple Access (WCDMA) system, effect of using and or not using the interference cancellation at the neighboring base stations and effect of the sampling rate on U-TDOA accuracy in macrocellular and microcellular (WCDMA) system with AWGN and Rayleigh channel in order to choose a suitable value of the sampling rate.

A-Effect of the overlapping between the signals of all users in WCDMA system on cross correlation

The problem that the U-TDOA method faces in WCDMA systems is that the signals of all users are spectrally and temporally overlapping. Hence, it is not possible to use generalized or cyclic cross-correlation techniques to find the desired user's peak at the cross-correlation output among the peaks of other users. Figure(4)and(5) show the cross-correlation output for one user and multi users. To solve this problem, dispreading the received signal at BSs to obtain the data bits for the desired user only.

B-Effect of the Sampling rate on U-TDOA Accuracy

In this section, we study the effect of the sampling rate of the receiver on the position location accuracy. The accuracy of the U-TDOA estimates which are calculated by cross- correlation procedures, depends on the sampling rate of the signals.

Usually, the higher the bandwidth of the incoming signals the higher is the sampling rate of the system. However, even a signal with a comparatively narrow bandwidth can give more accurate U-TDOA estimates, if its sampling rate is increased. The reason is that as we increase the sampling rate of the system, the time quantization error in U-TDOA estimates decreases. Hence, wideband systems such as WCDMA that have a naturally higher sampling rate give more accurate position location results than systems with narrower bandwidths

a-Macrocellular Environments

Effect of the Sampling rate on U-TDOA Accuracy in Macrocellular WCDMA Environments For the three base station configuration, the base stations were located at BSI (0.0), BS2 (±7500, ±4330),BS3 (0 , ±8660). The average error is measured as a ratio with respect to the radius of the cell (error/R %) with and without Rayleigh channel effect.

The average error value is taken from (150) values.

Figure (6) shows the relation between the average error and the number of sample per chip without Rayleigh channel effect. The average error is decreased with the increasing of the number of sample per chip .The reason for this, is that when the sampling rate of the system is increased the time quantization error in U-TDOA is decreased.

Note the average error at 8 samples per chip is approximately 5m or 0.1% error/R. The figure (7) shows the average error due to the Rayleigh channel effect are greater than that of figure(6) because of multi path delays (4-paths). Note the average error at 8 samples per chip is approximately 7m or 0.138% error/R.

b- Microcell Environments

Effect of the Sampling rate on U-TDOA Accuracy in Microcellular WCDMA Environments For the three base station configuration, the base stations were located at BSI (0.0), BS2 (±1500 , ±866), BS3(0, ±1730)**.** Figure (8) shows the relation between the average error and the number of sample per chip without Rayleigh channel effect. The average error is decreased with the increasing of the number of sample per chip .The reason for this, is that when the sampling rate of the system is increased the time quantization error in U-TDOA is decreased. Note the average error at 8 samples per chip is approximately 6m or

0.6 % error/R. The figure (9) shows the average error due to the Rayleigh channel effect is greater than that of figure (8) because of multi path delays (4-paths). Note the average error at 8 samples per chip is approximately 10m or 1% error/R.

Microcellular versus Macrocellular

It is interesting to compare the results of the previous simulations. The Figures indicate that the RMS PL performance of the three configurations is better for macrocellular than microcellular. Since the average error due to the microcellular system are greater than the macrocellular system . The results suggest that microcellular systems may be more sensitive to U-TDOA estimator accuracy than macrocellular systems and that performance of the PL system improves as the number of sample per chip increases.

C- Effect of Interference Cancellation on Average Error

While the signals from all MSs in other cells Interfere the MSs in this cell. In U-TDOA, the mobile signal must be measured by the three BSs and followed by cross- correlation between them to estimate $TDOA_{12}$ and $TDOA_{13}$. In the BS_1, there is no problem concerning the signal of the desired MS to be located, but if the MS is near BS_1 , the signal received by BS_2 and BS_3 will be week due to path loss, also due to the MSs in BS_2 and BS_3 and this will increase the error in MS position estimation.

To avoid the problems mentioned above by:

- Increasing the power of mobile at the estimated time only, the power control sends the order to this mobile to increase its power at this time. Figure (10) shows the effect of power increasing in average error.
- Using interference cancellation to decrease the required power at the estimated time. Figure (11) shows the effect of interference cancellation method and its advantage over increasing the power only. The power needed is 1.5dB for this method, while with no interference cancellation the power need is 5dB.

Conclusions

It has been found that some factors are very important in determining the expected accuracy of the PL process. From the implementation point of view, the two most important factors are the interference cancelation and the sampling rate of the system.

It has been observed that increasing the sampling rate of the system has a direct impact on the PL error. This happens because with increased sampling, the time quantization error in U-TDOA estimates decreases, resulting in more accurate PL estimation.

Hence, we expect the PL performance to improve further in the future as more high speed hardware replaces slower devices. Because of this relationship, broadband digital communication systems are more suited for U-TDOA PL as they naturally have a high sampling rate and bandwidth because of having a higher data rate than the narrowband digital systems.

Higher power signal is used for desired user signal to improve the signal quality at the neighboring base stations. It was shown that instead of just switching to the maximum power, it would be more practical and realistic to increase the mobile transmit power in increments,

until the desired signal quality at the neighboring cell sites is obtained.
It was shown that when we cancel the strong desired user signal, its negative effect on the received signal quality of other users is eliminated and the system BER is restored to its normal values. Parallel interference cancellation was made at other Base Stations by using of parallel interference cancellation at other base stations to improve the reception of the desired user's signal at the neighboring cell sites.

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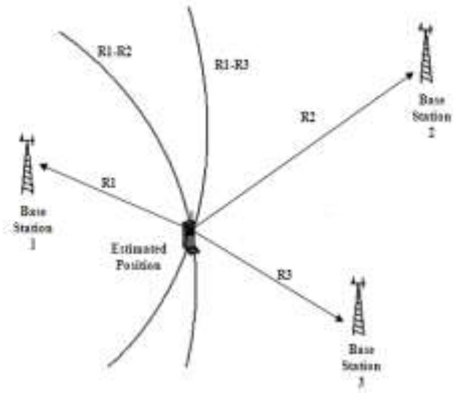

Figure(1): U-TDOA method

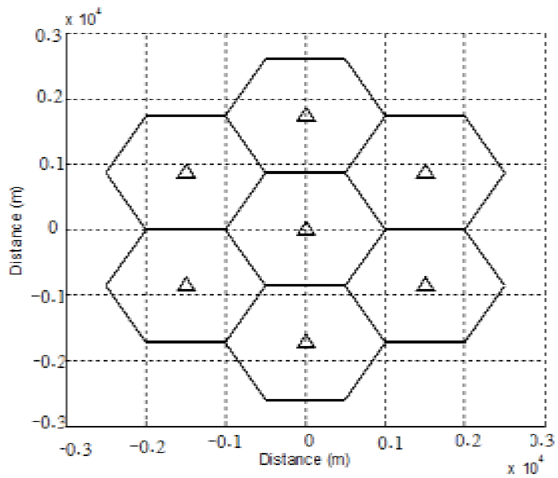

Figure (2): 7 cells cluster

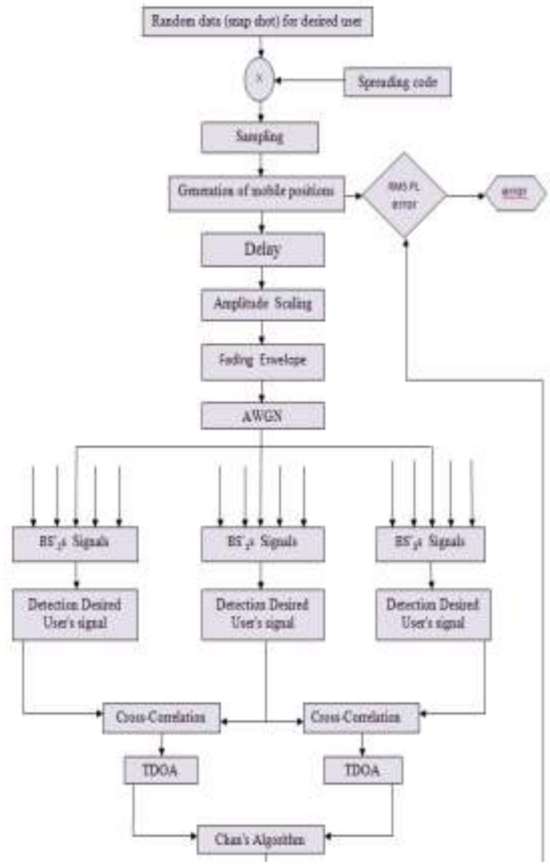

Figure (3) : the flow chart for general structure of the simulation

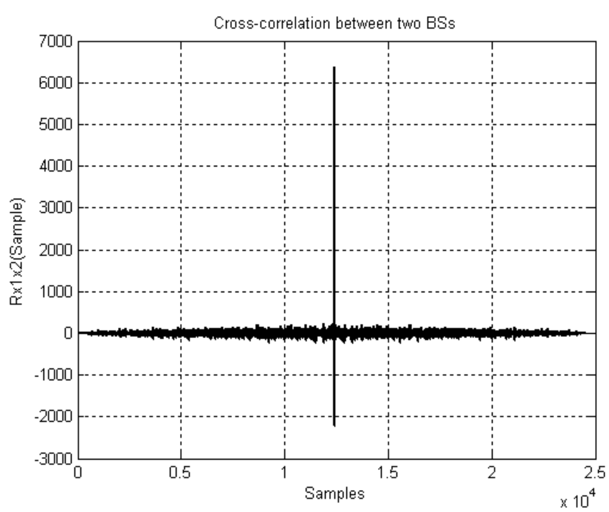

Figure (4): Cross-correlation (one user)

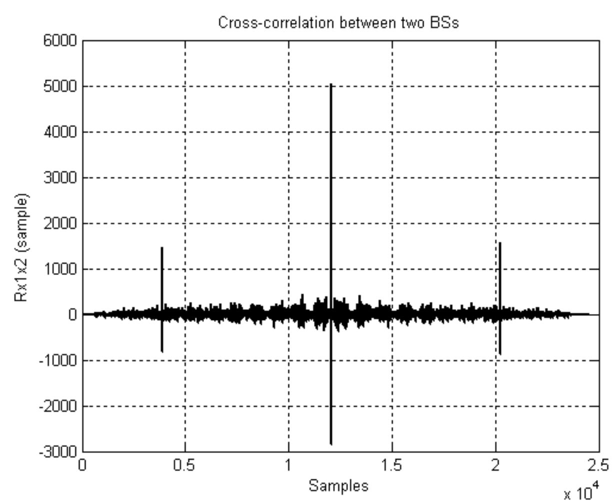

Figure (5): Cross-correlation (multiuser)

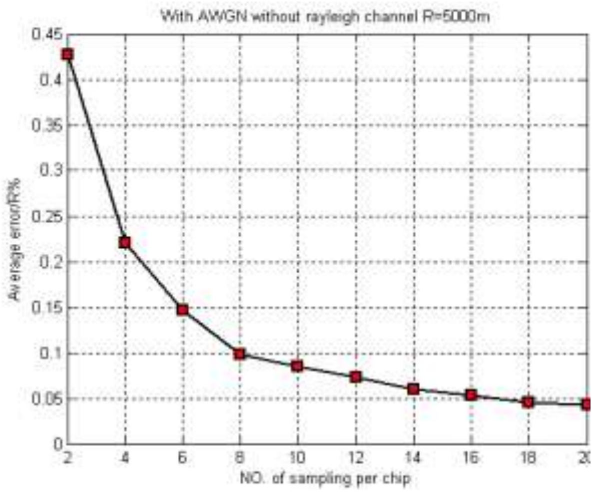

Figure (6): Average error /R % with sampling rate without Rayleigh channel

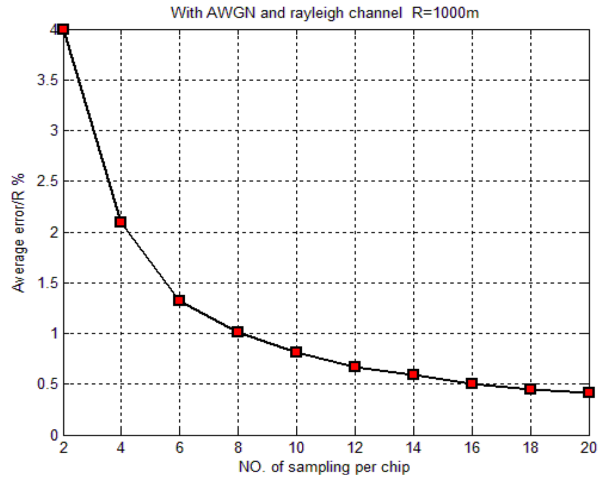

Figure (9): Average error /R % with sampling rate with Rayleigh channel

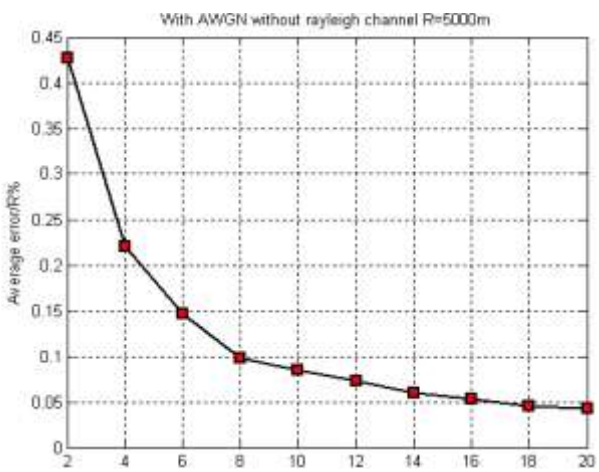

Figure (7): Average error /R % with sampling rate with Rayleigh channel

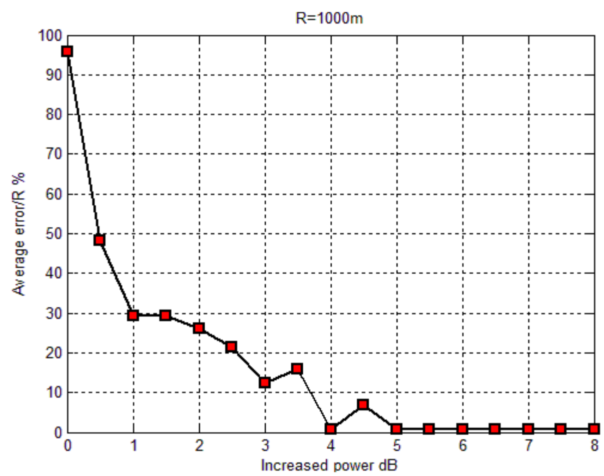

Figure (10): Average error /R % with increased power

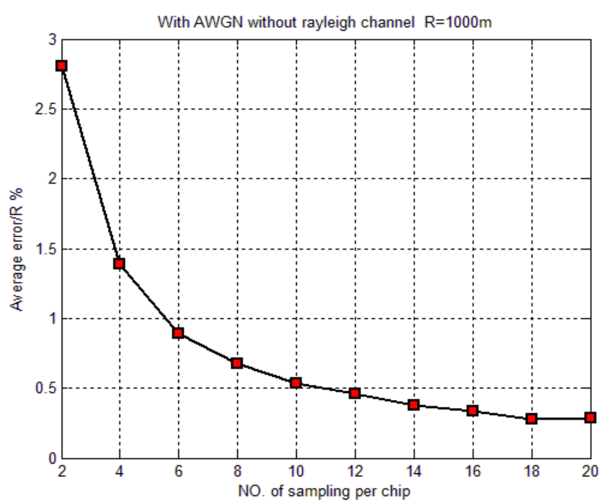

Figure (8): Average error /R % with sampling rate without Rayleigh channel

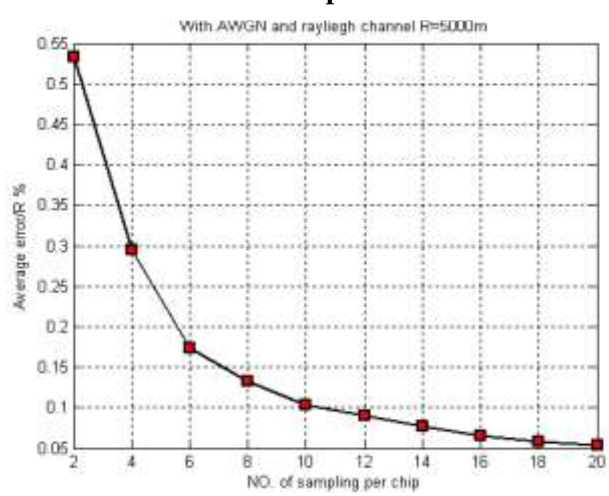

Figure (11) Average error/R with increased with Interference cancelation