REDUCTION OF RELATIVE POSITIONING ERROR AND INTERFERENCE SUPPRESSION IN WIRELESS OFDM BASED CELLULAR NETWORKS

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Abstract-

Localization of a mobile station (MS) in a cellular network is performed using multicarrier transmission for orthogonal frequency division multiplexing (OFDM)-based cellular networks. In this paper, we propose a multicarrier (MC)-based positioning system for Orthogonal Frequency Division Multiplexing (OFDM)-based cellular networks such as WiMAX or future 4G system together with a novel localization protocol that is optimized for this system A positioning system is proposed where the relative positioning and interference suppression is reduced compared to the previous methods. A localization protocol is defined in which four positioning methods are analyzed. For achieving this Cramer-Rao Lower Bound (CRLB) is implemented and the paper demonstrates the enhanced performance of Best linear unbiased estimator (BLUE) based algorithms to implement the proposed methods when locating a mobile station using cellular base stations.

Index Term- Best linear unbiased estimator (BLUE),Cramer–Rao lower bound (CRLB), interference suppression, multicarrier transmission, positioning error.

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I.INTRODUCTION

The phenomenal growth of wireless communications and wireless systems over the past decade provides high data rate with less energy consumption than before. The use of wireless devices such as cell phones, PDAs, and laptops (in general mobile stations – MSs) has become the enabler of viable location based services and applications that need position location information. The development of location based services (LBSs) that have been promised for many years now, but should become a reality in most of WiMax standards[1]. There are several applications that need location information such as automated vehicle location, concierge services, mobile commerce and public safety. Each of these applications requires accuracy and precision of position that is specific to its needs. In indoor areas, for applications such as inventory and asset management (such as locating wheel chairs in hospitals), the accuracy has to be within a few meters on a given floor of the building.

In cellular networks we locate a mobile station using several base stations. A common practice is to rely on range difference based positioning. Range measurements are obtained by sending a pseudo noise (PN) transmission or an orthogonal frequency division multiplexing (OFDM) signal [2]-[4]. For precise location determination in cellular networks it is essential to analyze the positioning error. Time-based range measurements can be done using an OFDM signal[5], and derived its theoretical limit by Cramer–Rao lower bound (CRLB). The position location information is usually specified with certain accuracy and precision. Accuracy refers to the error in distance from the determined position and the actual position.

Any system that locates a MS needs to get some characteristics related to the MS to determine its location. The position is determined using some algorithms. In addition, there are protocols that are required to transport the sensed information to entities that determine the location or provide other services.

There are no mandated positioning requirements for wireless local area networks (WLANs). Most deployed WLAN equipment follows the IEEE 802.11 standard or its enhancements like 802.11a,b, or g. For WiMax based services orthogonal frequency division multiplexing is the main technique in its physical layer[6][7]. There are three major types of location based services. The first type is global positioning system (GPS) assisted approach[8]. But this has little coverage in both indoors and dense urban environment. It also increases the cost of mobile station and battery consumption.

The second type is mobile report based scheme based on the measurements provided by the base stations to the mobile stations[9][10]. These may include relative delay (RD), round trip delay (RTD), received signal strength indicator (RSSI), time of arrival (TOA) and time difference of arrival (TDOA)[11][12]. The third type is based on the cell identification of the serving base station[14][15]. The estimation accuracy is poor in these two methods.

In this paper, a multicarrier (MC)-based positioning system for OFDM-based cellular networks has been proposed together with a novel localization protocol that is optimized for this system. The novel protocol includes both a MS-based solution and a network-based solution. The solution consists of three operating stages: a communication stage, a ranging stage, and a positioning stage. Four localization approaches are provided in the positioning stage for the multicarrier system. CRLB is implemented for these four methods .The impossible estimation of BLUE is removed and an enhanced performance of BLUE is obtained.

The rest of this paper organized as follows: Section 2 presents our approach for multicarrier positioning system. In Section 3, we review our related work regarding this approach. Finally, Section 4 concludes the paper.

II. MULTICARRIER POSITIONING SYSTEM

In this section a novel multicarrier based positioning system and a localization protocol is defined which comprises of a MS-based solution in section II-A and network based solution in section II-B. The positioning system is made of a central site connected to a number of base stations which are used to locate the mobile stations. A minimum amount of signal strength (let us say, x dB) is needed in order to be detected by the MS or mobile sets which may the hand-held personal units or those installed in the vehicles. The area over which the signal power lies above this threshold value x dB is known as the coverage area of a BS and it must be a circular area, in view of the BS to be isotropic radiator. It might so happen that either there may be an overlap between any two such side by side circles or there might be a gap between the coverage areas of two adjacent circles.

A cell must be designed such that it is most reliable i.e., it supports even the feeble mobile signal that occurs at the edges of the cell. The distance between the center and the farthest point in the cell from it, is a regular hexagon covers the maximum area.

Each base station is located at the centre of the cell with a known location and the position of mobile station is to be located as shown in fig.1. A cluster chosen to encompass MS is denoted by the hexagonal structure.

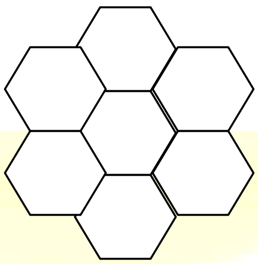

Fig 1.Hexagonal Structure

A. Protocol for Network based Solution

This category is referred to as "network based" because the mobile network, in conjunction with network-based position determination equipment is used to position the mobile device. Here the BSs must cooperate together to locate the MS using the central site as in fig.2.

In the communication stage, the serving BS, BS1, initiates the transmission of a "Locate Request" to MS on the downlink. MS receives the request along with TOTBS1 of LWBS1 from BS1 and TOTMS of MS. MS accepts the reception of the request and waits for the transmission from the BS.

In order to allow repeat retransmissions between BS1 and MS TOTBS1 is selected a large value till all the acknowledgements are received correctly.

In the ranging stage, BS1 transmits LWBS1 at TOTBS1. MS receives it and estimates its TOAMS. After waiting for a period of time T, MS transmits a LWMS at a predetermined TOTMS, where T is calculated as TOTMS – TOAMS. BS1 receives it and calculates its TOABS1. From the TOA, TOT values the relative delay (RD) and round trip delay (RTD) is estimated. Based on this the position of mobile station is located.

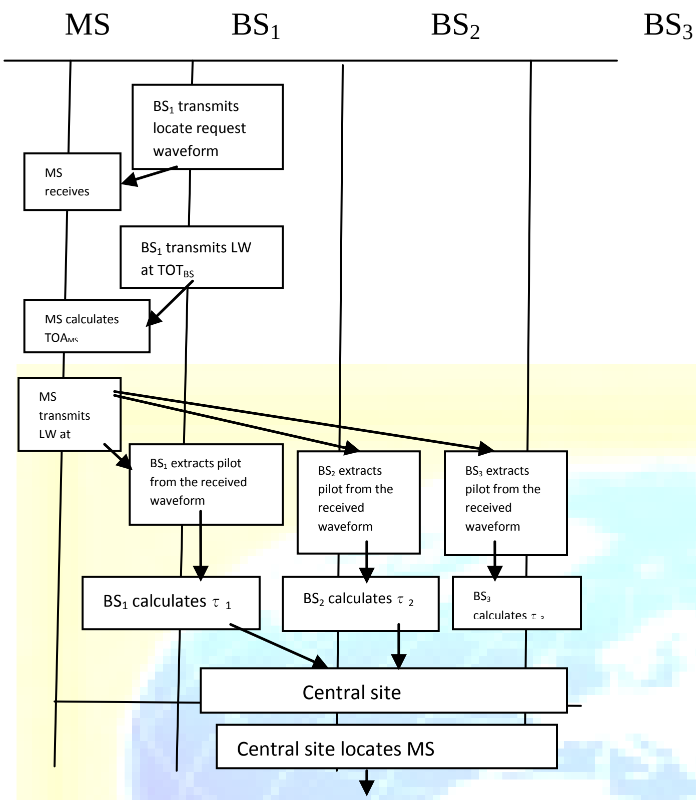

Fig. 2. Network-based solution

B. Protocol for MS- based Solution

The measurements and computation of a location position estimate are performed by MSs This category is referred to as "MS based" because the MS itself is the primary means of positioning the user, although the network can be used to provide assistance in acquiring the mobile device and/or making position estimate determinations based on measurement data and MS based position determination algorithms.

In the communication stage, MS, which intends to locate itself, is to initiate the transmission by sending a “Locate Request” waveform on the uplink. Since the “Locate Request” signal consists of data characters to be detected with an acceptable communication SNR as in fig.3. The serving BS, BS1 which can hear it in a communication sense and to notify the network of the request. The network assigns a time of transmission, TOTMS, and an estimated time of arrival (ETA) to MS by BS1.In order to allow repeat retransmissions between BS1 and MS TOTMS is selected to be large enough until all necessary acknowledgments are successfully received. ETA is selected in such that the largest possible propagation delay falls within the MC transmission. In the ranging stage, MS transmits a LW, LWMS, at TOTMS.

Assuming that BS*i* is one of the N BSs that can hear MS in a location sense. In this case, BS*i* receives LWMS, estimates its TOA, TOABS*i* , and waits for a period of time, Ti, before transmitting its LW, LWBS*i*, at TOTBS*i*. The time Ti is calculated by BS*i* as Ti = TOTBS*i*− Current time.

TOTBS*i* = ETA−$\tau_{i,d.}$ (1)

$\tau_{i,d.}$ is the estimated propagation delay on the downlink. Since $\tau_{i,d}$ is unknown, we use $\tau_{i,u}$ instead, where $\tau_{i,u}$= TOˆABS*i*−TOTMS is the estimated propagation delay on the uplink from MS to BS*i*. MS then receives LWBS*i* around ETA, extracts the pilots corresponding to LWBS*i* , and calculates its TOA*i*

$$T_{RTDi} = \tau_{i,d} + \tau_{i,u} \quad (2)$$

From the TOA, TOT values the relative delay (RD) and round trip delay (RTD) is estimated. Based on this the position of mobile station is located.

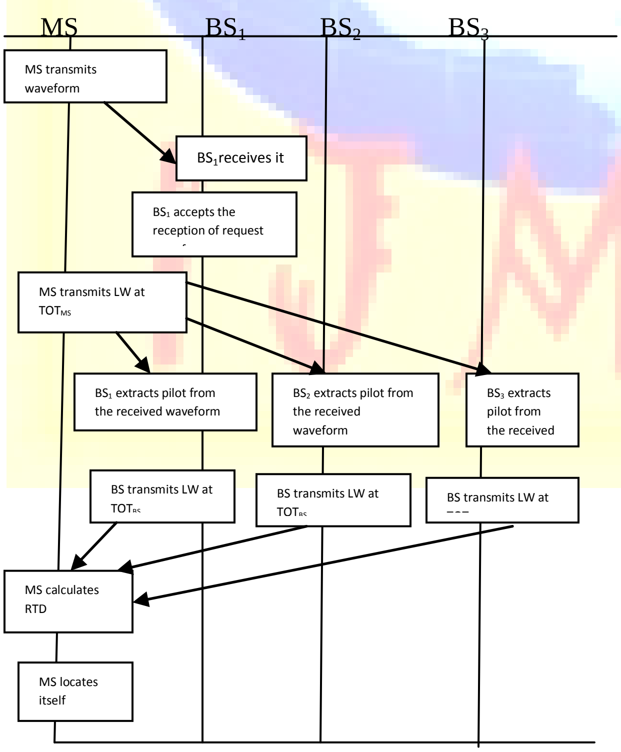

Fig. 3. MS-based solution

C. Pilot Configuration of the Locate Waveform

The pilot configurations of the LWs that are related with the two proposed solutions is discussed in this section. When the LWMS gets transmitted by MS on the uplink, all of the available subcarriers can be used to secure a sufficient performance, whereas, on the downlink, the number of subcarriers in LWBS*i* depends on whether the location solution is network-based or MS-based. When the solution is network-based, LWBS1 transmitted by the serving BS, BS1, contains all of the available subcarriers. When the solution is MS-based, only a portion of the subcarriers are selected for each LWBS*i* that is transmitted by BS*i*. We consider in this case a dispersed subcarrier variation which can introduce frequency diversity similar in concept to frequency reuse in cellular networks.

III. RELATED WORK

A. CRLB for the proposed protocol

The **Cramer-Rao Lower Bound** (CRLB) sets a lower bound on the variance of **any** unbiased estimator[19]. This can be extremely useful in several ways:

1. The estimator that achieves the CRLB, subsequently we make out that we have identified an MVUB estimator.
2. The CRLB can provide a benchmark against which we can compare the performance of any unbiased estimator.
3. The CRLB enables to rule-out impossible estimators. That is, it is physically impossible to find an unbiased estimator that beat the CRLB. This is of use in probability studies.
4. The theory behind the CRLB can tell that if an estimator exists that achieves the bound.

Proposed system defines localization using orthogonally that allow Frequency reuse with reduced interference.

Estimators are used to identify the synchronization between the signal received and their perspective for operation.

B. Proposed Protocol Using BLUE

In this section, the BLUE is derived for the four positioning methods. They include Time of arrival(TOA),Time difference of arrival (TDOA) and TSOA based positioning. No additional assumptions are needed about the PDF of the noise for the BLUE.

BLUE for a MS-Managed Solution includes each range estimate, ri , forms a circle centered at BSi with a radius ri. When only one circle exists, we have an infinite number of solutions for the coordinates of MS. When two circles exist, they may intersect at up to two points thus representing either an ambiguous solution or no solution at all. In general, when N such circles exist, they may intersect at up to $2 \cdot (1 + 2 + \cdots + N - 1)$ points, thus generally having no unique solution. In order to obtain a unique solution, one can use the BLUE after linearizing ri as in through a Taylor series expansion around a nominal position of the MS.

For a network-managed solution, there are three methods used in this paper: RTD/TOA-based BLUE, TDOA-based BLUE and TSOA-based BLUE[16]-[20].TDOA based BLUE has same performance with range difference based BLUE. In a network-managed solution, RTD/TOA-based BLUE has a better performance than other ranging based BLUE methods[21].

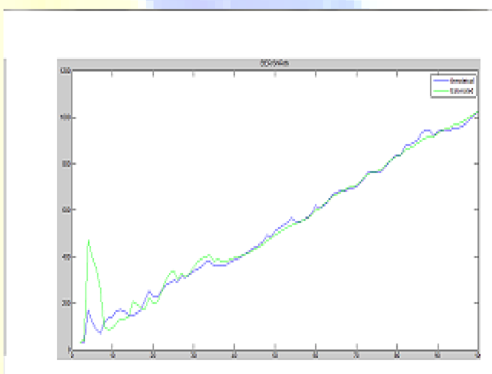

Fig. 4 CRLB implemented practically

C. System Performance Analysis

In this section, the performance of the proposed system is discussed and judged against the previous work in terms of difficulty, bandwidth efficiency, positioning error and interference. In the proposed scheme, the orthogonal property between distinct OFDM subcarriers is utilized to assure that the transmitted LWs from different BSs or MS do not interfere with one another even though the protocol attempts to have them received or transmitted at the same time. This is accomplished by choosing one LW to consist only of pilot tones that do not overlap in frequency with pilot tones from other LWs.

In the classical approach the mobile station (MS) determines time difference of arrival (TDOA) information from the received signals of at least three base stations (BSs). With these TDOAs the location of the MS is estimated. However, only at the cell edge a good reception of several BSs is guaranteed. Especially for future systems aiming a frequency re-use of one, interference is a restrictive factor. Hence, in the inner cell it is difficult to detect out-of-cell BSs with sufficient quality. Therefore, we propose an interference cancellation scheme to improve the performance in these critical situations for TDOA positioning.

An estimator is used at the receiver side to determine the accurate location of the mobile station. A CRLB estimator defines the lower and upper bounds. In the earlier methods only the impossible estimation of BLUE is done whereas here the impossible estimation is removed. The performance of BLUE is enhanced in the proposed system.

IV.CONCLUSION

In this paper, a novel multicarrier based positioning system with a corresponding localization protocol has been proposed for OFDM-based cellular networks. The presented protocol has a better localization accuracy as it reduces the relative positioning error in locating a mobile station using several base stations. Using the orthogonal property an interference cancellation scheme is achieved. The BLUE algorithm was used to implement the four positioning methods. An enhanced performance of BLUE has been obtained without any impossible estimation.

REFERENCES

[1] Y. Zhao, "Standardization of mobile phone positioning for 3G systems," IEEE Commun. Mag., vol. 40, no. 7, pp. 108–116, Jul. 2002.

[2] K. Yu, L. Sharp, and Y. J. Guo, Ground-Based Wireless Positioning. New York: Wiley, 2009, ch. 2.

[3] H. Ni, G. Ren, and Y. Chang, "A TDOA location scheme in OFDM based WMANs," IEEE Trans. Consumer Electron., vol. 54, no. 8, pp.1017–1021, Aug. 2008.

[4] C. Mensing, S. Sand, A. Dammann, and W. Utschick, "Data-aided location estimation in cellular OFDM communications systems," in Proc. 28th IEEE Conf. Global Telecommun., Nov.–Dec. 2009, pp. 20–26.

[5] D. Wang and M. Fattouche, "OFDM transmission for time-based range estimation," IEEE Signal Process. Lett., vol. 17, no. 6, pp. 571–574,Jun. 2010.

[6] WiMAX Forum, "Protocols and procedures for location based services,"Draft-T33-110-R015v01-B, May 2009.

[7] Part 16: Air Interface for Broadband Wireless Access Systems, IEEE Standard 802.16, 2009.

[8] M. Venkatachalam, K. Etemad, W. Ballantyne, and B. Chen, "Location services in WiMAX networks," IEEE Commun. Mag., vol. 47, no. 10, pp. 92–98, Oct. 2009.

[9] C. M. Bae, "Method of providing location services in WiMAX network irrespective of state of mobile station," U.S. Patent Applicat.US20080146261A1, Jun. 2008.

[10] M. Bshara and L. Biesen, "Fingerprinting-based localization in WiMAX networks depending on SCORE measurements," in Proc. 5th Adv. Int. Conf. Telecommun., 2009, pp. 9–14.

[11] M. Bshara, N. Deblauwe, and L. Biesen, "Localization in WiMAX networks based on signal strength observations," White paper of Vrije Universiteit Brussel, Brussels, Belgium, Aug. 2008.

[12] M. Bshara and L. Biesen, "Available measurements in current WiMAX networks and positioning opportunities," in Proc. 19th IMEKO World Congr. Fundamental Appl. Metrology, Sep. 2009, pp. 580–585.

[13] W. Jiao, P. Jiang, R. Liu, W. Wang, and Y. Ma, "Providing location service for mobile WiMAX," in Proc. IEEE Int. Conf. Commun.,May 2008, pp. 2685–2689.

[14] M. Bshara, R. Verscharegen, and L. Biesen, "Cell-ID positioning in WiMAX networks analysis of the clearwire network in Belgium," in Proc. Conf. ICT, Jun. 2009, pp. 1–6.

[15] M. Bshara, U. Orguner, and L. Biesen, "Tracking in WiMAX networks using cell-ID," in Proc. IEEE Mobile WiMAX Symp., Jul. 2009, pp. 102–106.

[16] K. Lay and W. Chao, "Mobile positioning based on TOA/TSOA/TDOA measurements with NLOS error reduction," in Proc. Conf. ISPACS, Dec. 2005, pp. 545–548.

[17] D. Munoz, F. Bouchereau, C. Vargas, and R. E. Caldera, Position Location Techniques and Applications. New York: Elsevier, 2009, pp.76–77.

[18] Y. Chan and K. Ho, "A simple and efficient estimator for hyperbolic location," IEEE Trans. Signal Process., vol. 42, no. 8, pp. 1905–1915, Aug. 1994.

[19] K. Cheung, H. So, W. Ma, and Y. Chan, "Least squares algorithms for time-of-arrival-based mobile location," IEEE Trans. Signal Process., vol. 52, no. 4, pp. 1121–1128, Apr. 2004.

[20] J. Xu, M. Ma, and C. Law, "Position estimation using ultra-wideband time difference of arrival measurements," IET Sci., Measurement Technol., vol. 2, no. 1, pp. 53–58, Jan. 2008.

[21] Guannan Zhao, Student, IEEE, Donglin Wang, Member, IEEE, Michel Fattouche, Member, IEEE, and Minglu Jin, Member, IEEE"Novel Wireless Positioning System for OFDM-Based Cellular Networks."

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