



Faculty of Electronic and Computer Engineering

**ENHANCED LOCATION AND POSITIONING IN WiMAX
NETWORKS WITH VIRTUAL MIMO BASE STATION**

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**ENHANCED LOCATION AND POSITIONING IN WiMAX NETWORKS
WITH VIRTUAL MIMO BASE STATION**

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**A thesis submitted
in fulfillment of the requirements for the degree of Master of
Science in Electronic Engineering**

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DECLARATION

I declare that this thesis entitled “Enhanced Location and Positioning in WiMAX Networks with Virtual MIMO Base Station” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date :

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering.

Signature :

Supervisor Name : Dr. AZMI AWANG MD ISA

Date :

DEDICATION

To my beloved wife and children, mother and father

ABSTRACT

Location and Positioning (L&P) techniques which utilize wireless broadband networks are often considered by the wireless communications industries to be a means for improving overall system performance and providing value added services. Conventional L&P methods rely on the availability of base station (BS) locations as well as the mitigation of propagation effects. It is known that location estimation accuracy suffers in poor geometric dilution of precision (GDOP) caused by BS location as conventional location algorithms generate large GDOP values which correspond to poor geometrical topology. In addition, non line of sight (NLOS) effects cause large errors in time of arrival (TOA) readings, which affecting mobile station (MS) estimation accuracy. In this thesis a new concept of virtual BS (VirBS) utilizing multiple input multiple output (MIMO) technology has been introduced and successfully applied to improve L&P accuracy. The performance of the proposed algorithm has been evaluated via computer simulations. The simulation results demonstrate that the proposed algorithm increased L&P accuracy without additional expenditure on network architecture. Furthermore, a new hybrid algorithm enhancement of mobile station (MS) location estimation by using a single MIMO base station (SMBS) with the virtual base station has been introduced. The SMBS algorithm with virtual base station utilizes both AOA and AOD measurement parameter (SMVirBS). The developed algorithm includes the effect of the geometric dilution of precision (GDOP) to assist with the location estimation accuracy. Simulation results show that the proposed technique outperforms the linear least square (LLS) algorithm in terms of estimated location accuracy.

ABSTRAK

Teknik lokasi dan kedudukan (L & P) yang menggunakan rangkaian jalur lebar tanpa wayar selalunya dianggap oleh industri komunikasi wayarles sebagai satu cara untuk meningkatkan prestasi sistem keseluruhan dan menyediakan perkhidmatan nilai tambah. Kaedah L & P konvensional bergantung pada jumlah stesen pangkalan (BS) yang terdapat di lokasi dan juga pengurangan kesan perambatan. Adalah diketahui bahawa ketepatan anggaran lokasi semakin berkurangan disebabkan oleh pengurangan ketepatan geometri (GDOP) yang lemah kerana lokasi BS sebagai algoritma lokasi konvensional menjana nilai GDOP yang besar. Nilai GDOP yang besar menunjukkan topologi geometri yang lemah. Di samping itu, kesan NLOS menyebabkan ralat besar dalam bacaan masa ketibaan (TOA) yang tentunya menjejaskan stesen mudah alih (MS) menganggar ketepatan bacaan. Dalam kertas kerja ini, satu konsep baru BS maya (VirBS) menggunakan teknologi berbilang input berbilang output (MIMO) telah diperkenalkan dan berhasil untuk meningkatkan ketepatan L & P. Prestasi algoritma yang dicadangkan telah dinilai melalui simulasi komputer. Keputusan simulasi menunjukkan bahawa algoritma yang dicadangkan dapat meningkatkan ketepatan L & P tanpa tambahan kepada jumlah stesen pangkalan. Seterusnya satu peningkatan anggaran lokasi MS menggunakan algoritma hibrid dengan stesen pangkalan MIMO tunggal dan stesen pangkalan maya (SMVirBS) juga telah diperkenalkan. Algoritma SMB dengan stesen pangkalan maya menggunakan kedua-dua parameter pengukuran AOA dan AOD (SMVirBS). Algoritma yang dibangunkan menggunakan kesan pengurangan ketepatan geometri (GDOP) untuk membantu dalam anggaran ketepatan lokasi. Keputusan simulasi menunjukkan bahawa teknik yang dicadangkan adalah lebih baik berbanding dengan algoritma linear least square (LLS) dari segi anggaran ketepatan lokasi.

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300m., AOD SD: 5 Degrees, AOA SD: 3 Degrees]

LIST OF ABBREVIATIONS

| | | |
|------------|---|-----------------------------------------|
| 3GPP | - | Third generation partnership project |
| AAS | - | Adaptive antenna systems |
| AMC | - | Adaptive modulation and coding |
| AOA | - | Angle of arrival |
| AOD | - | Angle of direction |
| ASNs | - | Access service networks |
| BL-SPECCOR | - | Band-Limited Spectral Correlation Ratio |
| BPSK | - | Binary phase shift keying |
| BS | - | Base station |
| BWA | - | Broadband wireless access |
| CDP | - | Cumulative Distribution Probability |
| CDSM | - | Circular disk of scatterer model |
| CEP | - | Circular error probability |
| CLOP | - | Circular lines of position |
| CP | - | Cyclic prefix |
| CSNs | - | Connectivity service networks |
| CYCCOR | - | Cyclic Cross-Correlation |
| DCD | - | DL channel descriptor |
| DL | - | Downlink |
| DOA | - | Delay of arrival |

| | |
|---------|-----------------------------------------------------------------------|
| ECID | - Enhance cell ID |
| ESPRIT | - Estimation of Signal Parameters by Rotational Invariance Techniques |
| FCC | Federal Communication Commission |
| FCH | - Frame control header |
| FDD | - Frequency division duplexing |
| FFR | - Fractional frequency reuse |
| FFT | - Fast fourier transforms |
| GCC | - Generalized cross correlation |
| GDOP | - Geometric dilution of precision |
| GIS | - Geographic information system |
| GLONASS | - Global orbiting navigation satellite system |
| GNSS | - Global navigation satellite system |
| GPS | - Global positioning system |
| IEEE | - Institute of Electrical and Electronics Engineers |
| IFFT | - Inverse FFT |
| L&P | - Location and positioning |
| LBS | - Location base service |
| LLOP | - Linear lines of position |
| LOPs | - Lines of positions |
| LOS | - Line of sight |
| LTE | - Long term evolution |
| MAC | - Medium access control |
| MCS | - Modulation and coding scheme |
| MF | - Matched filter |

| | |
|-------|-------------------------------------------------|
| MIMO | - Multiple input multiple output |
| ML | - Maximum likelihood |
| MMR | - Mobile multi-hop relaying |
| MS | - Mobile station |
| MSE | - Mean squared error |
| MUSIC | - Multiple signal classification |
| NAPs | - Network access providers |
| NLLS | - Non linear least squares |
| NLOS | - Non-line of sight |
| NRM | - Network reference model |
| NSPs | - Network service providers |
| OFDM | - Orthogonal frequency division multiplexing |
| OFDMA | - Orthogonal frequency division multiple access |
| OTDOA | - Observed time difference of arrival |
| PHY | - Physical layer |
| QAM | - Quadrature amplitude modulator |
| QPSK | - Quadrature phase shift keying |
| RMSE | - Root mean square error |
| ROS | - Ring of scatterers |
| RSA | - Range scaling algorithm |
| RSs | - Relay stations |
| RTG | - Receive/transmit Transition gap |
| SBM | - Single bounce marcocellular |
| SM | - Spatial multiplexing |
| SMBS | - Single MIMO base station |

| | | |
|----------------|---|-------------------------------------------------|
| SMVirBS | - | Single MIMO with virtual base stations |
| SNR | - | Signal to noise ratio |
| SOFDMA | - | Scalable OFDMA |
| SPECCOA | - | Spectral Coherence Alignment |
| SS | - | Signal strength |
| STC | - | Space time code |
| SVD | - | Singular value decomposition |
| TDD | - | Time division duplexing |
| TDMA | | Time division multiple access |
| TDOA | - | Time difference of arrival |
| TOA | - | Time of arrival |
| TTG | - | Transmit/receive Transition gap |
| TX-AA | - | Transmitter adaptive antenna |
| UCD | - | UL channel descriptor |
| UL | - | Uplink |
| UWB | - | Ultra wideband |
| VirBS | - | Virtual Base Station |
| WC | - | Wireless communication |
| WiMAX | - | Worldwide Interoperability for Microwave Access |
| WirelessMAN-SC | - | Single channel modulation |
| WLANs | - | Wireless Local Area Networks |

LIST OF PUBLICATIONS

The research papers produced and published during the course of this research are as follows:

Journal

1. A.A.M. Isa , **M.H. Othman**, N.Z. Haron , M.S.M. Isa, M.S.I.M. Zin, Z. Zakaria and A. A. A. Zaini, Combined TOA/DOA for Location Estimation in MIMO System, Journal Teknologi, Vol 6, 2014 (*Published*) (*Scopus*)
2. A.A.M. Isa , **M.H. Othman**, M.S.M. Isa, M.S.I.M. Zin, N.Z. Haron and Z. Zakaria, Improved Location and Positioning In WiMAX Networks with Virtual MIMO Base Stations, Advanced Science Letters, 2014 (*Published*) (*Scopus*)
3. A.A.M. Isa, M. Hud, **M. Othman**, M. Isa, M. Zin, N. Haron, and A. Jaafar, "Analysis of WiMAX Positioning Using Received-Signal-Strength Method," Journal of Telecommunication, Electronic and Computer Engineering, vol. 5., 2013 (*Published*)(*Scopus*)

Proceeding/Conferences

1. A.A.M. Isa, **M.H. Othman**, M.S. Johal, M.S.M. Isa, M.S.I.M. Zin, N.Z. Haron, Z. Zakaria and M.M. Ibrahim, Enhanced Location Estimation with a Single Base Station in WiMAX Network, 5th International Conference on Intelligent & Advanced Systems, 2014 (*Published*)(*Scopus*)

2. A.A.M. Isa, **M. Othman**, M. Isa, N. Haron, Z. Zakaria, and M. Zin, "Utilising MIMO for positioning in mobile WiMAX systems," in *Wireless Technology and Applications (ISWTA)*, 2013 IEEE Symposium on, pp. 7-10, 2013 (*Published*)(*Scopus*)
3. A.A.M. Isa, **M. H. Othman**, M.M. Hud, M.S. Johal, M.S.I.M. Zin, and M.S.M Isa, "Location Estimation Utilising WiMAX Preamble Detection Under ITU-R Channel Models," in *2013 IEEE Student Conference on Research and Development (SCORED)*, 2013(*Published*)(*Scopus*)

CHAPTER 1

INTRODUCTION

1.0 Research Background

Due to ever increasing demand for new services and applications, wireless broadband communications are becoming more popular since the users are provided with “anywhere and at any time” type of service (Awang Md Isa 2010). With the advent of Worldwide Interoperability for Microwave Access (WiMAX), the provision of mobile broadband connectivity together with other essential applications (e.g. L&P of mobile users) is becoming a reality. Furthermore it enables mobile broadband services at a vehicular speed of up to 120 km/h (Jefry G.Andrews, 2007). WiMAX complements and competes with Wi-Fi and third generation (3G) wireless standards in terms on coverage and data rates (Yarali et al. 2008). More specifically, WiMAX supports a much larger coverage area than wireless local area networks (WLANs). On the other hand, it operates in both outdoor and indoor environments and does not require line of sight (LOS) „visibility“ for a connection between the mobile station (MS) and base station (BS). It is also significantly less costly and provides higher data rates when compared to current third generation (3G) cellular standards. The WiMAX standard supports both fixed and mobile broadband data services; however, there is a great demand in the market for the latter (Koon Hoo et al. 2007). Furthermore, WiMAX has some