Faculty of Electronic and Computer Engineering

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

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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.

Signature :…….....

Name :…MUHAMMAD HAKIM OTHMAN.....

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 pengkalan. 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 Commision
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 acccess
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, 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 its 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