Faculty of Information and Communication Technology

NETWORK ENTRY PHASE OPTIMIZATION FOR WIMAX NETWORK

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NETWORK ENTRY PHASE OPTIMIZATION FOR WIMAX NETWORK

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DECLARATION

I declare that this thesis entitle “Network Entry Phase Optimization for WiMAX Network” is the result of my own research except as cited in the references. This thesis has not been accepted for any degree and is not concurrently submitted in submission of any other degree.

Signature : …….

Name : …….

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 Information and Communication Technology.

Signature	:	…….
Supervisor Name	:	…….
Date	:	…….

ABSTRACT

In the last few years, there has been a large growth in wireless broadband communication including Worldwide Interoperability for Microwave Access (WiMAX) technologies. The network entry process in WiMAX is the first process for Subscriber Station (SS) to join the WiMAX network. It referred to the early procedure performed by SS to register with Base Station (BS) that controls the WiMAX network. Scanning to ranging procedure is part of several steps associated with network entry process. The problem of long channel scanning and collision in ranging process can lead to the delay to the access time for initialization and recovery of service between SS and BS connection. Most of the current approaches are focused on reducing the scanning time and optimizing the ranging process but nearly everyone has ignored the influence of system parameters setting. Through this research, a technique is proposed to be used for IEEE 802.16 WiMAX standard with consideration on WiMAX network entry system parameter settings. The simulation environment has been set up to test different configuration condition in WiMAX environment. The intention is to investigate and make recommendation for necessary configuration for IEEE 802.16 standard. Simulation are done using ns-3 simulator and the findings are presented. Simulation results indicate proposed optimum key parameter value of DCD Interval, UCD Interval and Initial Ranging Interval with effect on QoS parameters that will allow the WiMAX network to operate in a higher level of performance and environments.

ABSTRAK

Dalam beberapa tahun kebelakangan ini, telah terdapat pertumbuhan yang ketara di dalam bidang komunikasi jalur lebar tanpa wayar termasuk bagi teknologi Operasi Merentasi Seluruh Dunia bagi Akses Gelombang Mikro (WiMAX). Proses kemasukan dalam rangkaian WiMAX adalah proses pertama untuk Stesen Pelanggan (SS) menyertai rangkaian WiMAX. Ia merujuk kepada prosedur awal yang dilakukan oleh SS untuk mendaftar dengan Stesen Pangkalan (BS) yang mengawal rangkaian WiMAX. Prosedur pengimbasan hingga peluasan ialah sebahagian dari beberapa langkah yang berkaitan dengan proses kemasukan dalam rangkaian. Permasalah pengimbasan saluran yang berpanjangan dan pelanggaran dalam proses peluasan boleh membawa kepada kelewatan masa akses bagi pengawalan dan pemulihan perkhidmatan antara sambungan SS dan BS. Kebanyakan pendekatan terkini tertumpu kepada mengurangkan masa pengimbasan dan mengoptimunkan proses peluasan tetapi hampir semua mengabaikan pengaruh penetapan parameter sistem. Melalui kajian ini, teknik dicadangkan untuk digunakan bagi standard IEEE 802.16 WiMAX ialah dengan mempertimbangkan penetapan parameter sistem pada kemasukan rangkaian WiMAX. Persekitaran simulasi telah diadakan untuk menguji keadaan konfigurasi yang berlainan dalam persekitaran WiMAX. Tujuannya adalah untuk menyiasat dan membuat cadangan untuk tatarajah yang diperlukan untuk standard IEEE 802.16. Simulasi dilakukan menggunakan simulator ns-3 dan penemuan dibentangkan. Keputusan simulasi menunjukkan nilai parameter optimum bagi Selang DCD, Selang UCD dan Selang Pengantara Awal yang dicadangkan dengan kesannya kepada parameter QoS yang akan membolehkan rangkaian WiMAX beroperasi di tahap prestasi dan persekitaran yang lebih baik.

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LIST OF ABBREVIATIONS

AAS	Adaptive Antenna System
AMC	Adaptive Modulation and Coding
ATM	Asynchronous Transfer Module
BE	Best Effort
BPSK	Binary Phase Shift Keying
BRH	Bandwidth Request Header
BS	Base Station
BW	Bandwidth
BWA	Broadband Wireless Access
CBR	Constant Bit Rate
CC	Convolutional Coding
CID	Connection Identifier
CP	Cyclic Prefix
CQICH	Channel Quality Indicator
CR	Contention Ratio
CRC	Cyclic Redundancy Check
CS	Convergence Sublayer
CTC	Convolutional Turbo Coding
DAC	Digital to Analogue Converter
DCD	Downlink Channel Descriptor
DL	Downlink
FCH	Frame Control Header
FDD	Frequency Division Duplex
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FRF	Frequency Reuse Factor

FTP	File Transfer Protocol
FUSC	Fully Used Sub-Carrier
GM	Grant Management
GMH	Generic MAC Header
GSM	Global System for Mobile communications
HARQ	Hybrid Automatic Repeat Request
HHO	Hard Hand-Off
HSPA	High Speed Packet Access
HTTP	Hyper Text Transfer Protocol
IE	Information Element
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
ISI	Inter-Symbol Interference
LOS	Line Of Sight
LTE	Long Term Evolution
MAC	Medium Access Control
MAP	Media Access Protocol
MAU	Minimum Allocation Unit
MDHO	Macro Diversity Hand Over
MIMO	Multiple Input Multiple Output
NF	Noise Figure
NLOS	Non Line-of-Sight
OCR	Overall Coding Rate
OFDM	Orthogonal Frequency Division Multiplex
OFDMA	Orthogonal Frequency Division Multiple Access
OSR	Over Subscription Ratio
P2P	Peer to Peer
PDU	Packet Data Unit
PHY	Physical Layer Protocol
PL	Path Loss
PUSC	Partially Used Sub-Carriers
QAM	Quadrature Amplitude Modulation

QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RSSI	Received Signal Strength Indicator
rtPS	Real Time Polling Service
SDU	Service Data Unit
SIMO	Single Input Multiple Output
SNIR	Signal to Noise + Interference Ratio
SNR	Signal to Noise Ratio
SS	Subscriber Station
TDD	Time Division Duplex
TDM	Time Division Multiplexing
UCD	Uplink Channel Descriptor
UL	Uplink
UMTS	Universal Mobile Telephone System
VBR	Variable Bit Rate
VoIP	Voice over IP
WiMAX	Worldwide Interoperability for Microwave Access

LIST OF PUBLICATIONS

Mohamad Firdaus Ghazali, Abdul Samad Shibghatullah and Shahrin Sahib. (2010). WiMAX: Network Entry Phase Optimization for Bandwidth Improvement Solution. 4th International Symposium on Broadband Communication, ISBC 2010, Melaka, Malaysia, 11 – 14 July 2010.

Mohamad Firdaus Ghazali, Abdul Samad Shibghatullah and Shahrin Sahib. (2010). Investigating the Network Entry Phase Optimization in WiMAX Network. Seminar of Information Technology 2010, SIT 2010, Melaka, Malaysia. 27 October 2010.

CHAPTER 1

INTRODUCTION

1.1 Background Introduction

The Worldwide Inter-operability for Microwave Access (WiMAX) is a telecommunication technology based on IEEE 802.16 standard (IEEE 2012). WiMAX supports two types of network topologies which is Point-to-Multipoint (PMP) and Mesh (Kejie Lu et al. 2008). In PMP, the link connection is only between Base Station (BS) and Subscriber Station (SS). The standard was designed to evolve with media access control (MAC) layer consists of three sub layers. They are the service specific convergence sub layer (CS), MAC common part sub layer (CPS), and the security sub layer (Maode Ma and Yan Zhang 2008).

The main functionalities of the MAC CPS are including network entry, connection management, Quality of Service (QoS) control, air-link control, Protocol Data Unit (PDU) operation, mobility and power management, and multicast and broadcast service (Ming Wu, Fei Wu, and Changsheng Xie 2008). This thesis is particularly concern with network entry.

Network entry process as part of MAC CPS sub layer is the first step for Subscriber Station (SS) joining the WiMAX network. It referred to the early procedure subscriber SS perform to register themselves with the Base Station (BS) that controls the 802.16 network (Bum-Gon Choi et al. 2009). There are several steps associated with network entry such as scanning to ranging, intersection of SS's and BS's capabilities, authentication and

authorization, SS registration and connection establishment (Pero Latkoski and Borislav Popovski 2009).

The scanning to ranging steps usually affected with delay and service disruptions between SS and BS. This is caused by long channel scanning and collision in ranging process. This research focuses on the mandatory steps of scanning to ranging (Pero Latkoski and Borislav Popovski 2009) and propose a WiMAX system parameter setting to manage the effect of long channel scanning and collision in ranging process. The relationship between scanning to ranging steps and WiMAX system parameters setting will be considered. Assessment on WiMAX parameter setting has been used in other problem domain such as Denial of Service (DoS) vulnerabilities of WiMAX network (Juan Deng, Richard R. Brooks, and James Martin 2012), and geolocating of WiMAX station based on timing adjustment ranging parameter (Don E. Barber Jr. 2009).

1.2 Background of the Research Problem

The problem during scanning to ranging steps in network entry will degrade the access time for initialization and recovery of service in WiMAX network. For example, a lengthy channel scanning will causes a service disruptions between the SS and BS (Jae-Kark Choi, Nan Hao, and Sang-Jo Yoo 2008) while the collision in ranging will lead to disconnection between SS and BS (Lidong Lin, Bo Han, and Weijia Jia 2006). As part of functionalities mechanism for network entry in MAC CPS, this could result inexpected delay and under utilization of WiMAX link (Hai L. Vu and Sammy Chan 2008).

Thus, how the effect of long channel scan and collision in ranging process during scanning to ranging steps in network entry is managed? One method is by “reduce scanning

time" (Zdenek Becvar and Pavel Mach 2010) and another is "optimization of ranging process" (Lidong Lin et al. 2007). Reducing scanning time approaches have had success in reduce a number of channels to scan so that fast scanning is achieved (Jae-Kark Choi, Nan Hao, and Sang-Jo Yoo 2008) and optimization of ranging process approaches was appealing in term of optimizing the connection probability and average connection delay (Namsuk Lee et al. 2010).

Other approaches also exist such as to upgrade the IEEE 802.16 protocol performance regarding the delay during subscriber network entry process (Pero Latkoski and Borislav Popovski 2009), analyzing the collision probability (Ben-Jye Chang, Ying-Hsin Liang, and Sung-Ju Hsieh 2010) and analytical modeling of network entry process (Matthias Hollick et al. 2007).

Most of the current approaches are primarily focused on modification of scanning and ranging procedure. All of these approaches correspond to the IEEE 802.16 standard but most of them are not easily implemented and have ignored the ability of WiMAX system parameter setting. Most of them also not considered to implicate with better communication system's QoS for WiMAX network.

To the best of our knowledges, there are only 2 works of (Pero Latkoski and Borislav Popovski 2009) and (Matthias Hollick et al. 2007) that look at influence of WiMAX protocol parameter during network entry to deal with delay problem caused by long channel scanning and collision in ranging process.

1.2.1 What May Help?

The overview of the current approaches has shown that while these approaches may be relevant for the associated environments, they do not provide solutions that could help in both

process of scanning and ranging in WiMAX network entry. The question is, what is the appropriate technique that can be used to relate the specified process of scanning to ranging in network entry that can deal with the problem of long channel scanning and collision in ranging process?

Reduce the channel scan approaches are able to achieve a fast scanning process but this approaches may not guarantee SS to acquire precise information for association with BS. Optimization of ranging process may improve the connection but it will sometimes disregard the performance of WiMAX network traffic flows.

The main characteristic for a solution that we are looking for is the ability to be easily modified WiMAX network entry process. The capabilities of WiMAX system parameters settings, especially related to WiMAX network entry process is matched with our requirements. Thus, in this research we propose evaluate to WiMAX system parameters with consideration to scanning to ranging steps in WiMAX network entry. Details of the specified WiMAX network entry process are discussed in Chapter Two.

1.3 Research Aim and Objectives

The process of designing an efficient system model for network entry phase calls for study of innovative and useful techniques that can improve IEEE 802.16 networks. The aim of this research therefore is to predict the effect and influence of significant protocol parameters for joining the network. By doing so, it should show that appropriate protocol parameters are crucial for optimization of network entry process. The work in this research will focuses on the following objectives:

1. The first objective is to determine and gather information the current approaches in reducing the scanning time and optimize the ranging process of WiMAX network entry to tackle the problem of scanning to ranging steps delay. The reason for this is to learn from current approaches the mechanism in dealing with the issue of WiMAX network entry phase with regards to scanning to ranging steps.

2. The second objective is to propose a solution technique that can improve the effect of long channel scanning and collision in ranging process for scanning to ranging steps in WiMAX network entry phase. The aim is to propose a modification to the original setup of IEEE 802.16 system parameters setting.

3. The third objective is to analyze the proposed technique whether it can manage the problem of long channel scanning and collision in ranging process while improve the WiMAX system.

1.4 Research Methodology

The research methodology used in this research to accomplish the requirements for this thesis will include as follow as summarized in Figure 1.1:

1. The literature survey through related research is used to obtain information IEEE 802.16 network entry and initialization process capabilities. The information on delay of scanning, synchronization, and ranging process in WiMAX network entry phase and current approaches to deal with long channel scanning and collsion in ranging is