CROSS LAYER DESIGN OF INTERFERENCE AWARE MULTI-HOP MOBILE RELAY WIMAX NETWORK

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A project report submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical – Electronics and Telecommunications)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

MAY 2011

Dedicated, in thankful appreciation for support, encouragement and understandings to my father and mother, Dzulkurnain b. Mohd Isa and Zaimah bt. Mahamood and to all my beloved friends.

ACKNOWLEDGEMENTS

In the name of ALLAH S.W.T., the Most Merciful and the Most Gracious.

Alhamdulillah, a lot of thanks to ALLAH S.W.T for His blessing for me to complete my project and this thesis is the symbolic of the support and guidance that I get from all my family and friends.

First and foremost, I would like to express my heartily gratitude to my supervisor, Prof. Dr. Norsheila bt. Fisal for the guidance and enthusiasm given throughout the progress of this project.

My appreciation also goes to my family who has been so tolerant and supports me all these years. Special thanks for their encouragement, love and emotional supports that they had given to me. Besides, I would like take this opportunity to thank all my friends, PhD students in UTM – MIMOS Centre of Excellence (COE) for their technical support and moral guidance.

I also would like to thank to those who has given the constructive comments and ideas in completing this project and I hope this project could give the advantages and knowledge for all the readers.

I am also indebted to my siblings for their supports throughout my life.

ABSTRACT

The MMR (IEEE 802.16j) WiMAX standard provides a mechanism for creating multi-hop relay, which can extend coverage and capacity and be deployed as a high speed wide area wireless network. Interference in wireless system is one of the most significant factors that limit the network capacity and scalability of wireless relay networks. Cross layer design (CLD) and optimization is known to improve the performance of wireless communication and mobile networks. In order to design a spectrally efficient IEEE 802.16j relay network, a joint design and optimization technique that relies on Physical layer which has the interference information, as well as scheduling and route selection mechanism in Data Link layer will be opted using software NCTUns and programming languange. The proposed scheme includes a novel interference-aware route construction algorithm and an enhanced scheduling scheme, which consider both traffic load and demand interference conditions. This interference-aware design should lead to better spatial reuse and thus higher spectral efficiency. By taking average 10 mobile users into consideration, the results show that the throughput is enhanced up to 8.5% from the normal implementation. It can be concluded that, the CLD approach will select the best route selection based on the SNR calculation and improve the scheduling for this network.

ABSTRAK

MMR (IEEE 802.16j) WiMAX merupakan satu piawai yang memberikan mekanisma untuk menghasilkan geganti banyak arah lompatan, yang mana mampu untuk meluaskan liputan dan kapasiti dan boleh menghasilkan jalur lebar tanpa wayar bagi kawsan yang luas. Masalah gangguan interferens di dalam rangkaian tanpa wayar adalah merupakan salah satu faktor yang boleh menghadkan kapasiti rangkaian tersebut. Rekaan penyilangan antara lapisan adalah mampu untuk menambah baik prestasi rangkaian komunikasi tanpa wayar. Untuk membolehkan penghasilan yang efisyen terhadap rangkaian IEEE 802.16j, rekaan pencantuman yang optimum yang bergantung kepada lapisan Fizikal yang mana mempunyai informasi interferens, juga informasi bagi memilih haluan di dalam lapisan Pautan Data dihasilkan menggunakan bantuan program simulasi jaringan (NCTUns) dan pengaturcaraan C. Skim yang dihasilkan mengandungi algoritma binaan laluan tanpa interferens dan skim peninggian daftar laluan, mengambil kira beban trafik dan kondisi interferens. Dengan mengambil kira 10 sampel pengguna mobil, hasil kajian menunjukkan output capaian dapat ditingkatkan kepada 8.5% daripada keadaan rangkaian biasa. Kesimpulannya, penghasilan penyilangan antara lapisan akan membantu untuk memilih laluan yang paling baik berdasarkan pengiraan SNR seterusnya dapat mengatasi masalah interferns di dalam rangkaian tanpa wayar.

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LIST OF ABBREVIATIONS

WiMAX	-	Worldwide Interoperability for Microwave Acces
OFDM	-	Orthogonal Frequency Division Multiplexing
OFDMA	-	Orthogonal Frequency Division Multiple Access
MMR	-	Multihop Mobile Relay
BS	-	Base Station
RS	-	Relay Station
MS	-	Mobile Station
T-RS	-	Transparent Relay Station
NT-RS	-	Non-transparent Relay Station
PHY	-	Physical layer
MAC	-	Medium Access Control
SNR	-	Signal to noise ratio
BER	-	Bit error rate
UL	-	Uplink
DL	-	Downlink
QoS	-	Quality of Service
GUI	-	Graphical User Interface
SE	-	Simulation Engine
UGS	-	Unsolicited Grant Service
rtPS	-	Real-time polling service
nrtPS	-	Non Real-time polling service
CID	-	Connection identifier

LIST OF SYMBOLS

dBm	-	power ratio in decibels in reference to 1 mW
MHz	-	megahertz
Mbps	-	megabit per second
kbps	-	kilobit per second

CHAPTER 1

INTRODUCTION

1.1 Project Background

WiMAX (Worldwide Interoperability for Microwave Access) is an IP based, wireless broadband access technology that provides performance similar to 802.11/Wi-Fi networks with the coverage and QOS (quality of service) of cellular networks. WiMAX can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 - 15 km) for mobile stations. In contrast, the WiFi/802.11 wireless local area network standard is limited in most cases to only 100 - 300 feet (30 - 100m).

The new mobile multi-hop relay (MMR), 802.16j network architecture imposes a demanding performance on relay stations. These relays will functionally serve as an aggregating point on behalf of the BS for traffic collection from and distribution to the multiple MSs associated with them. WiMAX 16j promises to support mobility up to speeds of 120 km/h. The peak DL data rates are up to 63 Mbps per sector and peak UL data rates are up to 28 Mbps per sector in a 10 MHz channel with the inclusion of MIMO antenna technique. Peak data rates of 300 Mbps are achievable. The speed of data can reach 10 Mbps within 10 km range from a mobile station to base station.

Traditionally, layered architecture like OSI and TCP/IP model, defines a hierarchy of services to be provided by the individual layers (Bertsekas and Gallager, 1992). However, this method does not lead to an optimum solution for wireless network. Basically, cross layer design (CLD) involved feedbacks received from other layer to optimize the information in the current layer so that the performance is enhanced (Raisinghani and lyer, 2004). CLD will sense the SNR of downlink channel when there is a request of downlink communication, and send the data packet to the nearest relay nodes. The algorithm specified in CLD will dynamically choose the available relay station based on available spectrum before reaching the subscribers or users. The subscriber stations are located in fixed, nomadic or mobile wireless coverage.

1.2 Problem Statement

In MMR 802.16j network, the Mobile Station (MS) is compatible with each other, but the Base Station (BS) in IEEE 802.16e is modified to support relay operations. A cell of 802.16j consists of one Multihop Relay Base Station (MR-BS), several RSs, and several MSs.

The MMR network is aiming for the improvement of network coverage via non-transparent (NT) mode relaying using two or more hops. The problem in any relay network is that, once relay is used, the bandwidth is parted in every relay existed in the network which will reduced the total of bandwidth in that particular network.

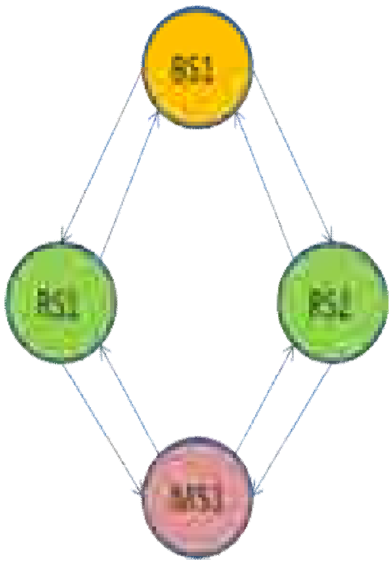

Figure 1.1: Multihop network

The network topology above describes the implementation of WiMAX MMR 802.16j NT in which the relay station (RS) can acts as a base station (BS) that will choose the path to send data from mobile station (MS) to BS. Current implementation in NCTUns network simulator programs the packets sent from MS to BS to follow the route that has been determined by RS, without considering any qualitative physical condition i.e. weak signal, which means that the MS will still have to follow this predetermined route even though the SNR received is low, although it is considered as the best path.

The problem arises when the interference in wireless network occurs (Figure 1.2), which will limit the network capacity and scalability of wireless relay networks. Therefore, an appropriate design of interference aware of MMR network should be presented in order to increase the network throughput and at the same time can enhance the coverage of the network. A cross layer design (CLD) method will make new adoptions to the MAC layer that rely on the signal-to-noise ratio (SNR) information in physical (PHY) layer and the scheduling slots in the medium access layer (MAC) is presented. The network performance of CLD in the MMR will be simulated using the NCTU-ns software.

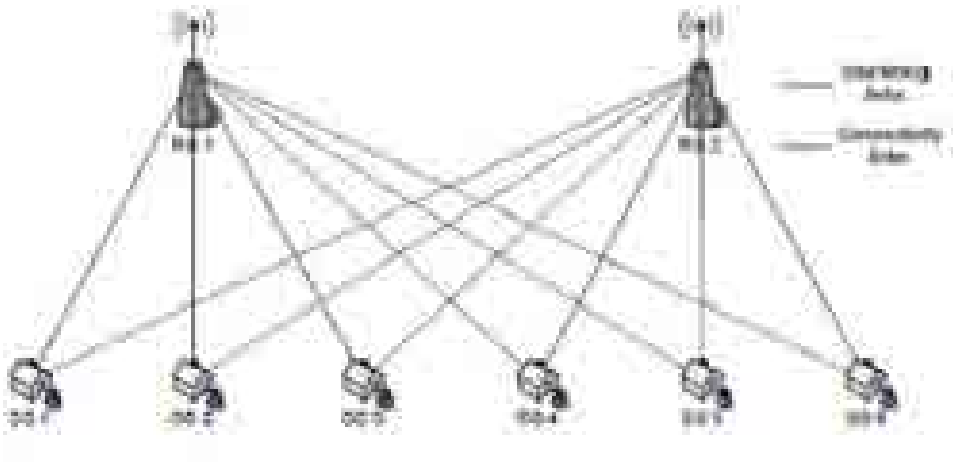

Figure 1.2: Example of interference link in multihop network

1.3 Scope of Work

The relay mode that will be used in this project is non-transparent relay mode for a two-hop 802.16j between mobile station and base station. Cross layer routing intends to play an essential role in improving the performance of MMR networks. Such cross-layer design lets protocols that belong to different layers cooperate in sharing network status information while still maintaining the layers' separation at the design level.

For this project, the software that is going to be worked with is a network simulation program, NCTUns version 6.0, run on Linux Fedora 11, using protocol stacks and global variable initialization defined for 802.16 network nodes. On NCTUns, the behaviour of MMR WiMAX will be predicted without an actual network being present. The cross layer design methodology will be adapted using C programming in the IEEE 802.16j modules in NCTUns.

The Quality of Service (QoS) of this network is measured in terms of the network throughput an end-to-end delay of the network.

1.4 Objective

1) To propose an efficient approach for increasing the utilization of WiMAX relay through appropriate design of multi-hop routing and scheduling

2) To design the cross-layer optimization mechanism in IEEE 802.16j in order to increase the performance of mobile networks.

1.5 Thesis outline

This project report is divided into five chapters namely introduction, literature review, methodology, results and conclusion. Each chapter will discuss on different issues related to the project. Chapter 1 covers on the introduction where it explains the background of this project, objectives, scopes of project and the project report outline. Chapter 2 covers on the literature review of WiMAX Multihop Relay, Relay frame structure, cross layer design, path and relay selection in MMR WiMAX. It also covers some literatures researchers. Chapter 3 discusses the methodology of simulation and network performance. Chapter 4 consists of results and analysis of this project. In this chapter, all simulation results, measurement setup and measurement results are explained. Finally, the last chapter consists of conclusion and some future works to improve the quality of this project.

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