



UNIVERSITI PUTRA MALAYSIA

MODELING OF RELAY DEPLOYMENT IN MULTIHOP RELAY NETWORK

MILAD M. ALI SALIH AL-DOOGHACHI

FK 2014 57



MODELING OF RELAY DEPLOYMENT IN MULTIHOP RELAY NETWORK

By

MILAD M. ALI SALIH AL-DOOGHACHI

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in
Fulfillment of the Requirement for the Degree of Master of Science**

January 2014

COPYRIGHT

All material contained within the thesis, including without limitation text, logos, icons, photographs, and all other artwork, is copyright material of Universiti Putra Malaysia unless otherwise stated. Use may be made of any material contained within the thesis for non-commercial purposes from the copyright holder. Commercial use of material may only be made with the express, prior, written permission of Universiti Putra Malaysia.

Copyright© Universiti Putra Malaysia



DEDICATION

This thesis is especially dedicated to my dearest and precious father, my

compassionate mother, my brother and sisters

all of my friends

and to my beloved home land IRAQ



Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

MODELING OF RELAY DEPLOYMENT IN MULTIHOP RELAY NETWORK

By

MILAD M. ALI SALIH AL-DOOGHACHI

January 2014

Chairman: Associate Professor Alyani binti Ismail, Ph.D.

Faculty : Engineering

Worldwide interoperability for microwave access (WiMAX) system is becoming more popular to be a better choice to the DSL and cable broadband services and also supports point to multi point and mesh networks. However, the fixed and mobile networks have some inherent problems such as low (SNR) at the cell edge, as well as dead spot that exists due to signal transmission is often affected by geographic conditions, such as buildings in cities and underground environments, shadowing, which leads to non line-of-sight (NLOS) communication. Therefore, WiMAX multi-hop relay technology is a key enabler to meet the growing demand and requirements for a good coverage, while minimizing the wireless backhaul requirement to increase link capacity and throughput enhancement. The MMR scheme employs relay stations (RSs) to the coverage the dead spot or can be used to provide extended network deployments temporary for emergency circumstances or special events.

In this study, the performance of three hop relay network has been evaluated using the Amplify and Forward Relay (AF) and Non Amplify and Forward Relay (NAF) due to the ability of relay to provide better performance in short distance. In addition of the relay station effect on the performance of the network in different applications the three hop network in both cases was successfully evaluated to provide better link quality to subscribers and enhance the data rate of the system.

In this thesis, the author proposed an accurate noise modeling for WiMAX MMR network to enhance the system performance in terms of Signal-to-Noise Ratio (SNR) estimation procedure, channel assignments, link capacity and data rate were studied based on the simulation implicated using MATLAB software version 7.4 (R2007a).

The results show that the performance of system base on multi-hop relaying is one of the most promising technologies that provides a more cost-effective enhancement of coverage, user throughput (25% higher total in data rate), and provides a better link (22% higher total in link-capacity) quality to subscriptions when the RS adopts to amplify and forward (AF) scheme.

Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia untuk memenuhi keperluan ijazah Master Sains

PEMODELAN KERAHAN RELAY DALAM MULTIHOP RELAY RANGKAIAN

Oleh

MILAD M. ALI SALIH AL-DOOGHACHI

Januari 2014

Pengerusi: Profesor Madya Alyani binti Ismail, Ph.D.
Fakulti: Kejuruteraan

Keantarakendalian di seluruh dunia untuk sistem akses gelombang mikro (WiMAX) menjadi lebih popular untuk menjadi pilihan yang lebih baik kepada perkhidmatan jalur lebar DSL dan kabel dan juga menyokong titik ke pelbagai titik dan rangkaian mesh. Walau bagaimanapun, rangkaian tetap dan mudah alih mempunyai beberapa masalah yang wujud seperti rendah (SNR) di pinggir sel, serta tempat mati yang wujud disebabkan oleh isyarat penghantaran kerap dipengaruhi oleh keadaan geografi, seperti bangunan di bandar-bandar dan persekitaran bawah tanah, bayang yang membawa kepada komunikasi bukan barisan-penglihatan (NLOS). Oleh itu, teknologi gergasi WiMAX multi-hop adalah pemboleh utama untuk memenuhi permintaan yang semakin meningkat dan keperluan untuk perlindungan yang baik, di samping mengurangkan keperluan wayarles backhaul untuk meningkatkan kapasiti link dan peningkatan pemprosesan. Skim MMR menggunakan stesen gergasi (RSs) untuk liputan tempat yang mati atau boleh digunakan untuk menyediakan rangkaian lanjutan pembekalan sementara untuk keadaan kecemasan atau acara-acara khas. Prestasi sistem juga boleh diperbaiki apabila pelbagai-hop gergasi berkerjasama berasaskan teknik dieksploitasi. Teknik ini adalah pemprosesan menghantar data serentak melalui pelbagai laluan yang berbeza dan kemudian menggabungkan maklumat yang diterima.

Dalam kajian ini, prestasi tiga hop rangkaian 'relay' telah dinilai menggunakan Forward Relay (AF) dan Bukan menguatkan dan Forward Relay (NAF) disebabkan oleh keupayaan relay untuk memberikan prestasi yang lebih baik dalam jarak pendek. Di samping kesan stesen relay kepada prestasi rangkaian dalam aplikasi yang berbeza tiga rangkaian hop dalam kedua-dua kes telah berjaya dinilai untuk menyediakan kualiti link yang lebih baik kepada pelanggan dan meningkatkan kadar data sistem.

Dalam tesis ini, penulis mencadangkan satu kaedah pengiraan untuk rangkaian MMR WiMAX untuk meningkatkan prestasi sistem dari segi Nisbah Isyarat-Hingar (SNR) prosedur anggaran, tugas saluran, kapasiti link dan kadar data telah dikaji berdasarkan simulasi terbabit menggunakan MATLAB versi perisian 7.4 (R2007a).

Hasil kajian menunjukkan bahawa prestasi asas sistem pada multi-hop menyampaikan adalah salah satu teknologi yang paling menjanjikan serta menyediakan peningkatan yang lebih berkesan kos liputan, pemprosesan pengguna (jumlah 25% lebih tinggi kadar data), dan menyediakan pautan yang lebih baik (jumlah 22% lebih tinggi dalam pautan berkapasiti) berkualiti kepada langganan apabila RS pakai untuk menguatkan dan menggunakan (AF) skim.



ACKNOWLEDGEMENTS

First and foremost, I would like to thank the most gracious Allah for giving me the strength, patience, courage, and determination for completing this work, Alhamdulillah. All grace and thanks belongs to Almighty Allah. This works would not have been accomplished without the help of so many people. In the following lines is a brief account of some but not all who deserve to be thanked.

I would like to extend my gratitude to Dr. Alyani binti Ismail for her supervision, advice, and guidance from the very early stage of this research as well as giving me extraordinary experiences throughout the work. Above all and the most needed, she provided me unflinching encouragement and support in various ways. My deepest gratitude and appreciation also goes to Professor Dr. Nor Kamariah binti Noordin for her valuable comments and suggestions which have been indispensable in the preparation of this thesis. Her professional review helped me to further improve the thesis.

I acknowledge the role of my family in the accomplishment of this work. The prayers of my parents and support of my brother and sisters who have made all this possible. I truly appreciate the comrade of my friends in the lab and all around the world who made my life more lively and colorful (Ali Zuhair, Dr. Yassin, Yaaqop, Aws, Dr. Bashar, Assam, Mohammed, Alaa, Ali ...).

And finally, I would like to express my sincere gratitude to all those mention above who not only provided much needed time but also their continued support and inspiration which strengthened my pledge to overcome all obstacles in completing this task, and I dedicate this thesis to these people whom I love very much.

I certify that a Thesis Examination Committee has met on 15 January 2014 to conduct the final examination of Milad M. Ali Salih on his thesis entitled "Modeling of Relay Deployment in Multihop Relay Network" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Khairulmizam bin Samsudin, PhD

Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Aduwati binti Sali, PhD

Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Mohd Fadlee bin A Rasid, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Norsheila Fisal, PhD

Professor
Universiti Teknologi Malaysia
Malaysia
(External Examiner)



NORITAH OMAR, PhD

Associate Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 10 March 2014

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Alyani binti Ismail, Ph.D.

Associate Professor
Engineering
Universiti Putra Malaysia
(Chairman)

Nor Kamariah binti Noordin Ph.D.

Professor
Engineering
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, Ph.D.

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

Declaration by graduate student

I hereby confirm that:

- This thesis is my original work;
- Quotations, illustrations and citations have been duly referenced;
- This thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- Intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- Written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published in book form;
- There is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: 15 January 2014

Name and Matric No.: MILAD M. ALI SALIH AL DOOGHACHI (GS20962)

Declaration by Members of Supervisory Committee

This is to confirm that:

- The research conducted and the writing of this thesis was under our supervision;
- Supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____
Name of
Chairman of
Supervisory
Committee: _____

Signature: _____
Name of
Member of
Supervisory
Committee: _____

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	iv
ACKNOWLEDGEMENTS	vi
APPROVAL	vii
DECLARATION	ix
LIST OF TABLES	xiv
LIST OF FIGURES	xiv
LIST OF ABBREVIATIONS	xvii
LIST OF SYMBOLS	xx
CHAPTER	
1 INTRODUCTION	1
1.1 Background	1
1.2 Motivation	1
1.3 Problem Statement	2
1.4 Objectives	3
1.5 Study Module	3
1.6 Thesis Organization	5
2 LITERATURE REVIEW	6
2.1 Introduction	6
2.2 WiMAX Background	6
2.3 Overview of WiMAX Multi-hop Relay Networks	7
2.3.1 Overview of Relay Types	9
2.3.1.1 Decode and Forward	9
2.3.1.2 Amplify and Forward	9
2.3.1.3 compress and Forward	9

2.3.1.4 Adaptive Forwarding	9
2.3.2 LOS and NLOS WiMAX Environments	10
2.3.2.1 LOS	10
2.3.2.2 NLOS	10
2.3.3 Usage Models in 802.16j	11
2.4 Relaying Techniques	11
2.4.1 Time Domain Relaying	11
2.4.2 Frequency Domain Relaying	11
2.4.3 Hybrid Time/Frequency Domain Relaying	12
2.4.4 Cooperative Relaying Techniques	12
2.5 Challenges in Planning of Cellular Relay-based Networks	12
2.5.1 Relay Location	12
2.5.2 Path Selection	13
2.6 Characteristics of Relay-based Networks	14
2.6.1 Throughput Enhancement	14
2.6.2 Coverage Enhancement	15
2.7 Chapter Summary	16
3 METHODOLOGY	18
3.1 Introduction	18
3.2 System Description	18
3.2.1 Channel Model in IEEE 802.16j	19
3.2.1.1 Path-Loss Model (Large scale)	19
3.2.1.2 Small Scale Fading Model	21
3.2.1.3 Slow Fading Model	21
3.2.1.4 log Normal Shadowing Model	22
3.2.1.5 WINNER Model	22
3.2.1.6 Multipath Model	22
3.2.1.7 Noise Calculation	23
3.2.1.8 Additiianve White Gassian Noise (AWGN)	23
3.2.2 System model for Amplify and Forward (AF)	23
3.2.2.1 Channel Gain	24
3.2.2.1.1 LOS link	24
3.2.2.1.2 NLOS link	24

3.2.2.2	Direct link scenario	25
3.2.2.3	One relay scenario	25
3.2.2.4	Two relays scenario	27
3.2.1	System model for NonAmplify and Forward (NAF)	29
3.3	Summary	38
4	RESULTS AND DISCUSSION	39
4.1	Introduction	39
4.2	Performance Parameters	39
4.3	Performance Evaluation	39
4.4	Channel Model	40
4.4.1	Path Loss Model	41
4.4.2	Log-normal Shadowing Model	41
4.5	Simulation Configuration	41
4.5.1	Multi-hop Relaying in IEEE 802.16j under the AF relay mode	41
4.5.2	Multi-hop Relaying in IEEE 802.16j under the NAF relay mode	58
4.6	Summary	65
5	CONCLUSIONS	66
5.1	Conclusion of Research	66
5.2	Recommendations For Future Research	66
	REFERENCES	67
	APPENDIX A	72
	APPENDIX B	74
	APPENDIX C	75
	BODATA OF STUDENT	79