UNIVERSITI PUTRA MALAYSIA

EFFICIENT SIGNALING SCHEDULE FOR CENTRALIZED AND DISTRIBUTED SCHEDULING ALGORITHMS FOR WIMAX MULTI-HOP RELAY NETWORKS

AHMAD SABRI MOUSA SAQER

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By

AHMAD SABRI MOUSA SAQER

Thesis Submitted to the School of Graduate Studies, University Putra Malaysia,

in Fulfillment of the Requirements for Degree of Doctor of Philosophy

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DEDICATION

قال تعالى:

((وَوَصَّيْنَا الإِنسَانَ بِوَالِدَيْهِ حَمَلَتْهُ أُمُّهُ وَهْناً عَلَى وَهْنٍ وَفِصَالُهُ فِي عَامَيْنِ أَنْ اشْكُرْ لِي وَلِوَالِدَيْكَ إِلَيَّ الْمَصِيرُ))

لقمان 14

This thesis is dedicated to:

my beloved parents,

my dearest wife and daughter who have waiting for me for a long time,

my brothers and sisters,

my parents, brother and sisters in-laws

all of my friends

and to my beloved home land Jordan.

ABSTRACT

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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December 2011

Chairman: Raja Syamsul Azmir bin Raja Abdullah, PhD

Faculty: Engineering

The Institute of Electric and Electronic Engineers (IEEE) 802.16j standard uses relay station to extend coverage and enhance throughput for remote users at the base station. The IEEE 802.16 standards specify services and how the transmissions should occur. However, the way how to run these services and when the transmission should be started are the task of scheduling algorithms which are not specified in the IEEE 802.16 standards. The IEEE standards left the design of scheduling algorithms open for the manufacturers. However, the scheduler is a very important component in wireless systems and the scheduling period presents the most common challenging issue in terms of time delay. This thesis presents new scheduling algorithms; centralized and distributed scheduling algorithms, for the WiMAX Multihop Relay (MR) Networks taking into account the bandwidth allocation signaling scheme for both the centralized and distributed scheduling modes. The proposed algorithms aim at making the MR

network auto-configurable and flexible through reducing overhead and improving the network throughput. The proposed algorithms were also customized to produce signaling with less time delay over relay-link.

In order to evaluate the proposed algorithms and validate their efficiency for IEEE 802.16j networks, the authors simulated the algorithms in QualNet simulator. Evaluation of the proposed centralized scheduling algorithm (MR-CSA) was carried out through comparing its performance with those of the Round Robin and the centralized pairing algorithms. On the other hand, the proposed distributed scheduling algorithm (MR-DSA) was evaluated by comparing its performance against performances of Greedy and the factor-graph-based low-complexity distributed scheduling algorithm (FGDS) algorithms in terms of delay, throughput, and overhead. Validation of the proposed algorithm (MR-CSA) was based on comparison of its performance with the performance of the centralized pairing algorithm while the proposed MR-DSA algorithm was validated through comparing its performance against that of the factor-graph-based low-complexity distributed scheduling algorithm (FGDS) algorithms in terms of throughput and the average packet throughput. The simulation results highlighted that the proposed algorithms (MR-CSA and MR-DSA) outperform all previous algorithms with the current signaling scheme. The proposed algorithms achieve higher performance in terms of end-to-end delay, throughput, overhead, link utilization, and fairness index than all other algorithms.

ABSTRAK

Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master of Science

PENJADUALAN PROSEDUR PENGIRAAN TERPUSAT DAN TERAGIHKAN UNTUK PELBAGAI LALUAN PENGHANTARAN DALAM JARINGAN WIMAX

Oleh

AHMAD SABRI MOUSA SAQER

Disember 2011

Pengerusi: Raja Syamsul Azmir bin Raja Abdullah, PhD

Fakulti: Kejuruteraan

Standard piawaian 802.16j Institut Jurutera Elektrik dan Elektronik (Institute of Electric and Electronic Engineers (IEEE)) menggunakan stesen penghantar untuk meluaskan liputan dan seterusnya meningkatkan jumlah penghantaran bagi pengguna pengguna terpencil di stesen pengkalan. Standard piawaian IEEE 802.16 menentukan jenis perkhidmatan dan cara bagaimana penghantaran tersebut sepatutnya berlaku. Walau bagaimana pun, cara bagaimana perkhidmatan ini dilakukan dan bilakah masa yg sepatutnya penghantaran bermula merupakan tugas bagi penjadualan prosedur pengiraan. Ini kerana penjadualan ini tidak ditentukan dalam standard piawaian IEEE 8012.6. Standard piawaian IEEE meninggalkan reka bentuk prosedur pengiraan berjadual kepada para pihak pengeluar. Akan tetapi, susunan acara merupakan komponen yang terpenting dalam system tanpa wayar dan tempoh masa bagi penjadualan merupakan isu yang paling mencabar dalam soal masa dan penangguhan

masa. Tesis ini membentangkan prosedur pengiraan berjadual yang baru iaitu pemusatan dan jadual penyebaran prosedur pengiraan untuk menghantarnya dalam pelbagai laluan penghantaran (Multihop Relay (MR)) bagi jaringan WIMAX. Justeru, ia mengambil kira lebar jalur pemberi isyarat yang diperuntukkan bagi cara pemusatan dan cara penyebaran terjadual. Matlamat prosedur pengiraan yang dicadangkan ini adalah untuk melaksanakan rangkaian MR yang tersusun dengan sendirinya dan fleksibel melalui pengurangan lebihan muatan dan memperbaiki jumlah penghantaran jaringan. Prosedur pengiraan yang dicadangkan ini juga disesuaikan bagi menghasilkan pemberian isyarat dengan pengurangan pertangguhan masa berbanding pautan pemberian dan penerimaan isyarat.

Bagi menilai prosedur pengiraan yang dicadangkan dan memperakiu kecekapan perlaksanaanya dalam rangkaian IEEE 802.16j, penulis mensimulasikan prosedur pengiraan menggunakan pensimulasi QualNet. Penilaian bagi penjadualan prosedur pengiraan terpusat yang dicadangkan dilaksanakan dengan cara membandingkan hasil prestasinya dengan Round Robin dan pasangan prosedur pengiraan terpusat. Dalam pada itu, pengagihan penjadualan prosedur terpusat (MR-DSA) dinilai dengan cara membandingkan kecekapannya melawan kecekapan Greedy dan graf faktor kerumitan rendah dalam pengagihan penjadualan prosedur pengiraan (FGDS). Ini berkaitan dengan soal penangguhan dari satu penghujung ke penghujung seterusnya, daya pemprosesan dan lebihan muatan. Pengesahan prosedur pengiraan yang dicadangkan adalah berasaskan kepada pembandingan hasil prestasinya dengan prestasi bagi penjadualan prosedur terpusat. Dalam pada itu, prosedur pengiraan MR-DSA yang dicadangkan telah ditentu sahkan melalui perbandingan prestasinya melawan graf

faktor kerumitan rendah dalam pengagihan penjadualan prosedur pengiraan (FGDS). Ia meliputi persoalan berkaitan daya pemprosesan dan purata pemprosesan paket data. Keputusan simulasi menekankan bahawa algoritma yang dicadangkan (MR-CSA dan MR-DSA) bersesuaian dengan semua algoritma yang terdahulu dengan skim isyarat semasa. Algoritma yang dicadangkan telah mencapai prestasi yang lebih tinggi dari segi kelewatan akhir-ke-hujung, throughput, overhead, penggunaan link, dan indeks keadilan daripada semua algoritma yang lain.

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In the final note, I would like to extend my sincere thanks to all and sundry, who helped me in one way or other, but whose names I have not been able to mention one by one.

Always and forever, thank you Allah.

APPROVAL

I certify that a Thesis Examination Committee has met on (**08 Dec 2011**) to conduct the final examination of (AHMAD SABRI MOUSA SAQER) on his thesis entitled "**Efficient Signaling Schedule for Centralized and Distributed Scheduling Algorithms for WiMAX Multi-Hop Relay Networks**" 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 (Doctor of Philosophy degree).

Members of the Thesis Examination Committee were as follows:

Abdul Rahman b. Ramli, PhD
Associate Professor
Faculty of Engineering
(Chairman)

Mohd. Fadlee b. A.Rasid, PhD
Associate Professor
Faculty of Engineering
(Internal Examiner)

Mohamed Othman, PhD
Professor
Faculty of Computer Science and Information Technology
(Internal Examiner)

Lawrence Wong, PhD
Professor
Department of Electrical and Computer Engineering
National University of Singapore
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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

Raja Syamsul Azmir b. Raja Abdullah, PhD

Associate Professor
Faculty of Engineering
University Putra Malaysia
(Chairman)

Borhanuddin B. Mohd. Ali, PhD

Professor
Faculty of Engineering
University Putra Malaysia
(Member)

Nor Kamariah Noordin, PhD

Associate Professor
Faculty of Engineering
University Putra Malaysia
(Member)

BUJANG KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia
Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

AHMAD S. M. SAQER

Date: 27 April 2012

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