



UNIVERSITI PUTRA MALAYSIA

***INTERFERENCE AVOIDANCE ROUTING AND SCHEDULING USING
MULTIPLE TRANSCEIVERS FOR IEEE 802.16 MESH NETWORK***

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MULTIPLE TRANSCIEVERS FOR IEEE 802.16 MESH NETWORK**

By

YAAQOB ALI AHMED QASEM

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

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قال تعالى:

((وَوَصَّيْنَا الْإِنْسَانَ بِوَالِدَيْهِ حَمَلَتْهُ أُمُّهُ وَهْنًا عَلَىٰ وَهْنٍ وَفِصَالَهُ فِي شَأْمٍ أَنَّ اشْكُرْ لِي وَلِوَالِدَيْكَ إِلَيَّ الْمَصِيرُ))

لنعمان 14

Dedicated to

To the most Merciful Allah S.W.T

*To my dearest parents (Ali Alrefaei and Fatima Alrefaei),
who are simply the best parents of all time*

To my wife for your love, your loyalty, and your support

*To my lovely sons (Sohaib, Haitham and Ali)
for being near when I needed you*

To my brothers (Ahmed, Mohammed, Luqman, Malik, Safwan)

*And to my sisters for their extraordinary love,
their endless care and encouragement*

Thank you

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

**INTERFERENCE AVOIDANCE ROUTING AND SCHEDULING USING
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By

YAAQOB ALI AHMED QASEM

November 2010

Chair: Nor Kamariah Noordin, PhD

Faculty: Engineering

Demand for broadband access networks has grown rapidly with the increased demand for Internet connectivity and multimedia services. Fixed broadband wireless access systems based on the IEEE 802.16 standard defines the wireless broadband access technology called WiMAX (Worldwide Interoperability Microwave Access), which introduces several interesting advantages including variable and high data rate, last mile wireless access, mesh and point to multipoint communication, large frequency range and QoS (Quality of Service) for various types of applications.

Optimization of routing and link scheduling has recently become one of the leading research trends in wireless mesh networks. In centralized scheduling for IEEE 802.16 mesh networks, all packets should be transported through the Base Station (BS). The

links to or from the BS become the system's bottleneck and the throughput is heavily impacted by the interference.

This thesis presents an Energy/bit Minimization routing and centralized scheduling algorithms (EbMR-CS) using multi-transceiver and multi-channel for IEEE 802.16-2004 mesh networks. Here, a routing tree is constructed based on the energy/bit minimization routing (EbMR). This algorithm looks for a short path from the subscriber station (SS) node to BS, while the optimal path is achieved when the whole path has the lowest EbMR. After the route is fixed, and the traffic demanded at each node is known, the total traffic arriving at a node is centrally scheduled such that the transmission interferences can be avoided. The proposed algorithm has considered some important design metrics such as fairness, reuse timeslot, balanced load, concurrent transmissions and hop count. These algorithms have two advantages: first, they avoid the collision with neighbouring nodes. Avoiding collision, scheduled transmissions have much higher throughput than what is possible with previous approaches. Secondly, the algorithms reduce the length of scheduling, increase the channel utilization ratio (CUR) and improve the throughput of the system. The results from the single and multi-transceiver systems showed that the algorithm reduced the length of scheduling up to 43% in the multi-transceiver system and 23% in single-transceiver system. Moreover, the channel utilization ratio (CUR) is found to be improved up to 45% in the multi-transceiver system and up to 19% in single-transceiver system. In addition, the proposed algorithm improved the system throughput up to 68% in the multi-transceiver system and 28% in the single-transceiver system.

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

**PELBAGAI PENGHANTAR-TERIMA YANG BERASASKAN
PENGELAKAN GANGGUAN BAGI LALUAN DAN PENJADUALAN
RANGKAIAN JARINGAN IEEE 802.16**

Oleh

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Permintaan untuk rangkaian akses broadband telah berkembang pesat sejajar dengan peningkatan permintaan sambungan internet dan perkhidmatan multimedia. Sistem akses wayarles jalur lebar berdasarkan standard IEEE 802.16 yang digelar WiMAX (*Worldwide Interoperability Microwave Access*) telah mendefinisikan teknologi akses wayarles jalur lebar. Ia memperkenalkan beberapa kelebihan yang menarik termasuk kadar data boleh ubah serta kadar data tinggi, jarak akses wayarles paling jauh, komunikasi mesh dan *point-to-multipoint*, julat frekuensi yang besar dan Kualiti Servis; QoS (*Quality of Service*) untuk pelbagai jenis aplikasi.

Pengoptimuman penghalaan dan penjadualan pautan kini menjadi salah satu trend penyelidikan yang utama dalam rangkaian wayarles mesh. Dalam penjadualan terpusat untuk rangkaian mesh IEEE 802.16, semua pakej perlu diangkut melalui Stesen Pangkalan; BS (*Base Station*). Pautan ke atau dari sistem BS menjadi rintangan kepada sistem dan daya pemprosesan amat dipengaruhi oleh gangguan.

Tesis ini mempersembahkan algoritma – algoritma peminimuman penghalaan Tenaga/bit dan penjadualan terpusat (EbMR-CS) menggunakan multi-penghantar terima dan multi-saluran untuk rangkaian mesh IEEE 802.16-2004. Di sini, pohon penghalaan dibina berdasarkan peminimuman penghalaan Tenaga/bit (EbMR). Algoritma ini mencari laluan terpendek dari nod Stesen Pelanggan;SS (*Subscriber Station*) ke BS, manakala laluan optimum dicapai apabila keseluruhan laluan mempunyai EbMR terendah. Setelah laluan ditetapkan serta lalu lintas yang diminta pada setiap nod diketahui, maka jumlah keseluruhan lalu lintas yang tiba di sebuah nod dijadualkan terpusat sehingga gangguan penghantaran boleh dielakkan. Algoritma yang dicadangkan telah mempertimbangkan beberapa metrik penting seperti kesaksamaan, penggunaan kembali celah masa, beban yang seimbang, penghantaran serentak dan kiraan lompatan. Algoritma ini memiliki dua kelebihan. Pertama, mengelakkan pertembungan dengan nod bersebelahan. Dengan menghindari pertembungan, penghantaran berjadual mempunyai daya pemprosesan jauh lebih tinggi daripada apa yang mungkin dengan pendekatan sebelumnya. Kedua, algoritma mengurangkan julat penjadualan, meningkatkan nisbah penggunaan saluran; CUR (*Channel Usage Ratio*) dan meningkatkan daya pemprosesan sistem. Hasil dari sistem penghantar terima tunggal dan sistem multi-penghantar terima menunjukkan bahawa algoritma mengurangkan julat penjadualan hingga 43% pada sistem multi-penghantar

terima dan 23% sistem penghantar terima tunggal. Selain itu, nisbah penggunaan saluran (CUR) memperlihatkan peningkatan sehingga 45% pada sistem multi-penghantar terima dan peningkatan 19% sistem penghantar terima tunggal. Selain itu, algoritma ini meningkatkan daya pemrosesan sistem hingga 68% pada sistem multi-penghantar terima dan 28% buat sistem penghantar terima tunggal.



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I certify that a Thesis Examination Committee has met on 25th November 2010 to conduct the final examination of Yaaqob Ali Ahmed Qasem on his master of science thesis entitled “Interference Avoidance Routing and Scheduling Using Multiple Transceivers for IEEE 802.16 Mesh 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 degree of Master of Science.

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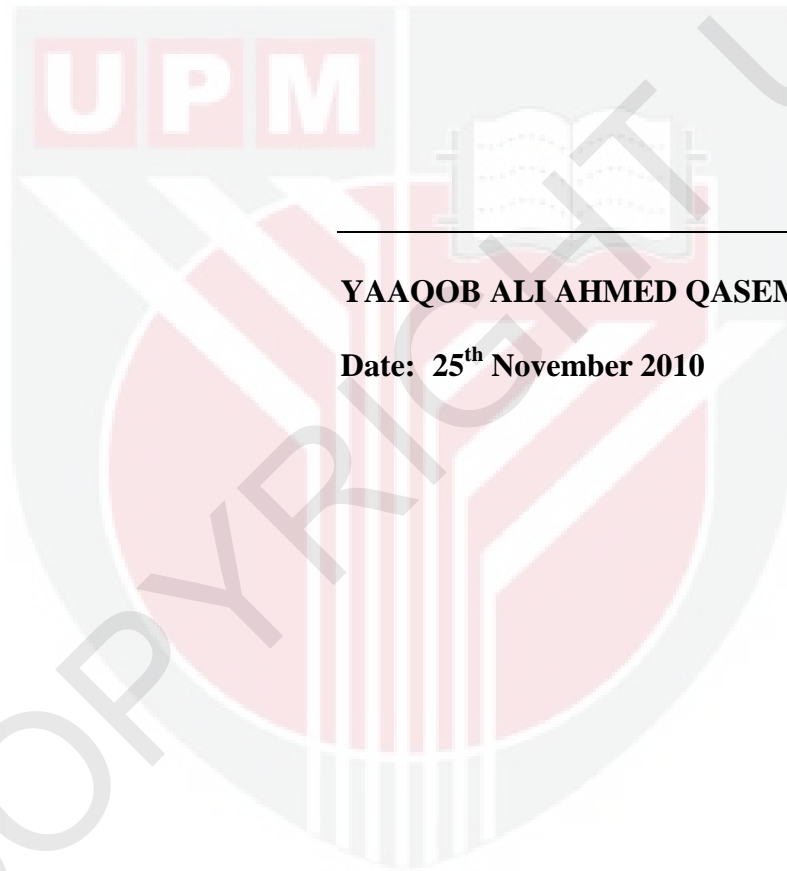
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DECLARATION

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 institution.



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