



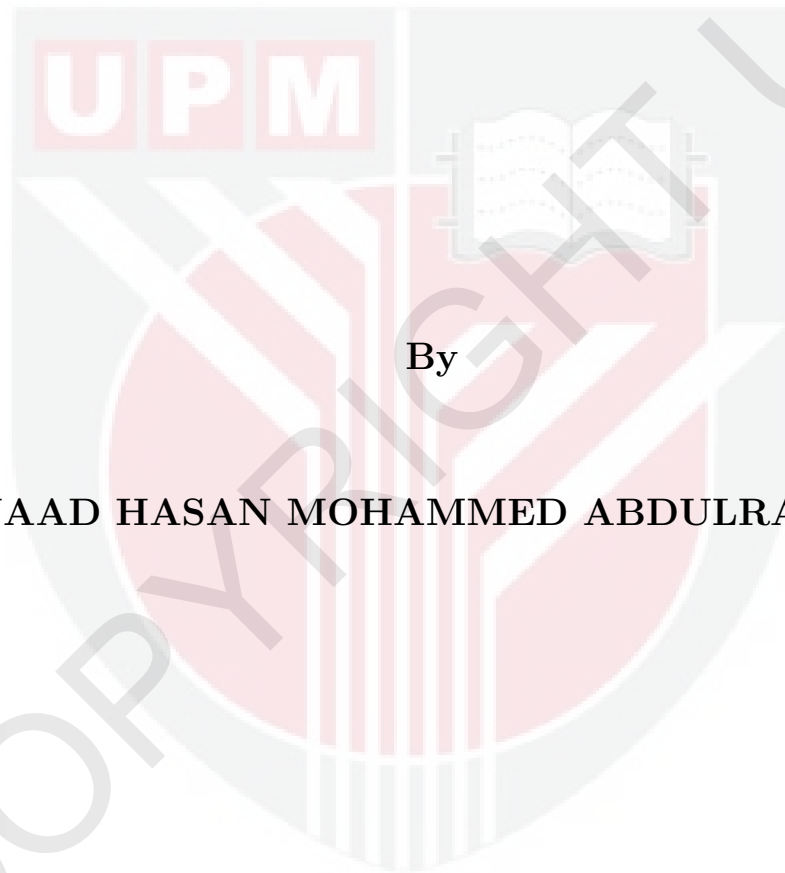
**UNIVERSITI PUTRA MALAYSIA**

***RESOURCE MANAGEMENT ALGORITHMS FOR  
WAVELENGTH DIVISION MULTIPLEXING  
OPTICAL METRO SLOTTED RING NETWORKS***

**FUAAD HASAN MOHAMMED ABDULRAZZAK**

**FSKTM 2012 14**

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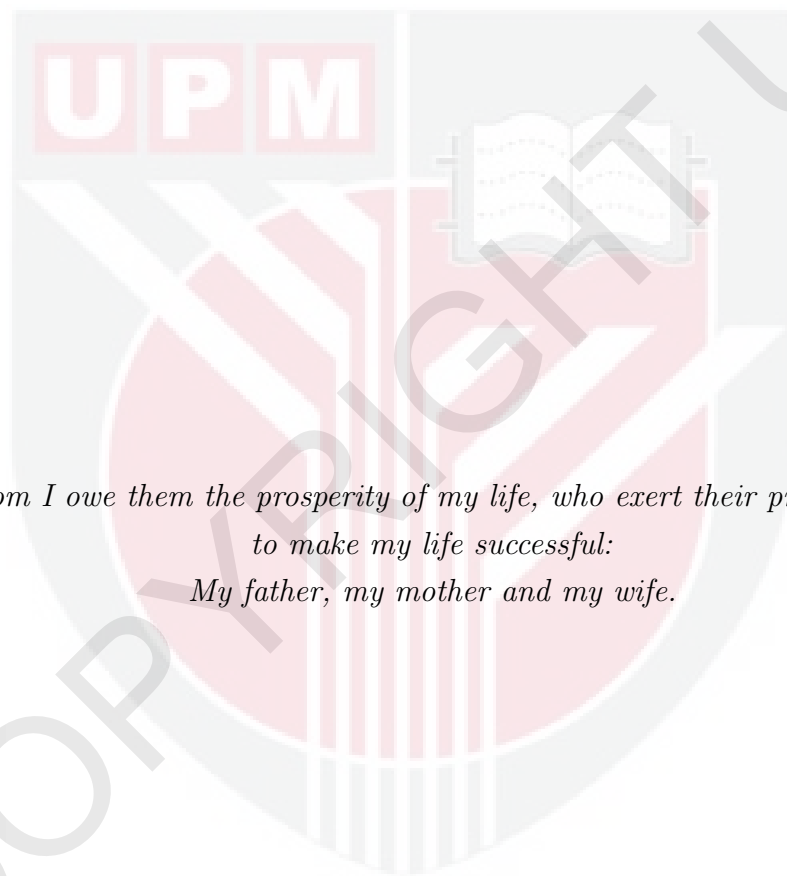


By

**FUAAD HASAN MOHAMMED ABDULRAZZAK**

Thesis Submitted to the School of Graduate Studies, Universiti  
Putra Malaysia in Fulfilment of the Requirements for the Degree of  
Doctor of Philosophy

February 2012



*To whom I owe them the prosperity of my life, who exert their precious effort  
to make my life successful:  
My father, my mother and my wife.*

Abstract of 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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**February 2012**

**Chair: Assoc. Prof. Shamala Subramaniam, PhD**

**Faculty: Computer Science and Information Technology**

The performance of the optical packet ring is highly dependent on the method of resource sharing deployed. In addition, the increase in demand of bandwidth by web applications relying on multicasting has made optical fibers a preferred solution. Therefore, fair sharing with collision avoidance have to be ensured when MAC protocols are designed. The most promising technology for the optical network development is the optical packet switched (OPS) WDM networks designed for the Metropolitan Area Networks (MANs). In addition, Hybrid Optoelectronic Ring NETWORK (HORNET) and High-performance Optical-Packet-Switched Metro Area Network (HOPSMAN) ring architectures, have been studied as a next generation platform for MANs in this research. These architectures employ a separate wavelength as the control information channel. This control information enables the nodes to monitor their access to the transmission media. Each node is equipped with a tuneable transmitter and fixed/tuneable receiver for the purpose of data communication. Access nodes

are equipped with a fixed transmitter and fixed receiver for the control information exchange. In this research, the management of the shared network resources has been researched extensively with the intention to enhance the performance of the network and overcome the MAC protocols related limitations. Among the pertinent issues addressed are the network under utilized resources, the best-than-average access for the upstream nodes in the network, the existence of misbehaving nodes and the partiality towards homogeneous traffic. Buffers and network bandwidth are the main resources analysed, where their consumptions have been enhanced in the aim of ensuring fairness and QoS support. This research presents novel algorithms to enhance the performance of the Wavelength Division Multiplexing (WDM) dual ring network. The proposed Enhanced Virtual Output Queues Management (EVOQM) algorithm provides an elevated fairness for unicast and multicast data in the network. In addition, it is able to provide provision which are extended for QoS support. The Dynamic Based Bandwidth Reservation (DBBR) algorithm is designed to ensure that fair bandwidth access for both upstream and downstream nodes are achieved. The proposed DBBR aims also to prevent misbehaving (i.e. malicious) nodes from affecting the network performance. The third proposed algorithm which is the Dynamic Scaling Bandwidth Reservation (DSBR) has been proposed to enhance the bandwidth utilization in HOPSMAN slotted WDM ring architecture. HOPSMAN considers a minimum of at least one node as a server node in unidirectional ring HORNET architecture with tuneable receiver at each node in the network. This proposed algorithm optimizes a collaborative resource management strategy with traffic heterogeneity to enhance the utilization of network resources and ensures the requested QoS pre-requisites are guaranteed. The realization of these strategies have been achieved and

displayed by the reduction of packet loss (i.e. maximizing the total value of transferred packets) in the network. Thus, leading to the improvement of the throughput while adhering to the delay pre-requisites. The performance evaluation of the proposed algorithms has been done through a detailed and extensive discrete-event-simulation analysis. Metrics of network throughput, packet loss and delay measures, have been the main basis for the acquired results.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**ALGORITMA PENGURUSAN SUMBER UNTUK RANGKAIAN  
PANJANG GELOMBANG PEMULTIPLEKSAN OPTIKAL  
METRO SLOT CINCIN**

Oleh

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Prestasi cincin paket optik amat bergantung kepada kaedah perkongsian sumber yang digunakan. Di samping itu, peningkatan jumlah permintaan untuk sumber jalur lebar oleh aplikasi web yang bergantung kepada multicasting telah membuat gentian optik sebagai salah satu kaedah penyelesaian yang terpilih. Oleh itu, perkongsian yang adil serta yang mengelakkan perlanggaran perlu dipastikan dalam proses merekabentuk protokol pencapaian media. Suis Gentian Optik (OPS) Pemultipleksan Pembahagi Panjang Gelombang (WDM) merupakan di antara pilihan utama rangkaian yang direka untuk Rangkaian Kawasan Metropolitan (MAN). Di samping itu, HORNET dan cincin seni bina HOPSMAN, telah dikaji dalam penyelidikan ini sebagai platform generasi akan datang untuk MAN. Seni bina tersebut menggunakan panjang gelombang yang berasingan sebagai saluran maklumat kawalan. Maklumat kawalan ini membolehkan nod untuk memantau akses mereka kepada media penghantaran. Setiap nod dilengkapi dengan pemancar dan penerima tuneable tetap

/ tuneable untuk tujuan komunikasi data. Nod akses dilengkapi dengan pemancar tetap dan penerima tetap bagi pertukaran maklumat kawalan. Dalam penyelidikan ini, pengurusan sumber-sumber rangkaian yang dikongsi telah dikaji secara meluas dengan niat untuk meningkatkan prestasi rangkaian dan mengatasi batasan protokol MAC. Antara isu terpenting yang perlu ditangani adalah penggunaan sumber rangkaian yang tidak digunakan, akses yang terbaik berbanding dengan purata bagi nod hulu dalam rangkaian, kewujudan nod berkelakuan tidak senonoh dan pengurusan yang berat sebelah ke arah lalu lintas homogen. Baris gilir dan jalur lebar rangkaian adalah sumber utama yang dianalisis, di mana penggunaan sumber tersebut telah dipertingkatkan dengan tujuan untuk memastikan keadilan dan sokongan QoS. Kajian ini membentangkan dua algoritma novel untuk meningkatkan prestasi rangkaian cincin WDM. Algoritma yang dicadangkan iaitu Pengurusan Baris gilir Maya yang ditingkatkan (EVOQM) memastikan pengurusan yang adil untuk data unicast dan multicast dalam rangkaian. Selain itu, ia dapat menyediakan peruntukan yang diperlukan bagi menyokong QoS. Skema Bandwidth Dinamik Berdasarkan Tempahan (DBBR) telah direka untuk memastikan akses jalur lebar yang adil bagi kedua-dua nod hulu dan hiliran. Algoritma yang dicadangkan bertujuan adalah juga untuk mencegah kelakuan yang tidak senonoh yang dilakuoleh sesebuah nod. Algoritma ketiga yang dicadangkan adalah Scaling Dynamic Bandwidth Reservation (DSBR) dan digunakan untuk meningkatkan penggunaan jalur lebar dalam senibina cincin slotted HOPSMAN WDM. HOPSMAN menganggap sekurang-kurangnya satu nod adalah pelayan dalam senibina cincin satu arah Hornet dengan penerima tuneable di setiap nod dalam rangkaian. Algoritma yang dicadangkan mengoptimumkan sumber melalui kerjasama strategi pengurusan dengan kepelbagaian trafik un-



tuk meningkatkan penggunaan sumber rangkaian serta memastikan pra-syarat permintaan QoS dijamin. Pencapaian strategi ini telah dicapai dan dibuktikan melalui pengurangan kehilangan paket (iaitu memaksimumkan jumlah nilai yang diperolehi oleh paket yang dipindahkan) dalam rangkaian. Justeru, mendapatkan peningkatan prestasi di samping mematuhi prasyarat kelambatan. Penilaian prestasi algoritma yang dicadangkan telah dilakukan secara terperinci dan meluas melalui simulasi diskret-acara. Metrik daya pemrosesan rangkaian, kehilangan paket dan pengukuran kelambatan telah menjadi asas utama bagi keputusan yang diperolehi.

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I certify that a Thesis Examination Committee has met on 3 February 2012 to conduct the final examination of Fuaad Hasan Mohammed Abdulrazzak on his thesis entitled "Resource Management Algorithms For Wavelength Division Multiplexing Optical Metro Slotted Ring 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.

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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 University Putra Malaysia or at any other institution.

Fua'ad Hasan Mohammed Abdulrazzak

Date:

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