

UNIVERSITI TEKNOLOGI MARA

**LAST THROUGHPUT AND
QUALITY-OF-SERVICE AWARE
(LTQA) SCHEDULING ALGORITHM
IN LONG TERM EVOLUTION (LTE)
FEMTOCELL NETWORK**

MUHAMMAD NAQUIDDIN BIN SAHRANI

Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Electrical Engineering)

College of Engineering

May 2022

ABSTRACT

The growing demands toward the indoor LTE networks has provide new challenges to the operators where Quality of Experience (QoE) as perceived by the end user needs to be provisioned. There are several shortcomings that need to be overcome such as the network signal from eNodeB that cannot fully penetrate the building. Moreover, the increasing number of users inside the building also degrades the network performance. One of the solutions is by deploying femtocell where it can help to improve the performance of the eNodeB in terms of capacity and signal. This thesis proposed an algorithm, namely, Last Throughput and Quality-Of-Service Aware (LTQA) that helps to improve the throughput performance for Non-Real-Time (NRT) service and allocate the resources fairly among the users in the macrocell and femtocell network. The LTQA algorithm works by comparing the previous and current throughput in the frequency domain scheduler to determine the metric to be used in order to choose the suitable flows to be allocated. A non-sharing type of resource allocation is deployed in order to avoid interference when allocating the resources among the macrocell and the femtocells user's using the ratio of 1:1. To gauge the efficacy of the LTQA algorithm, several scheduling algorithms, namely, Proportional Fairness (PF), Priority Set Scheduler (PSS), Blind Equal Throughput (BET), Maximum Throughput (MT) and Channel and QoS Aware (CQA) is compared against LTQA. The simulation of the scheduling algorithm was conducted using NS-3 and the performance of these packet scheduling algorithms was evaluated based on the performance metrics of throughput, delay, PLR and fairness for the VoIP, video and FTP applications. It can be concluded that LTQA scheduler outperformed the other algorithms as it could achieve 80.89% and 85.28% throughput improvement, 49.9% and 51.01% decrease in PLR for the NRT traffic in the femtocell and macrocell networks respectively. In terms of fairness, the algorithm could accomplish up to 8.97% and 14.14% increase for the femtocell and macrocell network respectively using the Jain's Fairness index. Thus, it can be concluded that LTQA algorithm is the best candidate that could ensure fairness to the user in the multitier network environment.

ACKNOWLEDGEMENT

Firstly, I wish to thank God for giving me the opportunity to embark on my PhD and for completing this long and challenging journey successfully. My gratitude and thanks goes to my supervisor Assoc. Prof. Ir. Dr. Darmawaty Mohd Ali.

My appreciation goes to Faculty of Electrical Engineering who provided the facilities and assistance during sampling. Special thanks to my colleagues and friends for helping me with this study.

Finally, this thesis is dedicated to my father and of my very dear late mother for the vision and determination to educate me. This piece of victory is dedicated to both of you.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iv
ABSTRACT	v
ACKNOWLEDGEMENT	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF SYMBOLS	xv
LIST OF ABBREVIATIONS	xvii
CHAPTER ONE INTRODUCTION	1
1.1 Introduction	1
1.2 Flow Chart of The Research	4
1.3 Problem Statement	5
1.4 Objectives	6
1.5 Contribution of the Study	6
1.6 Limitation of the Study	7
1.7 Thesis Layout	8
CHAPTER TWO LITERATURE REVIEW	9
2.1 Introduction	9
2.2 Small Cells	9
2.3 LTE Femtocell: Network Architecture	12
2.3.1 Scheduling Algorithm in LTE	15
2.4 Review on Femtocells	39
2.4.1 QoS Management	40
2.4.2 Interference Management	41
2.4.3 Radio Resource Utilization	41
2.4.4 Fairness	42

2.5	Scheduling Algorithm in LTE/LTE-A Femtocell Network	43
2.6	Summary	48
CHAPTER THREE LAST THROUGHPUT-BASED AND QUALITY-OF-SERVICE AWARE (LTQA) SCHEDULING ALGORITHM		49
3.1	Introduction	49
3.2	Flow Chart of the LTQA Scheduling Algorithm	51
3.3	Time Domain (TD) in LTQA Algorithm	53
	3.3.1 Time Domain (TD) in Network Simulator-3 (NS-3)	54
3.4	Frequency Domain (FD) Scheduler in LTQA	56
	3.4.1 Frequency Domain (FD) In Network Simulator-3 (NS-3)	58
3.5	Summary	66
CHAPTER FOUR RESEARCH METHODOLOGY		67
4.1	Introduction	67
4.2	Network Simulation-3 (NS-3)	67
4.3	Basic Flow Chart of NS-3	70
4.4	Voip Traffic Flow	72
4.5	Video Traffic Flow	73
4.6	File Transfer Protocol (FTP) Traffic Model	73
4.7	Simulation Parameters	74
	4.7.1 General Parameters	76
	4.7.2 Macrocell Parameters	76
	4.7.3 Femtocell Parameters	77
4.8	Flow Chart of LTE Dual Stripe Network Simulator	78
4.9	Structure of LTE-Dual Stripe NS-3 Configuration	79
	4.9.1 LTE Configuration	79
	4.9.2 Evolved Packet Core (EPC) Configuration	95
4.10	Summary	111
CHAPTER FIVE RESULTS AND DISCUSSION		112
5.1	Introduction	112
5.2	Femtocells Environment	115