AN ADMISSION CONTROL METHOD FOR IEEE 802.11e CONTENTION ACCESS MECHANISM

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To my parents, siblings and Angeline

for their love and support to make the journey

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ABSTRACT

IEEE 802.11 Wireless Local Area Network (WLAN) is a shared medium communication network that transmits information over wireless links for all 802.11 stations in its transmission range. With the applications over 802.11 WLAN increasing, customers demand more and more new features and functions. The support of audio, video, real-time voice over IP and other multimedia applications over 802.11 WLAN with Quality of Service (QoS) requirements is the key for 802.11 WLAN to be successful in multimedia home networking and future wireless communications. Recently, the IEEE 802.11 task group e specified a distributed access approach, called Enhanced Distributed Channel Access (EDCA), which supports service differentiation in the Medium Access Control (MAC) layer. It ensures the packets sent by each mobile station can be differentiated by assigning different access parameters. However, no assurance can be given to higher priority traffic in terms of throughput and delay performance. The problem is especially apparent when the wireless channel is overloaded causing the bandwidth share of each flow to diminish. Admission control is the solution for the problem addressed above. In this research, a simple measurement based admission control method is proposed to enhance the QoS of EDCA network when it is heavily loaded. The proposed method can control the number of allowed wireless stations in the WLAN network without degrading the QoS (medium access delay and throughput) of the existing flows under a high load condition. Several QoS parameters such as delay and throughput are analyzed to investigate the performance of the proposed method. The simulation is done using Network Simulator ns-2 to study the QoS. The results have shown that the proposed method can protect the QoS of high priority applications and at the same time sacrificing the QoS of low priority flow at a moderate level.

ABSTRAK

Rangkaian Setempat Wayerles (WLAN) IEEE 802.11 merupakan satu rangkaian komunikasi dengan perkongsian medium yang menghantar maklumat melalui laluan wayerles di antara semua stesen IEEE 802.11 yang berada dalam jarak penghantaran dan penerimaan. Keupayaan untuk menyokong aplikasi audio, video, suara melalui IP (VoIP) dan aplikasi multimedia lain yang memerlukan jaminan kualiti perkhidmatan (QoS) adalah kriteria penting untuk mempopularkan Rangkaian Setempat Wayerles IEEE 802.11. Kumpulan Tugas e di bawah IEEE 802.11 menyediakan piawaian untuk meningkatkan kualiti perkhidmatan (QoS) dalam Rangkaian Setempat Wayerles. Salah satu kaedah yang diperkenalkan dalam piawaian itu ialah Saluran Capaian Teragih (EDCA), yang mampu menyokong pengkelasan aplikasi di lapisan Kawalan Capaian Media (MAC). Ia memastikan paket yang dihantar oleh setiap stesen bergerak mendapat layanan yang berbeza berdasarkan tahap kepentingan aplikasi tersebut. Namun, tiada kepastian mutlak yang dapat dijanjikan kepada aplikasi berkepentingan tinggi dalam pencapaian truput dan lengahan walaupun EDCA telah digunakan. Kualiti perkhidmatan tetap akan menurun apabila tahap beban dalam medium wayerles sudah melebihi kapasiti yang boleh ditampung. Kawalan kemasukan adalah kaedah untuk menangai masalah yang disebut di atas. Dalam tesis ini, satu kaedah kawalan kemasukan yang menggunakan pengukuran tahap beban dalam medium wayerles telah dicadangkan. Kaedah yang dicadangkan dapat mengawal bilangan stesen wayerles tanpa menurunkan kualiti perkhidmatan aliran sedia ada semasa keadaan beban tinggi. Lengahan dan truput telah dianalisis untuk mengkaji prestasi kaedah ini. Simulasi ini telah dijalankan dengan menggunakan perisian simulasi rangkaian ns-2 untuk mengkaji kualiti perkhidmatannya. Keputusan penyelidikan telah menunjukkan kaedah yang dicadangkan dapat melindungi kualiti perkhidmatan untuk aplikasi keutamaan tinggi dan pada masa yang sama mengorbankan kualiti perkhidmatan aplikasi keutamaan rendah pada tahap yang tidak keterlaluan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AC	-	Access Category
ACK	-	Acknowledge
ACM	-	Admission Control Method
AIFS	-	Arbitrary Inter Frame Space
AP	-	Access Point
ARP	-	Automatic Rate Fallback
BER	-	Bit Error Rate
BSS	-	Basic Service Set
CSMA/CA	-	Carrier Sense Multiple Access with Collision Avoidance
CSMA/CD	-	Carrier Sense Multiple Access with Collision Detection
CTS	-	Clear to Send
CW	-	Contention Windows
DCF	-	Distributed Coordination Function
DDRR	-	Distributed Deficit Round Robin
DFS	-	Distributed Fair Scheduling
DIFS	-	DCF Inter Frame Space
DSDV	-	Destination-Sequenced Distance Vector
DSR	-	Dynamic Source Routing
DSSS	-	Direct Sequence Spread Spectrum
EDCA	-	Enhanced Distributed Channel Access
EDCF	-	Enhanced Distributed Coordination Function
ETSI	-	European Telecommunications Standards Institute
FHSS	-	Frequency Hopping Spread Spectrum
HCF	-	Hybrid Coordination Function
HIPERLAN	-	High Performance Local Area Network
IEEE	-	Institute of Electrical and Electronics Engineers

IFS	-	InterFrame Space
IP	-	Internet Protocol
IR	-	Infrared
LAN	-	Local Area Network
LLC	-	Logical Link Control
MAC	-	Medium Access Control
MS	-	Mobile Station
NAV	-	Network Allocation Vector
NOAH	-	Non Ad-Hoc
ns-2	-	network simulator 2
NUC	-	Network Utilization Characteristic
OFDM	-	Orthogonal Frequency Division Multiplexing
OSI	-	Open System Interconnection
PCF	-	Point Coordination Function
PHY	-	Physical Layer
PIFS	-	PCF Inter Frame Space
QoS	-	Quality of Service
RTS	-	Ready to Send
SIFS	-	Short Inter Frame Space
STA	-	Station
TCP	-	Transport Control Protocol
UDP	-	User Datagram Protocol
VoIP	-	Voice over Internet Protocol
Wi-Fi	-	Wireless Fidelity
WLAN	-	Wireless Local Area Network

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter provides an overview of this thesis. Section 1.1 briefly discusses the background and motivation for this research. Section 1.2 formulates statement of problems to be solved in this research. Section 1.3 lists research objectives. Section 1.4 defines scope of work. Section 1.5 discusses the contributions of this research. Finally, Section 1.6 describes the organization of this thesis.

1.2 Research Background and Motivation

Nowadays, Wireless Local Area Network (WLAN) is becoming more important because users want the connectivity of a wired LAN, coupled with the mobility of a wireless link. With WLAN being developed to achieve data rates comparable to those of wired LANs, more and more interests have been taken in developing these systems. The IEEE 802.11 Working Group developed an International Standard so that inexpensive, interoperable equipment could be designed by different manufacturers and used to build a wireless infrastructure. The IEEE 802.11 Standard [1] defines the Medium Access Control (MAC) sublayer, MAC Management protocols and services, and three Physical Layers (PHY). The IEEE 802.11a [2] and IEEE 802.11b [3] define the other Physical Layers. Currently, the IEEE 802.11a and IEEE 802.11g [4] Physical Layer can support a maximum transmission speed of 54Mbps. The medium access controller provides the interface between a host computer bus and the Physical Layer radio. The MAC is common for 802.11 Standard and its extensions. The PHY provides information to the MAC about the status of the channel (idle, busy). These layers are shown in Figure 1.1.

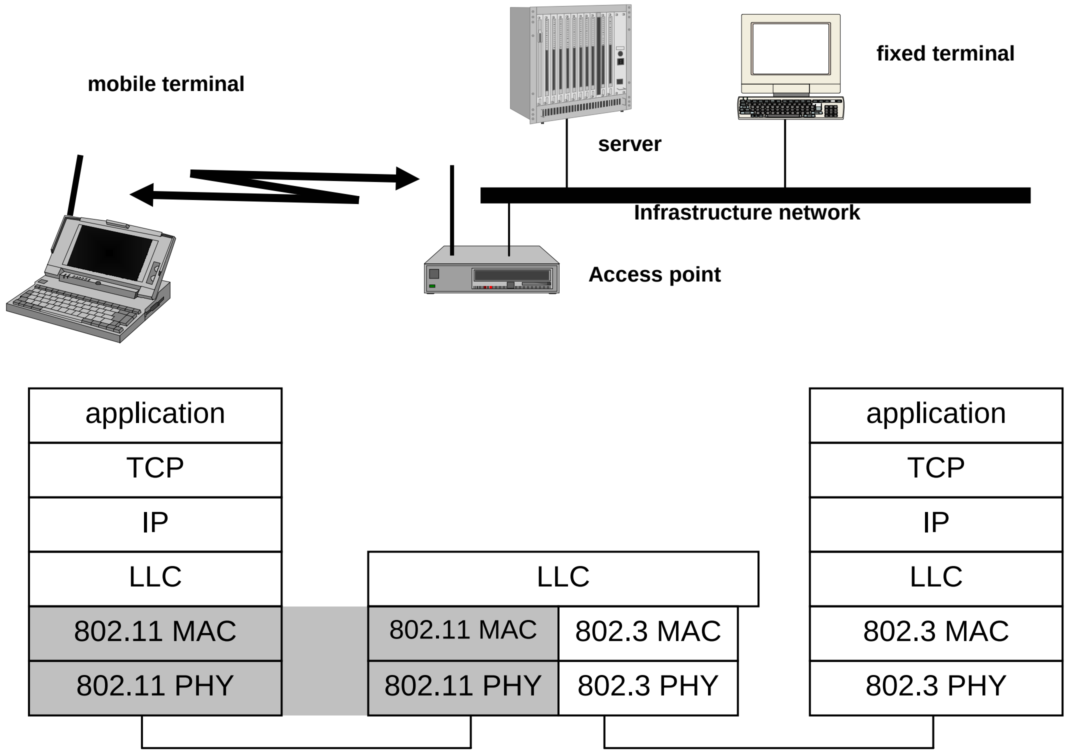

Figure 1.1 Protocol Layers in Wireless Local Area Network

In wired networks, the network can have a very high bandwidth by increasing the number of links or link capacity. However, in wireless networks, there is only one medium that is shared by all the nodes (as shown in Figure 1.1) that are in the same radio communications range, and the radio frequency bandwidth is limited. Hence, packet collisions are unavoidable due to the fact that traffic arrivals are random and there is non-zero propagation time between transmitters and receivers. Therefore, MAC schemes are used to coordinate access to the single channel in the network.

With the provisioning of high-speed Wireless LAN (WLAN) environments, it is possible to offer high-speed data services to the users. Hence, traffic classes (e.g., VoIP or Video Conference) with different QoS requirements will be provided in future WLANs. Supporting QoS requirements of different applications has become the key challenge for IEEE 802.11 WLAN to be successful in future wireless communications.

Since these traffic classes require distinct specific features, such as delay sensitivity or guaranteed bandwidth requirement, it is desired to provide a service differentiation mechanism in the IEEE 802.11 Standard. The existing standard of IEEE 802.11 does not support service differentiation because it was initially created for the data communications. Many research [5] [6] [7] [8] [9] [10] [11] [12] [13] have been carried out to propose a suitable and robust service differentiation or QoS mechanism for WLAN.

In [5], the author analytically studied the performance of the IEEE 802.11 protocol with a dynamically tuned backoff based on the estimation of the network status. The author in [6] proposed a simple and efficient method to modify the CSMA/CA protocol such that station priorities can be supported in IEEE 802.11 MAC. In [7], Imad and Castelluccia presented three service differentiation schemes for IEEE 802.11. The first one is based on scaling the contention window according to the priority of each flow or user. The second one assigns different inter frame spacing to different users. Finally, the last one uses different maximum frame lengths for different users. The author of [8] proposed a priority-based fair medium access control (PMAC) protocol by modifying the Distributed Coordination Function (DCF) of the IEEE 802.11 MAC. The author in [9] proposed a distributed multiple access procedure to transport rel-time traffic over IEEE 802.11 WLAN. Vaidya et. al. [10] in the other hand presented a fully distributed algorithm for fair scheduling in WLAN. The algorithm can be implemented without using a centralized coordinator to arbitrate medium access. Simulation results showed that the proposal algorithm is able to schedule transmissions such that the bandwidth allocated to different flows is proportional to their weights. Qiang Ni et. al. [11] proposed an approach, called Adaptive Enhanced Distributed Coordination Function (AEDCF), which is derived from the new EDCF introduced in the upcoming IEEE 802.11e standard. The scheme aimed to share the transmission channel efficiently. Relative priorities are provisioned by adjusting the size of the Contention Window (CW) of each traffic class taking into account both applications requirements and network conditions.

Results showed that AEDCF outperformed the basic EDCF, especially at high traffic load conditions. In [12], Banchs and Perez proposed an extension of the DCF function of IEEE 802.11 to provide weighted fair queuing in Wireless LAN. Simulation results showed that the proposed scheme is able to provide the desired bandwidth distribution independent of the flows aggressiveness and their willingness to transmit. Wasan et. al. [13] proposed a novel fair bandwidth allocation mechanism based on deficit round robin scheduling. Service differentiation is provided by translating the user throughput requirements into the 802.11 MAC Inter frame space parameter. Simulation results showed that the proposed mechanism provided low variability of throughput and delay and has the advantage of low complexity.

Recently, the IEEE 802.11 task group e [14] is specifying a distributed access approach, called Enhanced Distributed Channel Access (EDCA), which supports service differentiation in the MAC layer. It ensures the packets sent by each mobile station can be differentiated by assigning different access parameters. However, supporting service differentiation in the MAC protocol does not guarantee that the QoS requirement of the each traffic class to be fully satisfied. Since each mobile station may transmit packets egotistically in a distributed environment, network load might be led to an unacceptable level. An admission control strategy could mitigate the effect of egotistic transmission. It could ensure that the acceptance of a new traffic stream will not cause the QoS of any ongoing sessions below an unacceptable level.

From the issues mentioned above, we have decided to explore the QoS issue of IEEE 802.11 WLAN and address the QoS problem when the network is heavily loaded. The details of the research will be explained in the succeeding sections. Figure 1.2 summarizes the research background and the motivation of the research.

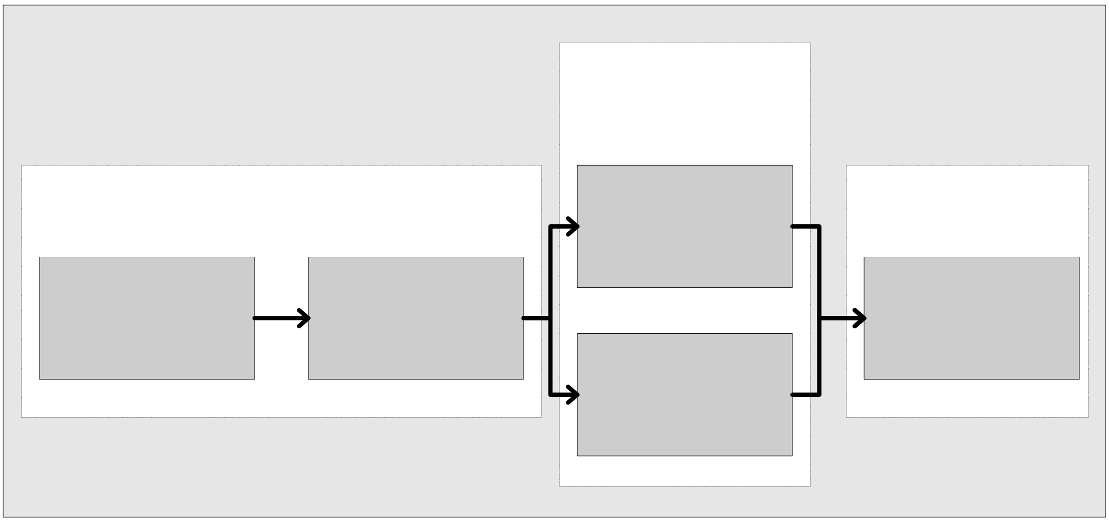

Figure 1.2 Background of QoS Issue in WLAN

1.3 Problem Statement

Based on the reviews done, two questions arise and need to be answered. From the literature findings, it is found that there are so many QoS method proposed for resource allocation in IEEE 802.11 to support high priority flows in future. Dajiang and Charles [15] found out that under heavy loaded condition, the QoS of wireless traffic will still degrade even though there is a good service differentiation implemented in the MAC Layer of the mobile station. From literature findings, not many works have been dealing with the solution to maintain QoS when the wireless medium is heavily loaded. Therefore, it triggers the first question of this research as follows:

- *How can an admission control method be implemented in EDCA MAC layer of the WLAN access point?*

When the WLAN is heavily loaded, admission control is needed to ensure the QoS of the existing flows do not degrade. Several admission control methods have been proposed in the IEEE 802.11 wireless network [16][17][18][19][20]. Sachin and Kappes proposed a concept of measurement based admission control method in their publication [21]. The method was proposed for IEEE 802.11 MAC which does not have any QoS mechanism in it. There were no results provided in the proposed method. Based on the concept proposed by Sachin and Kappes, the next question to ask is:

- *How good is the proposed admission control in maintaining the QoS of the existing flows under heavy load condition?*

It is just not sufficient to propose an admission control method but as well to study how the admission control method performs especially under heavy loaded conditions.

1.4 Research Objectives

In order to solve the problem posed in the preceding sections, the research objectives are set out as follows: -

1. To propose and simulate a measurement-based admission control method in the Medium Access Control (MAC) layer of the access point in the IEEE 802.11e network that can control the amount of traffic contending for the wireless medium.

2. To investigate the performance of the admission control method (ACM) on the delay and throughput of the multimedia flows under heavy load condition. The proposed ACM should protect the QoS of high priority flows while not starving the low priority flows seriously.

1.5 Scope of Work

Considering the restricted resources and time frame allocated, the scope of this research work is defined as follows:

1. The entire work only involves simulation because it is difficult to conduct experiments with real equipments and large number of nodes. The research simulates a proposed measurement based admission control method in the MAC layer of the base station in the WLAN using ns-2 network simulator.

2. In the research, it is decided not to look at the mobility and handover issue, since that would increase the workload and the complexity of the research. Hence, the simulation only involves one cell which comprises of one base station and a number of mobile stations.

3. The EDCA module contributed by [37] in ns-2 is used in the research. The admission control method is added in the EDCA module. Several QoS metrics such as delay, variation of delay, and throughput are analyzed. Comparison is only made between WLAN with admission control implemented and the WLAN with no admission control admitted.

4. Most of the 802.11b commercial network cards support some kind of Automatic Rate Fallback (ARP) mechanisms which will adjust the data rate to a lower one when there are a lot of packet errors. However, ns-2 does not support multirate functionality. Therefore, in the simulation, all mobile stations transmit with the data rate 11Mbps.

5. In the wireless channel model of the current version of ns-2, the received power of the packet only depends on the distance of the sender and the receiver. But in real life, there are a lot of other factors influencing the received power of a packet. In our research, our main concern is on MAC layer. Therefore, we assume the limitation of the physical layer implementation in ns-2 will not affect the findings of our research.

6. Other physical factors such as radio interference, noises are not considered in this research. Thus the channel is assumed to be error free.

1.6 Research Contributions

The following are the contributions of this research:

1. A proposal and implementation of a measurement based admission control method in the IEEE 802.11e EDCA MAC.

2. A performance study on admission control method proposed in this research.

1.7 Thesis Organization

This thesis is organized into five chapters. The first chapter serves as an introductory chapter which covers research background and motivation, problem statements, objectives, scope of work, and research contributions.

Chapter 2 outlines the background of the Wireless Local Area Network (WLAN). The chapter will cover the basics of WLAN, including IEEE 802.11, QoS in IEEE 802.11 and the previous contributed works in QoS of IEEE 802.11. Besides, the last part of the chapter will also focus on the fundamental of ns-2 network simulator.

Chapter 3 will introduce the architecture and implementation of the proposed admission control method. The method will be explained using diagrams and finite state machines. The ACM is implemented in ns-2 network simulator.

Chapter 4 presents the performance evaluation of the ACM. The simulation results are obtained from simulation in EDCA with ACM and EDCA without ACM. The results are presented in graphs and analyzed.

Finally, chapter 5 wraps up the thesis with the conclusion and some recommendations for future research.

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