PERFORMANCE EVALUATION AND ENHANCEMENT OF EDCA PROTOCOL TO IMPROVE THE VOICE CAPACITY IN WIRELESS NETWORK

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A thesis submitted
in fulfillment of the requirements for the degree of Doctor of Philosophy

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DECLARATION

I declare that the study entitled "Performance Evaluation and Enhancement of EDCA Protocol to Improve the Voice Capacity in Wireless Network" is the result of my own study except as cited in the references. The study has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

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Date : …………………………………………………..

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

Signature :………………...

Supervisor Name : Assoc. Prof. Dr. Zahriladha Bin Zakaria

Date :……………………..

DEDICATION

The sake of Allah, my Creator and my Master,

My great messenger, Mohammad S.A.W who taught us the purpose of life,

My beloved father and mother,

My beloved wife Ghada

My beloved daughters Asma, Len and Mariam,

My brothers and sisters

All the people in my life who touch my heart,

I dedicate this research.

ABSTRACT

Enhanced Distributed Channel Access (EDCA) protocol is used to support quality of service (QoS). However, using the default parameter values for EDCA protocol leads to increasing the collisions in the wireless network and decreasing the capacity. This is due to the default EDCA protocol gives the access point and wireless stations the same priority to access the medium, in spite of the access point has high load traffic compared with normal wireless stations. Therefore, in this research work a new algorithm was proposed to enhance the capacity of the EDCA protocol and increase the number of the active voice users. The idea of the algorithm was based on creating different contention window ranges between access point and wireless workstations, and changing the technique of increasing the contention window value when the collision happened. Through the proposed algorithm, the Minimum Contention Window (CW_{min}) and Arbitration Inter Frame Space (AIFS) parameters were adapted based on the percentage of the collision in the network. By applying the proposed algorithm, the throughput of EDCA protocol was increased by 42.9% and it can support 14 voice users rather than 11 in the default EDCA protocol. The QoS requirements were achieved when the network contained 14 voice users. The end to end delay became 86.44 ms and the packet loss percentage was 0.06 %. In addition to that the uplink and downlink voice throughputs covered the data rate requirements. Moreover, a new mathematical model was designed based on the Markov chain mechanism in order to evaluate the performance of the EDCA protocol under saturation and non saturation conditions, which aimed to separate between the uplink and downlink throughputs with different data types. The separation between uplink and downlink throughputs is based on separating the model equations between the access point and the stations. This separation contributes in determining the effect of access point on the network performance as well as it allows in evaluating the algorithms that based on the differentiation between the access point and stations. The OPNET simulator and the mathematical model were used to evaluate the performance for the proposed algorithm. Therefore, by applying the proposed algorithm, the collisions in network will be decreased and leading to the enhancement of the network capacity. It is believed that this study is useful to cover more voice users in the public wireless network that deployed in bus stations, restaurants, parks, airports and etc.

ABSTRAK

‘Enhanced Distributed Channel Access’ (EDCA) protokol digunakan untuk menyokong ‘Quality of Service’ (QoS). Walau bagaimanapun, menggunakan nilai parameter yang tetap bagi protokol EDCA akan membawa kepada peningkatan perlanggaran dalam rangkaian tanpa wayar dan ianya akan mengurangkan kapasiti. Ini disebabkan ketetapan protokol EDCA memberikan keutamaan pusat akses dan stesen tanpa wayar yang sama untuk akses medium tersebut, walaupun pusat akses mempunyai trafik muatan yang tinggi berbanding stesen tanpa wayar yang normal. Oleh itu, dalam kerja penyelidikan ini, algoritma baru telah dicadangkan untuk meningkatkan kapasiti protokol EDCA dan meningkatkan bilangan pengguna suara. Idea untuk algoritma ini adalah mewujudkan tetingkap perdebatan yang berbeza antara pusat akses dan perlantar kerja tanpa wayar, dan merubah teknik dalam meningkatkan jumlah tetingkap perdebatan apabila perlanggaran berlaku. Melalui algoritma yang dicadangkan, ‘Minimum Contention Window’ (CWmin) dan parameter ‘Arbitration Inter Frame Space’ (AIFS) telah disesuaikan berdasarkan peratusan perlanggaran dalam rangkaian. Dengan menggunakan algoritma yang dicadangkan, daya pemprosesan protokol EDCA telah meningkat sebanyak 42.9% dan ia boleh menyokong 14 pengguna suara berbanding 11 daripada protokol EDCA yang tetap. Syarat-syarat QoS telah dicapai apabila rangkaian mengandungi 14 orang pengguna suara. Kelewatan hujung ke hujung menjadi 86.44 ms dan peratus kerugian paket ialah 0.06 %. Tambahan pula, daya pemprosesan suara pautan naik dan pautan turun meliputi syarat-syarat kadar data. Selain itu, model matematik telah direka berdasarkan mekanisma rantaian Markov untuk menilai prestasi protokol EDCA di bawah kondisi tepu dan bukan tepu, yang bertujuan untuk memisahkan daya pemprosesan pautan naik dan pautan turun dengan mengasingkan persamaan model antara pusat akses dan stesen. Pemisahan ini menyumbang dalam mengenalpasti kesan pusat akses kepada prestasi rangkaian dan juga kerana ia membolehkan dalam menilai algoritma yang berdasarkan perbezaan di antara pusat akses dan stesen. Simulasi OPNET dan model matematik digunakan untuk menilai prestasi algoritma yang dicadangkan. Oleh itu, dengan menggunakan algoritma yang dicadangkan, perlanggaran dalam rangkaian akan menurun dan ini akan membawa kepada perningkatan kapasiti rangkaian. Adalah dipercayai bahawa kajian ini amat berguna bagi menampung pengguna suara dalam rangkaian tanpa wayar awam yang ditempatkan di stesen bas, restoran, taman, lapangan terbang dan lain-lain.

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AC	-	Access Category
ACK	-	Acknowledgment
ACW	-	Adaptive Contention Window
a-EDCA	-	Adaptive Enhanced Distributed Channel Access
AID	-	Association Identifier
AIFS	-	Arbitration Inter Frame Space
AIFSN	-	Arbitration Inter Frame Space Number
AM	-	Active Mode
AP	-	Access Point
APP	-	Application Specific Function
B-EDCA	-	Balanced Enhanced Distributed Channel Access
BSA	-	Basic Service Area
BSS	-	Basic Service Set
BSSID	-	Basic Service Set Identifier
CNAME	-	Canonical Name
CRC	-	Cyclic Redundancy Check
CS-ACELP	-	Conjugate Structure Algebraic Code Excited Linear Prediction
CSMA/CA	-	Carrier Sense Multiple Access with Collision Avoidance
CSRC	-	Contributing source
CSRC count	-	Contributing Source Count
CTS	-	Clear To Send

CW	-	Contention Window
CW_{max}	-	Maximum Contention Window
CW_{min}	-	Minimum Contention Window
DA	-	Destination Address
DCF	-	Distributed Coordination Function
DCW	-	Dynamic Contention window
DIFS	-	Distributed Inter Frame Space
DLSR	-	Delay since last Sender Report
DS	-	Distribution System
DSCP	-	Differentiated Service Code Point
DSSS	-	Direct Sequence Spread Spectrum
ECN	-	Explicit Congestion Notification
EDCA	-	Enhanced Distributed Channel Access
EDCAF	-	Enhanced Distributed Channel Access Function
ESS	-	Extended Service Set
FCS	-	Frame Check Sequence
HTTP	-	Hypertext Transfer Protocol
IBSS	-	Independent Basic Service Set
IEEE	-	Institute Of Electrical and Electronic Engineering
IETF	-	Internet Engineering Task Force
IP	-	Internet Protocol
ISDN	-	Integrated Service Digital Network
LSR	-	Last Sender Report timestamp
MAC	-	Medium Access Control
MATLAB	-	Matrix Laboratory
MIMO	-	Multiple Input and Multiple Output
MITCW	-	Modification of Initial and Thereafter Contention Window

MMPDU	-	MAC Management Protocol Data Unit
MPDU	-	MAC Protocol Data Unit
MSDU	-	MAC Service Data Unit
NAV	-	Network Allocation Vector
NTP timestamp	-	Network Time Protocol Timestamp
OFDM	-	Orthogonal Frequency Division Multiplexing
OPNET	-	Optimum Network performance
OUI	-	Organizationally Unique Identifier
PCF	-	Point Coordination Function
PCM	-	Pulse Code Modulation
PDA	-	Personal Digital Assistant
PDF	-	Probability Density Function
PDU	-	Protocol Data Unit
PHY	-	Physical
PSM	-	Power Save Mode
PSTN	-	Public Switched Telephone Network
PT	-	Payload type
QoS	-	Quality of Service
RA	-	Receiver address
RAMPS	-	Random Adaptive MAC Parameters Scheme
RR	-	Receiver Report
RTCP	-	Real Time Control Protocol
RTP	-	Real Time Protocol
RTS	-	Request To Send
SA	-	Source Address
SDES	-	Source Description
SDU	-	Service Data Unit

SIFS	-	Short Inter Frame Space
SIP	-	Session Initiation Protocol
SR	-	Sender Report
SSID	-	Service Set Identification
SSRC	-	Synchronization Source
TA	-	Transmission Address
TCP	-	Transmission Control Protocol
TOS	-	Type of Service
TXOPlimit	-	Transmit Opportunity Limit
UAC	-	User Agent Client
UAS	-	User Agent Server
UDP	-	User Datagram Protocol
VAD	-	Voice Activity Detection
VOIP	-	Voice Over Internet Protocol
WLAN	-	Wireless Local Area Network

LIST OF APPENDICES

LIST OF PUBLICATIONS

The research papers produced and published during this research are as follows:

1. Abu-Khadrah, A., Zakaria, Z., Othman, M. and Zin, M.S.I.M., 2016. Markov Chain Model and Performance Enhancement for EDCA Protocol. *Journal of Communications*, 11(8), pp.748–757.

2. Abu-khadrah, A., Zakaria, Z., Othman, M. and Zin, M.S.I.M., 2015. Markov Chain Model for EDCA Protocol under Saturation and Non-Saturation Conditions. *Journal of Communications*, 10(8), pp.596–602.

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6. Abu-khadrah, A., Zakaria, Z. and Othman, M., 2015. New Algorithm to Enhance the Capacity of EDCA Protocol to Tolerate More Voice Users by Adjusting Contention Window. *Advanced Science Letters*, 21(1), pp.5–11.

7. Abu-Khadrah, A., Zakaria, Z., Othman, M. and Zin, M.S.I.M., 2015. Evaluating the performance for DCF protocol and EDCA protocol. *Jurnal Teknologi*, 72(5), pp.51–55.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Recently, IEEE802.11Wireless Local Area Network (WLAN) has been extensively deployed in many different environments for enterprise, office, home and public networking. It is considered one of the most popular techniques used in wireless network. The simplicity of configuration, ease to expand and low costs are its main properties (Yoo & Kim, 2014). Nowadays, there is a huge usage of the Internet in different fields of life, and there is a need of supporting the Internet in public locations such as parks, restaurants, bus stations and airports. These locations do not have a fixed number of users, and can be increased dramatically. Therefore, a wireless network is suitable in these locations as it can accept more users with a low cost (Yu & Yao, 2012). The IEEE802.11 standards are used in a wireless network. These standards are very popular because they use unlicensed channels. In 1997, the IEEE802.11a standard was issued with a data rate 2 Mb/s. Currently, the data rate has increased to 600 Mb/s in the IEEE802.11n standard (Lee & Kim, 2010).

Real time applications such as Voice Over Internet Protocol (VOIP) and video conference are considered the main challenges that face wireless network (Charfi et al., 2013). These applications succeed within specific conditions in the delay time and packet loss percentage. For example, the VOIP call succeeds when the end to end delay is less than 150 ms and the packet loss percentage does not exceed more than 1% (Kazemitabar et al., 2010; Fitzpatrick et al., 2007). The VOIP is one of the fastest growing internet applications. There is a trend to use the VOIP application instead of the traditional