UNIVERSITI PUTRA MALAYSIA

QUALITY OF SERVICE PROVISIONING SCHEME FOR REAL-TIME APPLICATIONS IN IEEE 802.11 WIRELESS LOCAL AREA NETWORK

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By

ROGER NG CHENG YONG

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

February 2006

To my Family and Friends

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

QUALITY OF SERVICE PROVISIONING SCHEME FOR REAL-TIME APPLICATIONS IN IEEE 802.11 WIRELESS LOCAL AREA NETWORK

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February 2006

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This thesis presents a novel quality of service (QoS) provisioning scheme for real-time applications in IEEE 802.11e wireless local area networks (WLAN). The emerging 802.11e standard is tackling the exploding volume of traffic in WLANs with a long -term solution based on QoS-architectures. QoS delivers predictability and consistency into existing variability of best-effort delivery system offered in internet protocol (IP) and IEEE 802.11 wireless networks.

Service differentiation in WLAN networks is achieved by means of assigning packets (from the network layer) to different access categories (AC), a set of fixed medium access control (MAC) level parameters that defines the priority echelon for each AC. Thus real-time applications are assigned higher priority ACs to ensure better service and to ensure that the delay constraints of these applications are promptly dealt with.

An algorithm called Slide and Translate (SNT) is proposed for IEEE 802.11 WLANs. The SNT adapts contention parameters of individual ACs based on the

network load in a basic service set (BSS). SNT is derived from the observations of the success and failures of previously proposed QoS provisioning schemes. The SNT adapts the backoff interval, minimum contention window (CW_{min}) and contention offset (CW_{offset}) to ensure the QoS constraints for the different ACs are dealt with.

To further understand the SNT, a simple mathematical analysis is presented on the inter-AC differentiation characteristics; subsequently, through simulation it is shown that SNT is able to maintain high medium utilisation over a wide range of offered loads while providing a high degree of isolation (in terms of throughput, delay and frame loss) to high priority traffic.

Further to this, an extension to the SNT called SNT-AC is proposed in order to achieve efficient end-to-end resource provisioning. SNT-AC uses an admission control algorithm to restrict flows in and out of the BSS. The admission controller resides in the IP layer and makes decision based on the MAC level feedback. The simulation results indicate that the close coupling QoS coordination can ensure both bandwidth and latency to admitted flows by controlling the effective offered load into the BSS. This guarantees high priority ACs protection against overwhelming traffic in a WLAN.

Finally a brief discussion on future directions of WLANs and hardware implementation issues conclude the thesis.

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

SKEMA MEMPROVISI KUALITI PERKHIDMATAN UNTUK APLIKASI MASA-NYATA DALAM RANGKAIAN TEMPATAN TANPA WAYAR BERASASKAN PIAWAIAN IEEE 802.11

Oleh

ROGER NG CHENG YONG

Februari 2005

Pengerusi: Profesor Madya Sabira Khatun, PhD

Fakulti: Kejuruteraan

Tesis ini mengutarakan satu skema baru yang berupaya memperuntukkan kualiti perkhidmatan untuk aplikasi masa nyata dalam rangkaian wireless tempatan. Draf piawaian 802.11e daripada IEEE adalah sebahagian hasil daripada penyelidikan yang bertujuan menampung keperluan trafik yang kian meruncing. Kualiti perkhidmatan memberikan jaminan dan konistensi kepada rangkaian yang sedia ada seperti rangkaian berasaskan Internet Protocol (IP) dan rangkaian tempatan tanpa wayar (WLAN) berasaskan piawaian IEEE 802.11.

Untuk membezakan kualiti perkhidmatan, WLAN membahagikan paket-paket kepada kelas yang dinamakan "access category" (AC). Setiap AC mempunyai parameter yang tersendiri yang digunakan untuk memperoleh servis daripada rangkaian. Untuk aplikasi atau perisian yang memerlukan perkhidmatan masa-nyata, ia perlu memastikan paket-paket di berikan kualiti perkhidmatan yang tertinggi.

Bagi tujuan memperuntukkan kualiti perkhidmatan yang sesuai, sebuah skema yang

dinamakan "slide and translate" di reka untuk mengagihkan lebar jalur kepada aplikasi atau perisian mengikut keperluan individu. Skema ini adalah hasil daripada kejayaan dan juga kegagalan beberapa skema yang pernah di cadangkan oleh para penyelidik sebelum ini. Skema SNT menyesuaikan parameter setiap AC seperti "minimum contention window (CW)", "contention offset (CWoffset) bagi tujuan memberikan kualiti perkhidmatan yang sesuai.

Untuk lebih memahami prinsip operasi SNT, satu analisis matematik di buat untuk menunjukkan keupayaan skema ini mengekalkan kualiti perkhidmatan dalam sesebuah WLAN. Melalui kaedah simulasi, penilaian berdasarkan "throughput", "delay" and "frame loss" di buat bedasarkan prestasi setiap AC.

Lanjutan daripada skema SNT, sebuah lagi skema yang di namakan SNT-AC diperkenalkan. SNT-AC menggunakan kawalan kemasukan untuk memastikan setiap aplikasi yang dibenarkan menggunakan rangkaian, akan medapatkan kualiti perkhidmatan yang diperlukan.

Akhirnya, tesis ini membincangkan hala tuju WLAN dan peranannya dalam rangkaian masa depan, selain itu satu perbincangan mengenai mereka bentuk perkakasan untuk tujuan kualit perkhidmatan juga di masukkan.

ACKNOWLEDGEMENT

First and foremost I would like to thank Dr. Sabira Khatun for giving me the opportunity to work with her and the fantastic team of researchers at the wireless laboratory. The past two years has been extremely challenging yet no less fruitful. I would further thank her for the countless hours of discussion and constructive advice on many aspects of the research and the thesis.

Additionally, no less amount of gratitude goes to Professor Borhannudin Md. Ali and Assoc. Prof. Dr. Khazani for their input and also their ideas on contemporary research in the area of networking. Specifically, the many presentations (probably half a dozen) over the past two years has somewhat aligned my research focus in a more relevant scope.

A big thank you goes to Dr. Bryan, Dr. David and Dr. Y.F Tan for their input on the simulation, mathematical analysis and insights. Their ideas really helped me through the difficult parts of this research.

Finally, another round of thank you go to my lab mates and friends, Loh, Yong, Sadat, Zura, and all the office staff in the faculty as well as the graduate school.

I certify that an Examination Committee has met on 22nd February 2006 to conduct the final examination of Roger Ng Cheng Yong on his Master of Science thesis entitled "Quality of Service Provisioning Scheme for Real-Time Applications in IEEE 802.11 Wireless Local Area Network" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

ROGER NG CHENG YONG

Date: 22 February 2006

TABLE OF CONTENTS

CHAPTER

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS/GLOSSARY OF TERMS

AC	Access Category
ACK	Acknowledgement
AEDCF	Adaptive Enhanced Distributed Coordination Function
AIFS	Arbitration Inter Frame Space (measured in us)
ANSI	American National Standards Institute
AP	Access Point
ARQ	Automatic Repeat Request
ATM	Asynchronous Transfer Mode
BE	Best Effort
BER	Bit Error Ratio
BI	Backoff Interval
BSS	Basic Service Set
BSSID	Basic Service Set Identification
CA	Collision Avoidance
CBR	Constant Bit Rate
CCA	Clear Channel Assessment
CCK	Complementary Code Keying
CCDF	Complementary Cumulative Distribution Function
CDF	Cumulative Distribution Function, synonymous to CCDF
CFB	Contention Free Burst
CFP	Contention Free Period

CL	Controlled Load (802.1D)
CP	Contention Period
CRC	Cyclic Redundancy Check
CSMA	Carrier Sense Multiple Access
CTS	Clear To Send
CW	Contention Window
CW_{max}	Maximum Contention Window
CW_{min}	Minimum Contention Window
DCC	Dynamic contention control
DCF	Distributed Coordination Function
DIFS	Distributed Coordination Function Interframe Space
DL	Downlink
DLC	Data Link Control
DS	Distribution System
DSSS	Direct Sequence Spread Spectrum
DTIM	Delivery Traffic Indication Message
EDCF	Enhanced Distributed Coordination Function
EIFS	Extended Interframe Space
EIRP	Equivalent Isotropically Radiated Power
ESS	Extended Service Set
ETSI	European Telecommunications Standards Institute
FCC	Federal Communication Commission – U.S
FHSS	Frequency Hopping Spread Spectrum

FTP	File Transfer Protocol
HCF	Hybrid Coordination Function
HTTP	Hypertext Transfer Protocol
IAPP	Inter AP Protocol
IBSS	Independent Basic Service Set – Ad hoc
IEEE	Institute of Electrical and Electronics Engineers- USA.
IFS	Interframe Space
IP	Internet Protocol
ISM	Industrial, Science, Medical (a frequency band)
ISO	International Organization for Standardization
ITU	International Telecommunications Union
LAN	Local Area Network
LLC	Logical Link Control
MAC	Medium Access Control
MLME	MAC Layer Management Entity
MPDU	MAC Protocol Data Unit
MPEG	Moving Pictures Expert Group
MSDU	MAC Service Data Unit
NAV	Network Allocation Vector
NC	Network Control
OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open System Interconnection
PC	Point Coordinator

PCF	Point Coordination Function
PDU	Protocol Data Unit
PER	Packet Error Ratio
PF	Persistence Factor
PHY	Physical Layer mode, coding and modulation scheme
PIFS	Point Coordination Function Interframe Space
PLCP	Physical Layer Convergence Protocol
PLME	PHY Layer Management Entity
PMD	Physical Medium Dependent
PPDU	Physical (layer) Protocol Data Unit
PSDU	PHY Service Data Unit QAM Quaternary Amplitude Modulation
QoS	Quality of Service
QPSK	Quaternary Phase Shift Keying
QSTA	QoS Station
RTS	Request to Send
RSVP	Resource Reservation Protocol
RESV	Reservation message
RSpec	Reservation specification for RSVP
SAP	Service Access Point
SDU	Service Data Unit
SFDUR	Superframe Duration
SIFS	Short Interframe Space
SNT	Slide and Translate

SS	Station Service
STA	Station
TBTT	Target Beacon Transmission Time
TCP	Transport Control Protocol
TID	Traffic Identifier
TS	Traffic Stream
TSPEC	Traffic Specification
TXOP	Transmission Opportunity
VBR	Variable Bit Rate
VoIP	Voice over Internet Protocol
WEP	Wired Equivalent Privacy
Wi-Fi	Wireless Fidelity (802.11 Annex B 1997)
WSS	Wide Sense Stationary
WSTA	Wireless STA

XCL	Extended Controlled Load (802.1D)
XCP	Extended Contention Period
XCRC	Extranneous Cyclic Redundancy Check
CSMA	Carrier Sense Multiple Access
CTS	Clear To Send
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FCC	Federal Communication Commission – U.S
FHSS	Frequency Hopping Spread Spectrum

xFTP	X version of File Transfer Protocol
x-HCF	Extended Hybrid Coordination Function
xHTTP	Extended Hypertext Transfer Protocol
x-IAPP	extendedInter AP Protocol
IBSS	Independent Basic Service Set – Ad hoc
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