

# Extending MAC-layer QoS from Wired to Wireless Segments, and from Single Cell to Multi-cell Overlapping Environment

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A dissertation submitted in fulfilment of the requirements for the University of Technology Sydney for the Degree of

Doctor of Philosophy



2013



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*~ Dedicated to my mother  
and to the memory of my father ~*

## ABSTRACT

Internet services today, especially real-time ones, require at least the same level of Quality of Experience (QoE) over radio links, as that provided by the wired parts for which most of the IP-based multimedia applications were originally designed. This leads to a problem of service quality consistency across the radio and wired segments of the network. In order to provide satisfactory QoE, provision of underlying layer Quality of Service, QoS, for multimedia applications over networks has been a long-standing and critical topic, especially within the radio access segment of the next generation wireless/mobile environment. With the assistance of QoE and multimedia adaption at the application layers, QoS components, such as QoS framework and service differentiation mechanisms, are better defined at MAC and IP layers; It is where radio limitation is commonly defined by time slot/division, frequency, code division, sector, and direction gain etc.

The problems of the QoS frameworks today vary from insufficient level of control, to scalability and complexity, as well as IP-mobility related problems. In the layer of medium access control (MAC), QoS fairness, especially in a highly loaded and/or overloaded system, is an issue in Contention Schemes for Service Differentiation. The shortcoming of efficiency (overhead and request collision) and complexity of polling schemes for Service Differentiation have also been observed. These two schemes would perform even worst in a multi-cell overlapping environment, rather than a single cell environment, without any central resources management.

This thesis investigates QoS supports for wireless network. The primary goal is to design effective QoS mechanisms/framework, in the context of medium access control in WLAN 802.11, to ensure wireless connectivity for multimedia traffic. Firstly, we propose a hybrid architecture following the principles of Differentiated Service (DiffServ) model over the core part of the network, and the principles of Integrated Services (IntServ explicit control) model locally over the wireless access segment. We then present in detail an example solution consistent with the hybrid QoS architecture principles, with an admission control core of Fair Intelligent Congestion Control (FICC). Within the framework, we analysed contention and polling schemes as the candidates of service differentiation in the MAC layer, and based on these results, we found our proposed the Multi-cycle Polling mechanism can actually meet the QoS requirements. We finally draw our attentions on Service Differentiation Scheme in a Multi-cell

Overlapping WLAN Environment. Due to widely use of WLAN almost in every smart-handset and notebook today and its shortcoming in spectrum efficiency and interference, the Co-existence/overlapping among WLAN themselves and other systems would become even more challenging. In fact, there is more and more serious interference incidents reported particularly in Metro transport systems in 2013. In this research, the graph colouring technique for grouping assignment is applied and the novel overlapping coordination scheme has been proved to effectively support QoS Service Differentiation in the interference environment. With the admission control core of FICC and the proposed Service Differentiation Schemes under the Hybrid framework, the wireless QoS issues have been well addressed for both single-cell and multi-cell environments.

## LIST OF PUBLICATIONS

The following is a list of publications by the author of this thesis together with his academic and industrial supervisors during the tenure of her research study.

- (1) Li Zheng, Doan B. Hoang; "Further Analysis and Tuning of Registered Multi-cycle Polling in Wireless Medium Access Management", 15th ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems, Cyprus Island, October 2012.
- (2) Li Zheng, Doan B. Hoang; "Wireless Hybrid QoS Architecture with an enhance of fair intelligence congestion control mechanism", journal of Wireless Engineering and Technology, Scientific Research Publishing, Volume 03, Number 03 (June 2012)
- (3) Li Zheng, Doan B. Hoang; "A QoS Mechanism of Registered Multi-cycle Polling in Wireless Medium Access Control"; IEEE-RIVF International Conference on Computing and Telecommunication Technologies, Hanoi, November, 2010.
- (4) Li Zheng, Doan B. Hoang and Ming Li. "Applying Fair Intelligent Congestion Control in a Hybrid QoS Architecture for Wireless Environment"; Seventh International Conference on Information, Communications and Signal Processing (ICICS 2009), Macau.
- (5) Li Zheng, Doan B. Hoang. "Overlapping Impacts and Resource Coordination for High-density Wireless Communication"; IEEE-RIVF International Conference on Computing and Telecommunication Technologies, Danang, July 2009
- (6) Li Zheng, Doan B. Hoang." Applying Graph Colouring in Resource Coordination for a High-density Wireless Environment"; IEEE 8th International Conference on Computer and Information Technology, Sydney, July 2008.
- (7) Li Zheng, Doan B. Hoang. "Performance Analysis for Resource Coordination in a High-density Wireless Environment"; 13th IEEE Symposium on Computers and Communications, Morocco, July 2008
- (8) Li Zheng, Arek Dadej, Steven Gordon. "Hybrid Quality of Service Architecture for Wireless/Mobile Environment"; IFIP TC6: Interworking 2002 on Converged Networking Data & Real-Time Over IP; Oct 2002, Perth.
- (9) Li Zheng, Arek Dadej, Steven Gordon. "Fairness of Distributed Coordination Function for Multimedia Applications"; the 7th International Symposium on Digital Signal Processing for Communication Systems, DSPCS'2003, December 2003, Gold Coast, Australia.

## **ACKNOWLEDGEMENTS**

The past few years have been a ‘period of intensive discovery’ for me. Firstly, I would like to express my gratitude to my supervisors Professor Doan B. Hoang at iNEXT – UTS Centre for Innovation in IT Services and Applications, Faculty of Information Technology, University of Technology, Sydney, Australia in the last few years of part-time research study.

My heartfelt thanks to my academic advisor Doctor Ming Li, at the School of Engineering and Information Technology, Deakin University, Geelong Victoria 3217, Australia, who has given me enormous guidance in participating in various studies at these research area. Without these guidance and support, I wouldn’t have been able to fulfil my research goal.

I am indebted to my colleagues in our office of Radio Access Engineering, SingTel Optus, Australia, for their valuable time and effort in contributing ideas from our practical deployment experiences. I am greatly influenced by their ‘clear thinking’. The ongoing motivations kept me never stop learning.

I also want to thank the academic fellows at the University of South Australia, Adelaide, Australia, where lots of research ideas and results were formed. This research would never have been possible without the scholarship funded by the University and Nortel Networks generously.

Finally, I want to thank my family for their supports and patience during my studies in the past years. Particularly, I want to thank my fiancée, Doctor Min Ling, for her endless love and encouragement throughout the tenure of my study.

## **CERTIFICATE OF ORIGINARITY**

I hereby certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Li Zheng

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