Throughput Management for CSMA/CA Networks: IEEE 802.11e Wireless LAN

Shafiqul Karim

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Signed Statement

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Dedication

I dedicate this thesis to my family. Without their loving care and support this thesis would not be possible.

Abstract

This thesis investigates the design and development considerations to introduce throughput differentiation and management capabilities into the Medium Access Control (MAC) layer of IEEE 802.11 Wireless Local Area Network (*WLAN*) systems, while also maximizing overall throughput performance.

The final control mechanism highlighted in this thesis requires only an initial user configuration to specify the required throughput differentiation and management rules prior to it operating in a fully autonomous manner. In order to maximize throughput performance the control mechanism is designed to seamlessly adjust the throughput differentiation and management rules to reflect the current network traffic load.

Throughout this thesis, we discovered and identified the great difficultly that is inherent in trying to create a control mechanism that is capable of operating autonomously in a broad range of possible traffic load conditions. The difficulties faced stemmed primarily from the design philosophy of a fully self-contained control mechanism within the MAC layer of the *AP* alone, and employing a completely passive/non-intrusive decision making procedure. Furthermore the idiosyncrasies of *TCP*-based traffic required special attention which could have otherwise been avoided if cross layer interaction was permitted.

The IEEE 802.11e MAC layer standard [1] is chosen to be the foundation for providing throughput management capabilities in a *WLAN*. In particular, the throughput management capability is provided using the IEEE 802.11e *Enhanced Distributed Channel Access* (*EDCA*).

The *EDCA* mechanism supports service differentiation across 4 different Access Categories (*AC*). Each *AC* has specific tunable parameters associated to it, which affects the level of probabilistic medium access it obtains against other *ACs*. The implementation and control objective of tuning parameters within *EDCA* are left open in the IEEE 802.11e standard [1].

We describe the process of selecting appropriate settings for the tunable parameters associated with each *AC* such that a specified throughput proportion allocation can be achieved between each *AC*. The selection process is aided by an analytical model of IEEE 802.11e *EDCA* under *saturation* load conditions [2]. The model allows us to identify, when

under *saturation* load conditions, the parameter combinations that achieves a required throughput proportion allocation amongst *ACs* and at the same time maximizes overall throughput performance.

Based on this information, we define *Control Scheme-1* that resides within the access point (*AP*) and, as required, notifies all stations in the *WLAN* what required parameters should be associated with each *AC*. Through this process, regardless of dynamically changing active station counts transmitting a particular *AC* traffic, we demonstrate the control scheme's ability to maintain a required throughput proportion allocation regime between *ACs*.

We then proceed to specify throughput proportion allocations between Downlink (DL) and Uplink (UL) paths in a *WLAN* under *saturation* load. *EDCA* allows for differentiating the *AP* and wireless client stations through the use of independent tunable parameters specifically associated to the *AP*. We make use of this feature directly by describing an updated parameter selection process. Therefore based on the new selection of parameters, we describe the new *Control Scheme-2* and demonstrate its ability to manage the *WLAN*.

We then investigate a new objective of developing a control that can also operate in *non-saturation* load conditions. In doing this, we still aim to maintain, wherever possible, the requirements of managing the throughput proportion allocation between the DL and UL and its respective *ACs*, and all the while focussing on maximizing throughput performance.

In order to achieve this goal, we divided the modification of *Control Scheme-2* into two parts. The first being modifications required to handle *non-saturation* load conditions in DL and subsequently modifications required to handle *non-saturation* load conditions in UL.

With both DL and UL modifications in place we verify that the completed control mechanism *Control Scheme-3* is able to achieve the required performance results across a wide range of test case scenarios. In addition, we compare these performance results to that obtained when employing the standard reference implementation of IEEE 802.11e *EDCA* [1].