Bandwidth Allocation for Quality of Service Provision in IEEE 802.16 Systems

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Contents

List of Tables

List of Figures

Signed Statement

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Dedication

This thesis is dedicated to my mum and dad.

Abstract

This thesis investigates various aspects of bandwidth allocation and scheduling in the Medium Access Control (MAC) layer of IEEE 802.16 systems. We highlight the important aspects of designing a scheduler and describe the scheduler design problem from a general perspective. That is, we provide a scheduler design framework driven by a set of objectives defined for the systems. In addition, we include Subscriber Station differentiation into our scheduler design. This approach is comprehensive, as it covers the requirements of both the network provider and the end users.

In developing the framework, we discuss the importance of achieving customer satisfaction. This leads to an interesting objective that maximises the number of satisfied customers, rather than network centric objectives, such as fairness. We contend that providing fairness to customers does not necessarily achieve the best outcome for customer satisfaction and artificially limits the choices available to service providers.

In order to maximise the number of satisfied customers, we analyse in detail the Dual-Queue (DQ) scheduling discipline proposed by Hayes *et al.* [2]. The DQ algorithms of Hayes' work are focused on wireline networks, and are not directly deployable in an 802.16 environment, as we discuss in this thesis. We propose a modified DQ implementation for 802.16 systems to handle real-time services. In 802.16 systems, there are two scheduling processes that we need to consider: Downlink (DL) scheduling for data transmission from the Base Station to the Subscriber Stations and Uplink (UL) scheduling for data transmission from the Subscriber Stations to the Base Stations. We investigate the DL and UL implementations separately

because the UL scheduling process is more complicated due to the fundamentally distributed nature of the problem.

We demonstrate that our proposed approach is able to operate effectively in an 802.16 system. We then compare the performance of our proposed DL and UL Dual-Queue schedulers to a Weighted Fair Queue scheduler in noisy environments, where re-transmissions are required. In addition, we also compare our proposed schedulers to an enhanced Weighted Fair Queue scheduler with an Explicit Packet Dropping mechanism. Furthermore, we show that our Dual-Queue system can handle mixed traffic profiles, such as video and voice.

Having proposed a DQ implementation that maximises the number of satisfied customers, we investigate alternative objectives that the DQ scheduler may try to achieve. We find that our proposed DQ implementation may fail to achieve these alternative objectives, and hence, we remedy this shortfall by proposing the Priority-Based Dual-Queue scheduler, which is made up of multiple DQs differentiated by the priority classes of connections. That is, each priority class is handled in a separate DQ. The Priority-Based Dual-Queue scheduler ensures connections that belong to the highest priority class are served ahead of connections that belong to lower priority classes at all times, even when there are changes in the priority class of connections in the system.

Lastly, we investigate the benefits of carrying out the DQ scheduling for both the DL and UL of an 802.16 network jointly. We first investigate a scenario where the network consists of only one-directional connections. We propose a joint scheme that is able to maximise the number of satisfied one-directional connections in the network. We then extend our investigation to another scenario where the network consists of bi-directional sessions, such as Voice over IP and video conferencing. In this case, we propose two joint schemes, which are able to maximise the number of satisfied bi-directional sessions.