Chapter 9
Admission Control and Scheduling for QoS Provisioning in WiMAX Networks

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ABSTRACT

Although the IEEE 802.16 standard, popularly known as WiMAX, defines the framework to support real-time and bandwidth demanding applications, traffic control mechanisms, such as admission control and scheduling mechanisms, are left to be defined by proprietary solutions. In line with that, both industry and academia have been working on novel and efficient mechanisms for Quality of Service provisioning in 802.16 networks. This chapter provides the background necessary to understand the scheduling and the admission control problems in IEEE 802.16 networks. Moreover, it gives a comprehensive survey on recent developments on algorithms for these mechanisms as well as future research directions.

INTRODUCTION

The IEEE 802.16 (2004) standard, often referenced as WiMAX (Worldwide Interoperability for Microwave Access Forum), has been developed aiming at standardizing the broadband wireless technology. The standard defines the air interface and the medium access protocol for Wireless Metropolitan Area Networks (WMAN), providing high transmission rates for commercial and residential access to the Internet.

In order to provide support to the big diversity of applications available on the Internet, such as voice, video and multimedia services as well as files transfer, the standard and its extension, IEEE 802.16e (2005), define signaling mechanisms between the base station and the subscriber stations and also five service levels: unsolicited grant service, real-time polling service, extended real-time polling service, non-real-time polling service and best-effort. In both directions, uplink (from the subscriber stations to the base station) and downlink (from the base station to the subscriber stations), the packets are associated with a service flow by the Medium Access Control

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(MAC) layer. A set of Quality of Service (QoS) parameters, maximum latency and minimum rate among them, is associated with each flow.

Despite such services provide the basis for QoS provisioning, a complete solution requires traffic control mechanisms, such as admission control and scheduling, not defined in the standard. The traffic control mechanisms enable a balance between the utilization of the network resources and the Quality of Service provisioning. Conservative mechanisms can increase the level of QoS offered to the users but, on the other hand, can result in a low network utilization. An aggressive traffic control, in turn, can increase the network utilization on the account of Quality of Service degradation. This tradeoff between utilization and Quality of Service is of fundamental importance in WiMAX networks, which aggregate different types of traffic in a limited resources architecture.

The scheduling mechanism aims at guaranteeing the bandwidth required by the subscriber stations as well as enabling the efficient wireless link usage. In a WiMAX point-multipoint topology network, the downlink scheduling requires a single scheduler at the base station, whereas the uplink scheduling needs two components, one of them at the base station and the second one at the subscriber station. The base station scheduler allocates bandwidth for the subscriber stations and the subscriber station scheduler determines which packets will be sent in the received transmission opportunities. The admission control mechanism restricts the number of users simultaneously present in the network so as to avoid the wireless link saturation and, consequently, violation of QoS contracts.

Though admission control and scheduling are distinct mechanisms, investigation is essential on mechanisms operating in conjunction so that the WiMAX networks fulfill one of their main purposes: to provide high data rates with Quality of Service. The rest of this chapter discusses in more details the admission control and scheduling mechanisms in WiMAX networks and presents a survey of the solutions proposed in the literature.

BACKGROUND

The architecture of a network utilizing the IEEE 802.16 standard has two main elements: Base Station (BS) and Subscriber Station (SS). The BS makes the communication between the wireless network and the core network, whereas the SS provides the user access to the core network by establishing connections with the BS in a Point-Multipoint (PMP) topology. The standard also allows Mesh topologies (optional). The main difference between the PMP and Mesh topologies lies on the fact that in a PMP network the traffic flows only between the BS and the SSs, whereas in the Mesh mode, the traffic can be routed through the SSs and can occur directly between two SSs. In this chapter we will analyze PMP topology networks.

The physical layer operates in a frames format, which are subdivided in time intervals called physical slots. In each frame, the slots are organized in a downlink sub-frame and an uplink sub-frame. The downlink sub-frame is utilized by the BS for the transmission of data and control information to the SSs. The uplink sub-frame is shared among all SSs for transmissions addressed to the BS.

The IEEE 802.16 standard allows two physical medium access modes: Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD). In the FDD mode the downlink and uplink channels operate simultaneously in different frequencies. In the TDD mode the uplink and downlink sub-frames share the same frequency, and so it is not possible to perform simultaneous transmissions in both directions. Each TDD frame has a downlink sub-frame followed by an uplink sub-frame.

The Medium Access Control (MAC) layer is connection oriented. Each connection is identified by a 16 bit identifier (Connection Identifier