Chapter 4

Quality of Service in Heterogeneous Traffic Wireless Systems

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ABSTRACT

The use of real-time delay-sensitive applications in wireless systems has significantly increased during the last years. Consequently, the demand to guarantee certain Quality of Service (QoS) is a challenging issue for the system’s designers. On the other hand, the use of multiple antennas has already been included in several commercial standards, where the multibeam opportunistic transmission beamforming strategies have been proposed to improve the performance of the wireless systems. A cross-layer based dynamically tuned queue length scheduler is presented in this chapter, for the Downlink of multiuser and multiantenna WLAN systems with heterogeneous traffic requirements. An opportunistic scheduling algorithm is applied, while users from higher priority traffic classes are prioritized. A trade-off between the throughput maximization of the system and the guarantee of the QoS requirements is obtained. Therefore the length of the queue is dynamically adjusted to select the appropriate conditions based on the operator requirements.

INTRODUCTION

The demand for using in-home Wireless Local Area Networks (WLANs) to support real-time delay-sensitive applications such as voice, video streaming or online-gaming has been remarkably growing during the last years. However, current IEEE 802.11 WLAN systems fail to fulfil the strict Quality of Service (QoS) requirements in terms of maximum allowed delay and/or delay jitter for such applications. The fact that the wireless environments are characterized by a harsh scenario for communications adds certain difficulties to guarantee QoS in WLAN based systems, where the wireless channel suffers from multiple undesired effects such as deep fades and multipath that produce errors to the original information. Therefore, providing QoS by
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using the scarce resources in the home wireless medium is a challenging aspect for such system objective.

Different notions of QoS are available at different communication layers (Zorba & Perez-Neira, 2007). At the physical layer, QoS means an acceptable signal strength level and/or Bit Error Rate at the receiver, while at the Data Link Control (DLC) or higher layers, QoS is usually expressed in terms of minimum guaranteed throughput, maximum allowed delay and/or delay jitter. The fulfillment of QoS requirements depends on procedures that follow each layer. At the DLC layer, QoS guarantees can be provided by appropriate scheduling and resource allocation algorithms, while at the physical layer, adaptation of transmission power, modulation level or symbol rate are employed to maintain the link quality.

The consideration of the physical layer transmission characteristics from the higher layers can significantly improve the efficiency of the wireless systems. The vertical coupling among layers is well-known as Cross-Layer (Shakkottai, Rappaport & Karlsson, 2003). Cross-layer between the physical layer and the higher layers seems to be unavoidable in wireless environments in order to exploit the physical layer instantaneous conditions. Such kind of schemes is needed to guarantee the QoS requirements in heterogeneous traffic systems, where the network includes users with different applications and different QoS restrictions. Cross-Layer further advantages can include improvements in terms of link throughput, reduction of the network latency, energy savings in the mobile nodes or minimization of transmitted power (Shakkottai, Rappaport & Karlsson, 2003).

One of the system resources that can be employed to improve the system performance in terms of both rate and QoS is the spatial resource. The Multiple-Input-Multiple-Output (MIMO) technology in multiuser scenarios shows very interesting results as several users can be simultaneously serviced within the same frequency, time and code. Its employment has been already standardized in IEEE 802.11n and IEEE 802.16e, while it is expected to be part of 4th Generation Long Term Evolution (LTE) Standard. Among all the techniques within the MIMO technology, the Multibeam Opportunistic Beamforming (MOB) strategy has been suggested in (Sharif & Hassibi, 2005) to boost the wireless link capabilities, showing high performance, low complexity design and only partial channel information is required at the transmitter side. MOB can be operated and adopted to fulfill the QoS requirements demanded by the users for their correct operation (Zorba & Perez-Neira, 2007).

An interesting remark concerning the QoS compliance in commercial wireless systems refers to the outage concept (Chalise & Czylwik, 2004), where due to the wireless channel characteristics, the 100% satisfaction of the strict QoS demands is impossible, for what is known as outage in the QoS requirements (Chalise & Czylwik, 2004). The notion of outage is widely used in cellular systems where several commercial systems (e.g. GSM and WCDMA) allow for 2-5% outage. Therefore, the extension of the QoS outage to WLAN based systems, when running delay-sensitive applications, seems to be the most tractable approach to asset their efficiency.

Taking into account the aforementioned concepts, the main contribution of this chapter is to propose a Dynamic Queue Length in the Data Link Control Layer, in order to guarantee certain QoS, in the Downlink of multiuser and multiantenna WLAN systems with heterogeneous traffic. Therefore, the proposed solution considers both the physical and application layers characteristics of the system. To be more precise, the length of the queue depends on the QoS system requirements, in terms of the system throughput and the maximum allowed delay (and jitter) of the delay-sensitive applications, where some outage is considered in the QoS requirements of these applications.
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