Chapter 8.9
Advanced Scheduling Schemes in 4G Systems

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ABSTRACT

The deterministic factor for 4G wireless technologies is to successfully deliver high value services such as voice, video, real-time data with well defined Quality of Service (QoS), which has strict prerequisite of throughput, delay, latency and jitter. This requirement should be achieved with minimum use of limited shared resources. This constraint leads to the development and implementation of scheduling policy which along with adaptive physical layer design completely exploit the frequency, temporal and spatial dimensions of the resource space of multi-user system to achieve the best system-level performance. The basic goal for scheduling is to allocate the users with the network resources in a channel aware way primarily as a function of time and frequency to satisfy individual user's service request delivery (QoS guarantee) and overall system performance optimization. Advanced scheduling schemes consider cross-layer optimization principle, where to fully optimize wireless broadband networks; both the challenges from the physical medium and the QoS-demands from the applications are to be taken into account. Cross-layer optimization needs to be accomplished by the design philosophy of jointly optimizing the physical, media access control, and link layer, while leveraging the standard IP network architecture. Cross-layer design approaches are critical for efficient utilization of the scarce radio resources with QoS provisioning in 4G wireless networks and beyond. The scheduler, in a sense, becomes the focal point for achieving any cross-layer optimization, given that the system design allows for this. The scheduler uses information from the physical layer up to the application layer to make decisions and perform optimization. This is a fundamental advantage over a system where the intelligence is distributed throughout the all entities of the network. In this chapter, the authors present an overview of the basic scheduling schemes as well as investigate advanced scheduling schemes particularly in OFDMA and packet scheduling schemes in all-IP based 4G systems. Game theoretic approach of distributed scheduling, which is of particular

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importance in wireless ad hoc networks, will also be discussed. 4G wireless networks are mostly MIMO based which introduces another degree of freedom for optimization, i.e. spatial dimension, for which scheduling in MIMO systems is very much complicated and computation intensive. MIMO resource allocation and scheduling is also covered in this chapter. The key research challenges in 4G wireless networks like LTE, WiMAX and the future research direction for scheduling problems in 4G networks are also presented in this chapter.

INTRODUCTION

Next-generation wireless communication systems are expected to provide a wide range of services with high as well as time-varying bandwidth requirements, with various QoS constraints. Rapid growth of wireless technology, coupled with the explosive growth of the Internet, has increased the demand for wireless data services. Traffic on 4G networks like LTE, WiMAX is heterogeneous with random mix of real and non-real time traffic and applications requiring widely varying and diverse QoS guarantee. This enforces a robust and application specific optimization of limited system resources. The allocation and management of resources are crucial for 4G wireless networks, in which the scarce wireless spectral resources are shared by multiple users with the objective of satisfying demanding requirements. The requirement of providing end-to-end QoS with scarce resources calls for high spectral efficiency. To fulfill these two requirements of high spectral efficiency and QoS provision in the highly dynamic environment of mobile radio requires the collaboration of several layers in the system and effectively demands for an optimization scheme which is cross-layer adaptive. In wireless networks particular, the different layers interact in a nontrivial manner in order to support information transfer. In cross-layer design of wireless networks, a number of physical and access layer parameters are jointly controlled in synergy with higher layer functions like resource allocation, admission control and routing. In layered networking architecture, each layer is designed and operated independently to support transparency between layers. Among these layers, the physical layer is in charge of raw-bit transmission, and the medium access control (MAC) layer controls multiuser access to the shared resources. However, wireless channels suffer from time-varying multipath fading; moreover, the statistical channel characteristics of different users are different. The sub-optimality and inflexibility of this architecture result in inefficient resource use in wireless networks. We need an integrated adaptive design across different layers. Therefore, cross-layered design and optimization across the physical (PHY) and MAC layers are desired for wireless resource allocation and scheduling. In short, to achieve the prerequisite service guarantees like high minimum data rate, low latency, user fairness of next generation wireless networks, proper designing of cross-layer optimized system is very important. In a packet network, one important component to achieve the aforementioned efficiency goals is a properly designed scheduling and resource allocation algorithm. Scheduling plays an important role in providing QoS support to multimedia communications in various kinds of wireless networks, including cellular networks, mobile ad hoc networks, and wireless sensor networks. Scheduling is basically a kind of cross layer optimization method mainly involving PHY and MAC to manage the system resources adaptively to achieve the system goal. If we choose PHY and MAC layers to optimize the network resources, the best way to meet the objective is by exploiting the frequency and temporal dimension of the resource space. Scheduling optimization approaches attempt to dynamically match the requirements

QoS-Constrained Resource Allocation Scheduling for LTE Network
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