Chapter 8

Guaranteeing User Rates With Reinforcement Learning in 5G Radio Access Networks

Ioan-Sorin Comșa  
Brunel University London, UK

Sijing Zhang  
University of Bedfordshire, UK

Mehmet Emin Aydin  
University of West of England, UK

Pierre Kuonen  
University of Applied Sciences of Western Switzerland, Switzerland

Ramona Trestian  
https://orcid.org/0000-0003-3315-3081  
Middlesex University London, UK

Gheorghiță Ghinea  
Brunel University London, UK

ABSTRACT

The user experience constitutes an important quality metric when delivering high-definition video services in wireless networks. Failing to provide these services within requested data rates, the user perceived quality is strongly degraded. On the radio interface, the packet scheduler is the key entity designed to satisfy the users’ data rates requirements. In this chapter, a novel scheduler is proposed to guarantee the bit rate requirements for different types of services. However, the existing scheduling schemes satisfy the user rate requirements only at some extent because of their inflexibility to adapt for a variety of traffic and network conditions. In this sense, the authors propose an innovative framework able to select each time the most appropriate scheduling scheme. This framework makes use of reinforcement learning and neural network approximations to learn over time the scheduler type to be applied on each momentary state. The simulation results show the effectiveness of the proposed techniques for a variety of data rates’ requirements and network conditions.

DOI: 10.4018/978-1-5225-7458-3.ch008
1. INTRODUCTION

The accelerated acquisition of powerful mobile devices is significantly contributing to the growing market of immersive multimedia applications. According to Cisco (2017), it is envisioned that by 2021 more than 80% of total mobile data will be represented by video traffic at different data rate requirements. In this context, the end-user Quality of Experience (QoE) will make the difference between network operators while providing these pretentious services (Trestian, Comsa, and Tuysuz, 2018). According to Ghinea, Timmerer, Lin, and Gulliver (2014), the concept of Multiple Sensorial Media (Mulsemedia) can enhance the user perceived QoE when experiencing poor video quality by incorporating additional senses such as: olfaction, wind, haptic, etc. However, the real factor that impacts the video quality degradation is denoted by the QoS provisioning schemes on the wireless interface that can differ from one operator to another. By providing higher video rates than the requested limit, the rate of packet drops is increased in order to keep the normal functionality of video decoders. On the other side, lower data rates for video services will increase the packet delays which have as a consequence a larger number of lost packets at the radio interface. Thus, guaranteeing certain data rates for video traffic is crucial in order to avoid the degradation of user perceived quality.

In 5th Generation (5G) of mobile communications standard, guaranteeing certain bit rate requirements is even stricter especially with the popularity of the new bandwidth hungry applications (i.e. high definition video, virtual reality traffic) (Elbamby, Perfecto, Bennis, and Doppler, 2018). This puts a significant pressure on Radio Resource Management (RRM) to provide these immersive services with very stringent QoS in multi-user scenarios (Li et al. 2017). Alongside of other RRM functions, the packet scheduler is in charge of allocating user data packets in frequency domain at each predefined Transmission Time Intervals (TTIs). According to Comşa (2014a), the scheduling process is conducted based on the scheduling rules aiming to maximize the satisfaction of particular QoS requirements. In literature, several scheduling rules are proposed to deal with the Guaranteed Bit Rate (GBR) objective. For example the scheduling rule proposed by Lundevall et al. (2004) is designed to work for WCDMA access networks and very low data rates of video services. Andrews, Qian, and Stolyar (2005) propose a scheduler for CDMA downlink networks in which a maximum number of 40 users are scheduled with the maximum rate of 160kbps. In the same type of access networks, the scheduler proposed by Kolding (2006) outperforms other GBR oriented schedulers for the considered networking scenarios. However, the proposed schedulers work appropriate only for particular scheduler states in terms of: access technologies, user rates, channel conditions, traffic load, etc. On one hand, these scheduling techniques must be upgraded for the novel access technologies imposed by 5G standard. On the other hand, the aim would be to use each of these scheduling rules on the best matching scheduler state in order to maximize over time the satisfaction of user rate requirements for various traffic types.

The proposed scheduling optimization problem must determine at each TTI the radio resources to be selected for all the active users as well as the most convenient scheduling rule to be followed in order to get the maximum possible GBR satisfaction outcome according to the scheduler momentary states. According to the selected scheduling rule, the resource allocation performs the frequency prioritization by favoring those users with poorer GBR satisfaction profile. If this frequency prioritization can be easily computed each TTI by simply calculating given scheduling metric for each user and radio resource, the scheduling rule selection must be a priori decided based on the momentary scheduler states. The idea is learn over time some preference values by applying random scheduling rules in many visits of scheduler states. But for the GBR-based maximization problem, this solution is unfeasible since the