Chapter 8
Spectrum Sharing for D2D Communications in Fifth-Generation Wireless Networks

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ABSTRACT

In this chapter, the authors discuss various spectrum sharing techniques to enable device-to-device (D2D) communications over the licensed spectrum. First, they highlight the need of spectrum sharing in fifth-generation (5G) wireless and mobile networks. Then, they formulate the expressions of useful performance metrics e.g., outage probability, achievable sum-rate, and spectral efficiency of these schemes to refine physical layer design aspects. To give a better picture, they deduce some major practical scenarios where these techniques can play a crucial role in deploying future generation wireless networks. They also cover relevant literature on the spectrum sharing and D2D communications. Numerical and simulation results are provided to elucidate the effect of various system/channel parameters on the considered spectrum sharing schemes over Nakagami-m fading channels.

INTRODUCTION

Wireless spectrum is one of the most critical resources necessary to realize radio communications. The utilization of spectrum is regulated throughout the world to provide data-oriented services while shielding from harmful interferences. Recent studies have shown that the large portion of the available spectrum is underutilized (Kaufman, Lilleberg, & Aazhang, 2013; Ye, Wu, Shu, & Qian, 2016). These studies also suggest the concept of spectrum sharing with the secondary system by employing advanced radio and signal processing techniques to enable direct communications between devices (Asadi, Wang, & Mancuso, 2014 and references cited therein). As the spectrum is becoming congested day by day, there is an urgent need to adopt flexible spectrum sharing techniques for the next generation wireless and mobile

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communication networks. In fact, these techniques can provide a promising solution to compensate the spectrum scarcity. First, the exploitation of spectrum sharing techniques has been introduced in cognitive radio by utilizing the concept of white spaces of the spectrum (Tandra, Mishra, & Sahai, 2009). Albeit, these approaches have also shown a great deal in enabling direct communication between devices to offload the cellular traffic at the base station (BS). As such, the device-to-device (D2D) communications can be regarded as a potential candidate for fifth-generation (5G) wireless communications and mobile networks due to its distinct features, e.g., proximity gain and efficient BS off-loading (Tehrani, Uysal, & Yanikomeroglu, 2014). Additionally, some recent works have highlighted its attribute as an intrinsic part of realizing sustainable and intelligent internet of things (IoT) environment (Bello & Zeadally, 2016). For instance, when the wireless devices are in proximity, the direct communications between them can offer an indispensable feature for multimedia applications, e.g., monitoring, video gaming, and file sharing.

The major practical scenarios where D2D communications can be employed for future wireless networks are demonstrated in Figure 1. In particular, when wireless communications are realized on higher frequency bands (above 3 GHz or mmWave communications), the problem of ubiquitous coverage can be resolved by employing D2D communications for providing relay cooperation to the licensed users. Other scenarios such as content distribution and cellular offloading can play a vital role in enabling more number of connected devices while compensating the heavy traffic on the BS. For instance, machine-to-machine communications and vehicular communications could be other realistic scenarios for realizing D2D communications. Further, in this section, a brief discussion on the concept of Ad-hoc networks, classification of D2D communications, and the details of current standardization of D2D communications are presented. In the next section, the descriptions of different state-of-art spectrum sharing techniques are provided. In the third section, this chapter first covers the recent developments and then it addresses key challenges for enabling spectrum sharing in the licensed band. In the fourth section, it introduces a

Figure 1. Practical scenarios of spectrum sharing for D2D communications