Chapter 33
Exploiting Polarization for Spectrum Awareness in Cognitive Satellite Communications

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ABSTRACT
The continuously increasing demand of spectrum and current static spectrum allocation policies are rendering the available radio spectrum scarce. To address the problem of spectrum scarcity in the satellite paradigm, cognitive satellite communications has been considered as a promising technique. In addition to the existing spectrum sharing dimensions such as frequency, time, and space, polarization can be exploited as an additional degree of freedom in order to explore the spectral gaps in the under-utilized licensed spectrum. In this context, this chapter firstly provides an overview of the existing works in polarization-based spectrum sharing. Secondly, it presents the theoretical analysis of energy detection technique for dual polarized Additive White Gaussian Noise and Rayleigh fading channels considering the spectral coexistence scenarios of dual and hybrid satellite systems. Thirdly, it provides the comparison of different combining techniques in terms of the sensing performance. Finally, it provides interesting future research directions in this domain.

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1. INTRODUCTION

Due to the increasing demand of broadband spectrum caused by a rapidly growing market for wireless multimedia services, current static allocation policy faces spectrum scarcity in particular spectrum bands and a significant amount of spectrum remains underutilized for almost 90% of time (Federal Communications Commission, 2002). Recent analysis in (Federal Communications Commission, 2010) suggests that the broadband spectrum deficit is likely to approach 300 MHz by 2014. Therefore, it becomes an important research challenge to investigate new network architectures which have ability to support higher system throughput and energy efficiency, providing a large-scale coverage. With regard to Satellite Communications (SatComs), there has been a continued pressure on satellite bands, especially in L and C bands due to the introduction of new terrestrial services such as 3G mobile telephony, WiMAX and Wi-Fi services and higher frequency bands i.e., Ku and Ka bands have been assigned for different satellite services. To enhance the system capacity, satellite systems have moved from payloads generating a single beam to the multi-beam platform. As in terrestrial cellular systems, multibeam satellite systems use frequency reuse concept to achieve the enhanced capacity. However, there is still a large gap to meet the spectral efficiency requirement for realizing the next generation Terabit/s satellites. In this context, investigating efficient spectrum sharing techniques in order to enhance the spectral efficiency while guaranteeing sufficient Quality of Service (QoS) is a highly relevant and challenging problem. This has led to the concept of cognitive SatComs which exploits spectrum sharing opportunities for the coexistence of two satellite systems or satellite and terrestrial systems (Sharma, S.K. Chatzinotas, S. & Ottersten, B., Sept. 2012) (Sharma, S.K., Chatzinotas, S., & Ottersten, B., 2013). Although the spectrum sharing literature is more mature in the terrestrial context, it has received limited attention in the satellite context. Recent contributions exploiting spectrum sharing opportunities in the context of cognitive SatComs include (Sharma, S.K. Chatzinotas, S. & Ottersten, B., Sept. 2012), (Yeo Hun Yun, & Joon Ho Cho, 2009) (Yeo Hun Yun, & Joon Ho Cho, 2009) (Sharma, S.K., Chatzinotas, S., & Ottersten B., 2013) (Sharma, S.K., Chatzinotas, S., & Ottersten, B., 2013) (Sharma, S.K., Chatzinotas, S., Ottersten, B., 2013) (Sharma, S.K., Chatzinotas, S., & Ottersten, B., 2014) etc. Furthermore, a few recent contributions have exploited the polarization domain for spectrum sharing purpose (Liu, F., C. Feng, C. Guo, Wang, Y., & Dong W., 2009) (Liu, F., Chuyen F., Caili G., Wang, Y., & Dong W., 2010) (Sharma,S.K., Chatzinotas, S., & Ottersten, B.) (Sharma, S.K., Chatzinotas, S., and Ottersten, B., 2012) (Caili Guo, Xiaobin Wu, Chuyen Feng, & Zhimin Zeng, 2013). In this chapter, firstly, we provide the importance of the polarization domain for spectrum sharing and then exploit it as an additional degree of freedom (dof) in order to investigate efficient SS and transmission schemes in the context of cognitive SatComs. Generally, Fixed Service Satellites (FSS) and terrestrial BS antennas use horizontal (H) and vertical (V) polarization, whereas Direct Broadcast Satellites (DBS) may use left and right hand circular polarization as well as H/V polarization. The state of polarization is important in determining the energy transfer efficiency between transmit and receive antennas (Stapor, 1995). By deploying two orthogonally polarized antennas, any type of receive or transmit polarization can be derived. Detecting the polarization state in addition to the energy of a certain carrier frequency can significantly enhance the spectrum efficiency by investigating suitable cognitive techniques in the polarization domain.

We consider the following two practical coexistence scenarios: (i) Dual satellite coexistence, and (ii) Hybrid satellite coexistence. For the dual satellite coexistence scenario, we consider Energy Detection (ED) technique for dual polarized Additive White Gaussian Noise (AWGN) channels using a dual polarized antenna. Subsequently, different combining techniques such as Maximum Ratio Combining (MRC),