

論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Coexistence Analysis for TV White Space Spectrum
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出典(和文)	学位:博士（学術）, 学位授与機関:東京工業大学, 報告番号:乙第4133号, 授与年月日:2016年9月30日, 学位の種別:論文博士, 審査員:高田 潤一,高橋 邦夫,山下 幸彦,秋田 大輔,府川 和彦
Citation(English)	Degree; Conferring organization: Tokyo Institute of Technology, Report number:乙第4133号, Conferred date:2016/9/30, Degree Type:Thesis doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	要約
Type(English)	Outline

Coexistence Analysis for TV White Space Spectrum

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Doctoral Thesis Outline

TV white space (TVWS) spectrum refers to the underutilized TV bands that are opened up for unlicensed use. Utilizing TVWS spectrum would result in more efficient and effective use of frequency spectrum and encourage the development of new and innovative unlicensed services benefiting the public. This thesis presents the study of coexistence between TVWS systems and digital TV (DTV) broadcast services. The thesis is constructed as follows.

Chapter 1 highlights the benefits of utilizing TVWS and gives an introduction to the thesis. The objective of this thesis is to identify the necessary conditions for harmonious coexistence between different types of DTV services and different types of whitespace devices (WSDs). The purpose is to protect the incumbent DTV service from the TVWS system that shares the spectrum. In principle, a WSD should maintain a keep-out distance d_k from a DTV receiver to avoid causing excessive interference to the latter. The challenge is that d_k varies with different circumstances. This thesis adopts a theoretical approach in evaluating d_k and other related parameters. Chapter 1 sets out the working direction for the remaining chapters.

Chapter 2 surveys various TV service requirements specified by different regulatory bodies, which allow us to calculate their respective coverage sizes. A survey is then presented on the standardized TVWS technologies: the IEEE 802.22 Wireless Regional Area Network (WRAN), IEEE 802.11af Wireless Local Area Network (WLAN), and IEEE 802.15.4m Low-Rate Wireless Personal Area Network (LRWPAN). This is followed by a survey on the proposed rules of governing TVWS utilization, which include the protection criteria required for TV broadcast, wireless microphones and other low power auxiliary stations. We conclude Chapter 2 by discussing the challenges of utilizing TVWS and its future.

Chapter 3 determines the necessary conditions for the coexistences between different types of WSDs and different types of DTV services, conditioned on the WSDs' co-channel, first and second adjacent channel operations. It considers three types of DTV services, i.e. the

Integrated Services Digital Broadcasting - Terrestrial (ISDB-T), Advanced Television Systems Committee (ATSC), and Digital Video Broadcasting - Terrestrial (DVB-T). And three types of WSD are considered, i.e. fixed WSD (FWSD), personal/portable WSD (PWSD), and sensing WSD (SWSD). FWSD and PWSD are governed by geo-location database (GDB), SWSD is not. SWSD performs spectrum sensing to detect a list of available DTV channels. Chapter 3 proposes a method of assigning the DTV channels to TVWS system that is deployed outside the DTV service contour in a cellular form. Novel contributions are made in identifying SWSD's operational channels and allowable transmit powers in the ISDB-T, ATSC, and DVB-T service areas, and identifying PWSD's operational channels near DTV service border.

Chapter 4 investigates the sensing criteria of SWSD that uses spectrum sensing to identify the list of available DTV channels. We quantify the level of sensitivity required for SWSD operations within the ISDB-T, ATSC, and DVB-T service areas. Sensing requirement expressed in terms of the smallest detectable signal power and the minimum number of energy samples to be collected is assessed. Chapter 4 also evaluates the effect of multipath fading. The losses in sensing accuracy caused by Rayleigh, Nakagami- m , and Nakagami-Rice fadings are quantified. We then introduce cooperative sensing to counter the effect of fading. The efficacies of two approaches of combining the sensing results, i.e. equal gain combining (EGC) and selection combining (SC), are assessed. We make novel contributions in deriving theoretical expressions for the average probabilities of detection (of EGC and SC techniques) in the presence of Nakagami- m and Nakagami-Rice fadings.

Chapter 5 concludes this thesis by giving an overall summary to all the works and highlighting the achievements. At the end, we present some suggestions for future works.