Issues and Resolution Efforts Pertaining to TV Whitespace Usage

Muhammad A. Raza, Zafar Iqbal, 이승찬, 최해웅, 이흥노*
광주과학기술원 정보통신공학부

raza@gist.ac.kr, zafar@gist.ac.kr, seungchan@gist.ac.kr,
haeung@gist.ac.kr, heungno@gist.ac.kr*

Muhammad A. Raza, Zafar Iqbal, Seungchan Lee, Haeung Choi, Heung-No Lee*
Gwangju Institute of Science and Technology
School of Information and Communications

Abstract

In TV broadcasting the whitespace refers to TV channels that are allocated to licensed operators but not being used by them locally. This results in inefficient utilization of the resource. On the other hand the increased usage of wireless communicating devices, especially unlicensed devices are facing difficulty in finding frequency spectrum to operate. In order to meet their demand it is proposed to grant permission to unlicensed devices to operate on TV channels not being used in their geographic region. When unlicensed WSOs operate freely it is quite possible that a WSO can cause interference to another WSO operating on same channel in the same geographic region. This situation is called as coexistence issue. This paper summarizes the common coexistence issues in TVWS system. The IEEE 802.19.1 working group has presented a draft to cope with coexistence issues. The architectural components of 802.19.1 are also summarized in the paper.

Ⅰ. INTRODUCTION

Digitization of Television (TV) transmission relinquished much of the TV spectrum. The TV spectrum that is not being used by licensed operators locally is referred as TV Whitespace (TVWS). In order to improve its utilization, unlicensed devices have been granted permission to operate in TVWS. Such device or their group is called as whitespace object (WSO). Due to unauthorized control of TVWS usage a WSO operating on a channel may be unaware of another WSO operating on the same channel, in its close proximity. Thus it may be causing interference to other WSO unknowingly. This situation is called as coexistence issue. Some of the working groups for wireless technologies are defining regulations to deal with coexistence issues and defining how to access TVWS band. The working groups (WG) of IEEE 802.22, 802.11, European Computer Manufacturers Association (ECMA)-392 etc. have initiated steps to include TVWS usage in the pertinent standard. For example 902.22 community develop MAC and PHY layer regulations to use TVWS, 802.11 WG include modification in MAC/PHY layer to meet requirements of channel access and coexistence issues in the TVWS. Similarly ECMA-392 has presented MAC and PHY layers for operation in TV Whitespace. However none of them considers coexistence issues among heterodyne WSOs, i.e. coexistence among WSOs operating on different wireless technologies. Therefore IEEE 802.19.1 working group presented a draft for resolving coexistence issues among heterodyne WSOs. In this paper we summarize some of the coexistence issues pertaining to the usage of TVWS band. This paper also provides a quick overview of the architectural components of IEEE 802.19.1 draft.

The coexistence issues are described in section II. The section III summarize the architecture of TVWS operation as defined in IEEE 802.19.1 draft. Finally section III concludes the paper.

Ⅱ. COEXISTENCE PROBLEMS IN TVWS OPERATIONS: SURVEY

In this section we present some issues pertaining to the usage of TVWS as presented in the literature. Since TVWS networks are deployed independently, without coordinating each other. Therefore individual network operators are unaware of each other's presence. If two or more networks are happened to be deployed to operate on the same channel they may interfere each other [1]. Even if they are using same wireless technology yet they cannot correct the issue due to unawareness of each other's location.

Another issue could arise due to networks of incompatible wireless technologies deployed in the region [2]. For example one network may be deployed using IEEE 802.22 technology while other may be deployed using ECMA-392 based technology. Due to incompatibility they may interfere each other, if both of them happen to operate on the same channel. The third aspect could arise due to social behavior of the

TVWS users [1]. When multiple WSOs are operating, it is quite possible that they may access TVWS channels extensively until it is depleted. This could lead to congestion in TVWS band and interfere shall increase rapidly. Another possible reason for interference could be out of band leakage from one network into another closely deployed. One of the possible reasons for frequency leakage could be due to poor designing or configuration of wireless transceivers.

A very common coexistence problem arises in densely populated areas due to scarcity of TVWS bands [1]. The frequency band available for TV operations is limited and in densely populated areas most of the TV bands are used by primary licensed operators. Since regulations mandates that the secondary users can use TV band only if primary user is not using it in spatio-temporal region. Thus in highly dens areas the TV bands available for TVWS operations is limited, demanding an efficient mechanism of spectrum sharing among secondary users.

Ⅲ. IEEE 802.19.1 SYSTEM

In order to regulate access to TVWS band, different working group for wireless technologies are developing their standard. For example IEEE 802.11 has made amendment, P802.11af, to their wireless local area network standard to incorporate support for TVWS operations. Similarly IEEE 802.22 has also included self-coexistence protocols and algorithms for wireless regional area networks to operate in the TVWS band. Moreover a European Computer Manufacturers Association (ECMA) has designed a standard named as ECMA-392 for operation in the TVWS. However none of them deal with inter-technology coexistence issues. In order to resolve coexistence issues (both intra and inter technology), IEEE 802.19.1 working group has presented a draft. The draft defines radio technology independent methods for coexistence among dissimilar or independently operated WSOs [13]. It outlines the coexistence system, its architectural and functional components, and their interrelations. The TVWS system is divided into three blocks. The main entity is the 802.19.1 coexistence system which is further divided into three logical components and five logical interfaces as shown in the Figure 1.The components of the architecture are defined as Coexistence Manager (CM), Coexistence Enabler (CE) and Coexistence Discovery and Information Server (CDIS). Note that WSO and TV Database (TVDB) do not belong to core 802.19.1 system. They interact with system through logical interfaces A and C respectively, as shown in the figure. The CE performs authentication and registration of a WSO to the system. It also acts as a communicating node between WSO and CM. The CM performs channel classification and selection mechanism in the system. It is also responsible for making coexistence decisions on identification of coexistence issues such as defined in Section II. It then instructs pertinent WSO to perform reconfiguration to solve identified coexistence problem. The CDIS maintains set of WSOs registered with CMs in the 802.19.1 system. It also defines set of nodes with overlapping transmission regions. The TVDB contains the location, operating area and schedule for all licensed TV operators. It also maintains list of available channels in each WSO region. The set of WSOs having overlapping transmission regions form a Coexistence Set (CS). The Coexistence Set Elements (CSE) shares a common channel. There are two possibilities for WSOs registration with 802.19.1 system. Firstly, all of the registered WSOs may belong to same CM and secondly the WSOs may belong to different CMs. In earlier case the channel sharing decisions among WSOs are made by the CM independently. However in former case the channel sharing decisions among interfering WSOs are made in consultation with pertinent CMs. The draft outlines algorithms for channel sharing in both of the scenarios.

The WSO and CE send registration request and reply, environment measurements request and reply, and reconfiguration request and results through logical interface A. All requests and replies related to WSO registration in the TVWS system took place between CM and CE through interface B1. The CM registration, coexistence set requests and replies between CM and CDIS took place through interface B2. Interface B3 is used for inter-CM communication for channel classification and coexistence solution procedures. The CM obtains available channel list and power management information for its registered WSOs from TV database through interface C. The detailed description of these components and interfaces is described in [13]. The 802.19.1 system also implements coexistence algorithms to provide coexistence services to WSOs. Two types of algorithms are defined in the draft; the discovery and the decision. The discovery algorithms are used by CDIS and CM to discover WSOs that may cause interference to each other. The discovery algorithm provides a CS for each WSO registered in the system. The CS is then executed by CM to alleviate the coexistence issues.

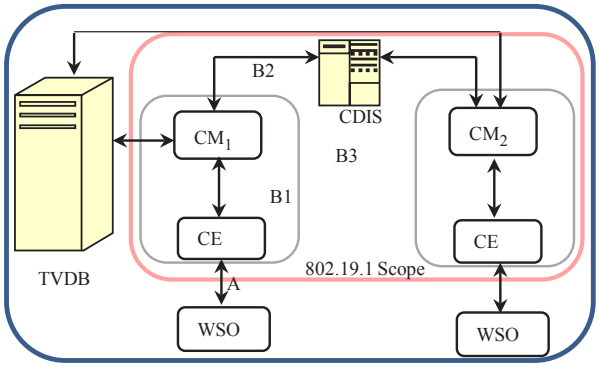

Figure 1 IEEE 802.19.1 TVWS System Architecture

The standard defined three topologies of the coexistence discovery and resolution mechanisms; the centralized, the autonomous and the distributed. In centralized case two or more CMs form a master slave relationship. The master CM performs all coexistence decisions for WSOs registered with it and for WSOs registered with its slave CMs. In autonomous decision making case each CM makes its channel selection decisions independent of other CMs. In distributed decision making case, a CM negotiates with other CMs about coexistence decisions.

IV. CONCLUSION

This paper reviewed the coexistence issues pertain to the usage of TVWS channels. Various wireless communication standards are focusing on defining measures for resolving the issues. In order to address the coexistence issues among heterodyne devices, the IEEE 802.19.1 working group has presented a coexistence system. The paper also summarizes the architectural components of the system and summarizes their functional aspects for coexistence decisions.

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