TV White Spaces Technical rules for Africa to enable efficient Spectrum Management

Jonathan PINIFOLO[1], Suvendi RIMER[1], Babu PAUL[1], Chomora MIKEKA[2], Justice SP MLATHO[2]

[1]*Department of Electrical and Electronic Engineering Science, University of Johannesburg , P.O. Box 524, Auckland Park Kingsway Campus, Johannesburg, South Africa*

[2]*Physics Department, University of Malawi, P.O. Box 230, Zomba, Malawi*

Abstract

Broadband Internet access has proved to be a key vital element of modern life and a crucial enabling factor for the global, information-age economy. TV White Spaces is one of the promising solutions for extending broadband connectivity to underserved areas employing UHF/VHF TV channels to allow the transmission of internet traffic over long distances using wireless communication. Regulators around the world are currently formulating rules and regulations that will facilitate deployment and access of TV White Spaces network. Radio Spectrum which is a finite resource is expected to accommodate voice and data traffic which is increasing at an unprecedented rate. Globally, traffic on mobile broadband networks has tremendously increased in the sense that current levels already exceed predictions made in 2010 for 2020. The statistics are in accordance to Huawei in China which is a global information and communications technology provider. As a result of the exploding popularity of many components being wireless in nature, the radio spectrum has become a scarce commodity in many countries and opening up of such UHF/VHF TV channels will definitely lead to increase in spectrum efficiency. Recent FCC rules permitting unlicensed use on a secondary basis of the TVWS promise a whole new set of possible applications. In an effort to ensure that these applications have been implemented, there is a need for creation and adoption of industry standards. FCC adopts a minimum distance between secondary user and TV service area to guarantee that the interference margin is not exceeded by secondary users. The transmission power for fixed secondary users is fixed to 4W which is a conservative setting. The principal objective of this paper is to present TV White Spaces Technical rules that are suitable for TVWS at Africa level to enable efficient spectrum Management.

Keywords: Spectrum, Malawi, Longley-Rice propagation model , DSA , TVWS.

1. Introduction

The Suggested Technical Rules and Regulations of Dynamic Spectrum Alliance (DSA) for the use of Television White Spaces contemplate that available frequencies and maximum transmit power for a white space device at a given location may be determined based on a geolocation and database method. In particular, database(s) designated by the regulator will provide this information based on the positional information from a master white space device, the height of the transmitting antenna (for fixed master devices), and use by licensed incumbents in or near the geographic area of operation of the white space device. The rules suggest that a database will supply a list of available frequencies and associated permitted transmit powers to white space devices pursuant to the algorithm in the Annexes A, B or C of DSA technical rules.

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Annexes A and B are based on the Longley-Rice propagation model. However, other point-to-point, terrain-based propagation models may also serve as the basis for spectrum availability calculations. One such model is the International Telecommunication Union's Radio communication Sector Recommendation P-1812 (ITU-R. P-1812). Like Longley-Rice, ITU-R. P-1812 is a path-specific propagation prediction method for point-to-area terrestrial services in the VHF and UHF bands (ITU).

The rest of the paper is organized as follows: related works are presented in Section II while Section III presents the interference mitigation strategy as proposed in the Malawi TVWS pilot network; the Malawi TVWS draft regulations are presented in Section IV and conclusion is drawn in Section V.

2. Related works

In this section, proposed interference mitigation approach using a cloud infrastructure for dynamic spectrum networks using spectrum resource as a service (SRaaS) will be discussed first, followed by regulatory framework as proposed by the Federal Communications Commission (FCC) and finally a discussion of the suggested technical rules and regulations for TVWS usage will be presented from the Dynamic Spectrum Alliance perspective.

1.1 SRaaS

Mfupe et al.(2014) propose "A Cloud Infrastructure for Dynamic Spectrum Networks Using Spectrum Resource as a Service (SRaaS)" In their paper, they envisage that future wireless dynamic spectrum networks (FWDSNs) will integrate techniques for rapid identification and sharing of radio frequency spectrum resources by means of radio techniques. Based on this vision, they propose a cloud framework for spectrum resource as a service (SRaaS) in the application layer, based on a national geo-location spectrum database (GLSDB) developed for South Africa. The SRaaS framework has the potential to unlock the future wireless dynamic spectrum networks firstly as the best short-term solution for minimizing any harmful interference in such network architectures as the TV white spaces (TVWS), secondly SRaaS can be used as a toolbox by regulators in the development of efficient dynamic spectrum regulations at a national level and thirdly, such regulations could be enforced and monitored through an SRaaS environment. Additionally, the authors argue that multi-tenancy and schema sharing techniques are utilized at the inter-regional level to allow the cross-border harmonization of RF spectrum regulation.

To clarify the design and functionality of the proposed database, the authors should have drawn the schema of their proposed database and discuss the algorithms used in the back end. Additionally, the authors should have discussed the superiority of their proposed SRaaS to known GLSDB like the ones used by Google and Microsoft.

The other missing element in the proposed SRaaS was on cost. It was cited as one of the drawbacks for the other published GLSDB solutions. However, the authors did not discuss the cost implications of their proposed solution.

1.2 Federal Communications Commission (FCC) Rules Overview

The USA Federal Communications Commission (FCC) made a ruling on TVWS [2] i.e. to:

- Provide for both fixed and personal/portable devices to operate in the TV white spaces on an unlicensed basis

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- ❖ Devices must include a geolocation capability and capability to access to a database of protected radio services
- ❖ Devices provide their location to their database, which returns a list of channels on which they may operate (channel lists are specific to the location of the device)
- ❖ Devices must complete the database access process before operating Databases are established and administered by third parties; were selected through a public notice process that solicited interested parties

Additional provisions to mitigate Interference Risk

- Fixed devices must register their locations in the database
- Fixed and personal/portable devices must provide identifying info to the database
- Devices cannot transmit without checking database and must recheck periodically
- All devices must include adaptable power control to use the minimum necessary power

As a follow up to the above highlighted rules, FCC Authorizes Nationwide use of TVWS. This action follows the launch of the Commission's on-line registration system for large entertainment, sports and similar venues where a significant number of unlicensed wireless microphones are used (unlicensed wireless microphone registration system). The Commission's rules permit unlicensed radio devices to transmit on white space in the spectrum bands used by the broadcast television service, i.e., 54-72 MHz, 76-88 MHz, 174-216 MHz, 470-608 MHz and 614-698 MHz. The FCC rules require that TV white space database systems protect the following radio services and receive-only operations (authorized services):

– 1) broadcast television stations (including full power, TV translator, low power TV, and Class A stations);
– 2) fixed broadcast auxiliary service (BAS) links (regular licensed and temporary);
– 3) receive sites (and received channels) of TV translator, low power and Class A TV stations, and multichannel video programming distributors (MVPDs – cable and satellite TV systems);
– 4) public safety and private land mobile operations;
– 5) offshore radio telephone service operations;
– 6) radio astronomy service operations at specific sites; and
– 7) low power auxiliary service operations (licensed and certain approved unlicensed wireless microphone venue sites).

1.3 Dynamic Spectrum Alliance (DSA)

In general the DSA suggests that;

a) White space devices ("WSDs") are permitted to operate on a license-exempt basis subject to the interference protection requirements set forth in these rules.
b) WSDs may operate in the broadcast television frequency bands, as well as any other frequency bands designated by the Regulator.
c) WSDs shall only operate on available frequencies determined in accordance with the interference avoidance mechanisms set forth in **§ 2**.
d) Client WSDs shall only operate on available frequencies determined by the database and provided via a master white space device in accordance with **§ 3(f)**.

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§ 2 Protection of Licensed Incumbent Services

Availability of frequencies for use by WSDs may be determined based on the geolocation and database method described in **§ 3** or based on the spectrum sensing method described in **§**

§ 3 Geolocation and Database Access

(a) A WSD may rely on the geolocation and database access mechanism described in this section to identify available frequencies.

(b) WSD geolocation determination.

(c) Determination of available frequencies and maximum transmit power.

(d) Time validity and database re-check requirements. A geolocation database shall provide master devices with a time period of validity for the frequencies of operation and maximum transmit power values described in paragraph (c).

(e) Fixed device registration.

(f) Client device operation.

(g) Fixed devices without a direct connection to the Internet.

(h) Security.

§ 4 Database Algorithm

The input to a geolocation database will be positional information from a master WSD, a classification code or other information characterizing a device's emissions performance, the height of the transmitting antenna for fixed master devices and use by licensed incumbents in or near the geographic area of emissions masks. If available, this information should be supplied to the database. If not, the device can provide its emissions performance to the database in another form. If a device is sophisticated enough to modify its emissions profile dynamically, then regulators can consider an approach in which the database provides a maximum power level per channel and then the device ensures – based on its emissions profile – that it falls below the ceiling provided by the database.

There is an Annex that provides the detailed parameters and methodology to calculate the frequencies and maximum power limits for White Space Devices in such a way as to limit the probability of harmful interference to other services to acceptable levels. The proposed methodology in this Annex is independent of the radio propagation models that might be used in the calculations described herein. However, it is imperative that point-to-point path-specific statistical radio propagation models that are capable of utilizing digital terrain/elevation models must be used.

There is need to define the various entities and their relationships with regard to frequency and signal strength calculations. Interference from White Space Devices (WSDs) is controlled by limiting their radiated power. The following definitions describe an approach for how those power limits can be calculated.

1.4 Protected services

1.4.1 Analog terrestrial television(ATT): PAL-I standard

The service area of an analog TV broadcast includes any locations where the signal to noise ratio of its signal is greater than or equal to 17.0 dB plus a link margin of 13 dB.

A service's signal to noise ratio (SNR) limit is the minimum theoretical operating level for a service to be functional, while the link margin accounts for the extra signal power that is

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typically required to cope with real-world environments. The link margin provides a buffer so that the service is somewhat robust against common signal impairments like multi-path, fading, and interference.

1.4.2 Digital terrestrial television (DTT): DVB-T2 standard

The service area of a digital TV broadcast includes any locations where the signal to noise ratio of its signal is greater than or equal to 17.0 dB plus a link margin of 13 dB. Given that the proposed methodology analyzes transmitters individually, Single Frequency Networks (SFNs) and Multi-Frequency Networks (MFNs) can be treated similarly.

1.5 Digital television (DVB-T2)

A digital TV receiver's sensitivity to White Space Device interference is a function of its adjacent channel rejection ratio (ACR). If a receiver is tuned to channel "N", it can tolerate signals on adjacent channels without harmful interference if the relative signal strength are less than a given threshold.

3. Interference Mitigation Strategy As Proposed In the Malawi TVWS Pilot Network

Since TVWS devices make opportunistic use of frequency voids that are unoccupied by primary users, they should not interfere with the existing licensee at all times and at all **locations**. Several studies have presented various mechanisms for preventing interference with the primary user (Baykas, T., et al 2012, Rahman, M.A.et al, 2012) These studies have primarily focused on the use of spectrum sensing techniques (Baykas, T., et al 2012 Chen Lei, 2011) and geo-location database access (Denkovska, M et al, 2011 ,Rahman, M.A.et al, 2012) or a combination of the two (Rahman, M.A.et al, 2012 , Villardi, G.P. et al ,2011, Xin Tao et al , 2013). The use of beacons has also been described in Villardi, G.P. et al (2011) while the Federal Communication Commission in the USA has imposed a White Space Device (WSD) transmit power limitation as another way of protecting the incumbent (Baykas, T., et al 2012). Some studies have also proposed various ways of managing interference between WSDs (Aulakh I.K, 2009, Ye, B et al, 2012). Authors in Ye, B et al, (2012) propose an intelligent TVWS management system that will control allocation of available channels to the secondary users in a manner that will allow maximum spectrum utilization.

Various TVWS networks have been deployed across the globe. In Malawi, a TVWS pilot network that provides broadband Internet to a secondary school, a rural community hospital, the Malawi Defense Force Airwing and the Department of Geological Survey was deployed in September 2013 (Mikeka, C. et al 2013, Zennaro, M.et al, 2014), While it is true that Malawi has a relatively low number of primary TV spectrum users, and hence more TV white spaces (Zennaro, M.et al, 2014) the move to allow secondary access in the TVWS may result in interference between the secondary users. With the imminent release of TVWS regulations from Malawi Communications Regulatory Authority (MACRA) and keen interest of commercial pilot deployments from various telecommunication operators; a need to have an interference mitigation strategy arose. Based on the intelligent TVWS management system proposed in Ye, B et al, (2012). This paper proposes inter-device interference mitigation in a TVWS network.

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We investigated the sources of interference in our deployed Television White Spaces (TVWS) network by specifying a specific region with active UHF transmitters that have first level priority to select channels of communication from those available in the region using GE06 channel arrangement. The remaining free channel(s) denoted by m are defined as White Spaces and are opportunistically used by White Space Devices (WSDs) in their own network, in our case, TVWS network. Using a newly proposed boundary condition called "Chomora condition" where m = 1 for k > m, (k being the number of WSDs), we compute the inter-device interference that could overwhelm the WSD given a known value of the WSD receiver sensitivity. A proposition is also made to use Simulated Annealing algorithm to minimize the inter-device interference. This algorithm is an optimizer implemented in the proposed simple and lightweight Interference Mitigation System (IMS) that comprises a Database and Interference Mitigation Engine (IME).

4. The Malawi TVWS Draft Regulations

According to the Malawi Communications Regulatory Authority (MACRA), the eligibility, requirements and grant of licenses are dependent upon the following.

(1) A person shall not operate or use Television White Spaces equipment (that is any equipment other than license-exempted TVWS devices) without a valid licence issued by the Authority.
(2) Any licence application to the Authority shall be in writing and in the manner prescribed by the Authority.
(3) Any person may apply for Television White Spaces licence in accordance with the procedures determined by the Authority.
(4) An application made pursuant to sub regulation (2) above shall include the following information:
    (a) a certificate of incorporation or registration;
    (b) the business plan and organizational structure;
    (c) the marketing plan and competition strategies of the applicant;
    (d) the technical plan and capability including network configuration, facilities, coverage capacity and improvement, interference management, interconnection security and technologies, (e) any other relevant information that the Authority may require.
(5) Failure to Submit documents of information:
    (a) If an applicant fails to submit documents or information as required under this regulation, the Authority shall not consider the application and the applicant shall be so informed in writing.
    (b) Resubmission of application under sub – regulation (2) above shall be treated as a new application.
    (c) An application under this regulation shall be accompanied by an application fee as determined by the Authority.

5. Conclusion

In this paper, some rules and regulations dictating the use of white spaces, particularly the TVWS have been presented from the various perspectives namely, FCC, CSIR, and DSA. A proposed set of rules and regulations that in part use portions of the related works by DSA, FCC and CSIR has been drafted for use in Malawi. An overview of these drafted regulations

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has been presented in this paper and awaits review and comments from stake holders in the Malawian industry, after which the regulations shall be gazetted for official use.

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Biographies

Jonathan Pinifolo holds an MSc Degree in Wireless Communication Systems passed with Distinction from Oxford Brookes University in the United Kingdom. He also holds an MBA from ESAMI. He is a PhD student in Electrical and Electronic Engineering at University of Johannesburg, South Africa and currently working as Deputy Director of Spectrum Management with Malawi Communications Regulatory Authority. He has got fourteen years of high level experience in telecom, gained at management level as well as technical operation in the field. His PhD research work is on design of Spectrum re-use system.

Suvendi Rimer received her BSc Electrical Engineering and Higher Diploma in Computer Science degrees from the University of the Witwatersrand. She completed her Masters (with distinction) and PhD degrees in Computer Engineering at the University of Pretoria. She also has a Masters in Business Administration from Bond University. Suvendi has thirteen years teaching experience in academia, starting at the University of Pretoria between 2002 and

2004. She is currently employed as a Senior Lecturer in the Department of Electrical and Electronic Engineering Science at the University of Johannesburg (UJ). Prior to joining academia, Suvendi worked as a software engineer in various commercial companies.

Babu Sena Paul received his B.Tech and M.Tech degree in Radio physics and Electronics from the University of Clcutta, West Bengal, India, in 1999 and 2003 respectively. He was with Phillips India Ltd from 1999-2000. From 2000-2002, he was lecturer of Electronics and Communications Engineering Department at SMIT, Sikkim, India. He received his Ph.D. degree from the Department of Electronics and Communication Engineering, Indian Institute of Technology, Guwahati, Assam, India in 2010. He has attended and published several papers in international and national conferences, symposiums and peer reviewed journals.

Chomora Mikeka is a Senior Lecturer in the Physics Department at Chancellor College Campus of the University of Malawi in Zomba. He is also the Director for the Malawi White Spaces Project in partnership with the Malawi Communications Regulatory Authority (MACRA) and Marconi Wireless T/ICT4D Laboratory in Trieste, Italy. Chomora Mikeka holds a PhD from the Division of Physics, Electrical and Computer Engineering at Yokohama National University, Japan. His PhD research was about power autonomous sensor radio based on cellular and digital TV RF energy harvesting.

Dr. Justice S.P. Mlatho (Bsc, Bsc (hons), MSc (Mlw), PhD (NWU, South Africa).Senior lecturer in Applied Physics (Solar thermal processes) in the University of Malawi (Chancellor College Campus). He is the current head of the Physics Department. Main research interests are developing renewable energy technologies for rural application, development of electrical communications technologies for Africa. Current research projects work involve TV White Spaces, Antennae design and development, Development of low-cost photovoltaic systems for rural applications and low-cost Biogas systems .

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