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TV white spaces exploitation through a bicameral geo-location database

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ABSTRACT

The exploitation of TV white spaces can meet the increasing demand for spectrum resources and create opportunities for deploying a variety of wireless services in a flexible manner. However, uncertainties from technologies, business models and regulatory policies hinder the take-off of TV white spaces exploitation. This paper proposes a bicameral (or two-chambered) geo-location database, which allows/supports both free and paid access to the TV white spaces: i.e., one chamber supports free access through opportunistic or geo-location database access; and the other chamber supports paid usage through secondary spectrum trading. Consequently, four technological scenarios for the acquisition of TV white spaces emerge, namely: sensing only, joint sensing and geo-location database access, geo-location database access only, and broker based secondary spectrum trading. An analysis of these scenarios is performed based on a theoretical framework for emerging technology evaluation while considering technological, business models and regulatory dimensions. The analyses show that free and paid access to TV white space complement each other; and that despite considerable infrastructure costs, the bicameral geo-location database is positioned to create viable TV white spaces exploitation value chains; hence have the most optimal technological, business and regulatory prospects.

1. Introduction

Technological innovation for new entrants in the wireless services market such as machine-to-machine (M2M) communications, broadband Internet access, etc.; and capacity extension for current operators are the main drivers for the need of additional spectrum. TV white spaces offer a very rare opportunity to meet this demand. TV white spaces are spectrum frequency bands unused by the Digital Video Broadcasting—Terrestrial (DVB-T) systems, interleaved in both frequency and space. The exploitation of TV white spaces in different countries, however, with the exception of the USA and the UK, has not yet taken-off. It has been grounded by uncertainties regarding enabling technologies, potential business models and regulatory policies.

The protection of incumbent systems is the main concern when developing cognitive radio (CR) networks operating in TV white spaces (Deb, Srinivasan, & Maheshwari, 2009; FCC, 2010; Peha, 2009). DVB-T systems and professional wireless microphones or PMSEs (Programme Making and Special Events) are considered to be incumbent users of the TV spectrum bands. PMSEs' owners are concerned that the exploitation of TV white spaces by CRs may harm their services, which are

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vulnerable to interference. Moreover, are DVB-T operators willing to share their bands? Most likely they are not, neither do they have incentives to improve their technologies to make sharper filters and increase the efficiency of UHF bands usage. Therefore, factors that will influence the alignment of incumbents to favor the sharing of their spectrum with CRs have to be clarified.

The development of viable business models and value chains is just as important for the success of the TV white spaces usage as it is for other segments of wireless communications (Ballon & Delaere, 2009; Casey, 2009; Nolan, Mullany, Ambrose, & Doyle, 2007). What are possible business models to emerge? Moreover, an established value chain for the exploitation of TV white spaces is still missing. This is important to investors. An understanding of what factors will influence or favor certain models for making money is an important aspect for the successful usage of TV white spaces. This implies that either gradual growth or extension of existing wireless services value chains, for example towards mobile commerce or e-business value chains platforms, should be adopted. The latter approach seems to be more feasible by virtue of higher accessibility of services deployed through the Internet.

Regulators are concerned about creating policies with incentives for using the white spaces while ensuring the protection of incumbent users of TV spectrum (ECC Report 159, 2011; Ghosh, Roy, & Cavalcanti, 2010; Ghosh et al., 2011; Hwang & Yoon, 2009; Peha, 2009). Questions that they have to answer include: What should be the operating parameters? How to build an accountability framework, that allows an interferer to be easily tracked down and disputes resolved either through legal or through other means? Further, how should cognitive devices be certified taking into account their ability to flexibly change operating parameters? It can be perceived that, these problems can be adequately resolved if different stakeholders in the value chain are involved or consulted. Otherwise, unilateral decisions by regulators on white space usage risks being counter-productive – either by being too restrictive rendering no technology operative, or by being too lax leading to increased harmful interference. Thus, clear identification of opportunities by involving other stakeholders can potentially balance the ecosystem and maximize economic value of the TV white spaces.

As Hwang and Yoon (2008) pointed out, in addition to the research on the technology to exploit TV white spaces, it is important also to analyze the market or industry, or the proper interplay between technology, strategy and policy required to succeed in the commercialization of dynamic spectrum access (DSA) technology. Sensing technology is more appealing to academic researchers than other stakeholders (Weiss, Delaere, & Lehr, 2010); whereas regulators favor the geo-location database approach (FCC, 2010; OFCOM, 2010a; RSPG, 2011). This could be done in a commons or under spectrum trading. However, in case of scarcity, market based spectrum usage is said to be the best way to allocate spectrum resources (Cave, Doyle, & Webb, 2007; Coase, 1959; ECC Report 169, 2011; Mastroeni & Naldi, 2010), such as through Broker based secondary spectrum trading (Bae et al., 2008; Mwangoka, Marques, & Rodriguez, 2011). Therefore, a comparative analysis of the factors that might lead to one approach over another is important for optimal spectrum usage.

To this end, this paper proposes a bicameral (two-chambered) geo-location database to accommodate viewpoints from diverse stakeholders, specifically the commons and secondary spectrum trading. Accordingly, four scenarios for spectrum acquisition are derived. To analyze the scenarios, this work proposes a theoretical assessment model that integrates the views from three categories of stakeholders: technology, business and regulatory. The assessment tries to answer the question whether access to TV white spaces should be free or paid, and how?

The paper proceeds as follows. Section 2 introduces a bicameral geo-location database model and different approaches for accessing the TV white spaces. In addition, the section introduces a Broker based model for secondary spectrum trading of the TV white spaces. In Section 3, four scenarios are derived and a theoretical model to analyze them is presented. Sections 4–6 assess derived models from three perspectives: technological, business and regulatory, respectively. Finally, Section 7 summarizes and concludes the paper.

2. Access modes for TV white spaces

2.1. Spectrum sensing

In spectrum sensing, devices try to detect the presence of protected services in each of the candidate channels. Once a vacant channel is determined, and there is assurance that interference to adjacent bands can be avoided, a device can start transmitting data in the bands. Furthermore, the device is expected to stop transmission as soon as the presence of incumbent activities is detected.

The feasibility of a sensing method depends on the accuracy of the sensed data. The accuracy/reliability of sensed information can be affected by shadowing and multi-path effects prevalent in wireless channels. Consequently, even though the sensitivity of the spectrum sensors could be high, the accuracy of the spectrum availability information would be affected by the method of rendering sensed data.

There are two main approaches namely (single-device) spectrum sensing and co-operative sensing.

2.1.1. Autonomous sensing

Autonomous spectrum sensing is the conventional way for getting spectrum information. It is a well researched approach. However, the chaotic nature of wireless channels renders this approach (on its own) infeasible in some scenarios, especially in densely populated areas. More-over, the presence of sensing functionality in a CR increases the complexity of the device and shortens battery life.