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Protocol to Access White Space database: Overview and Use case scenarios
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Abstract

Wireless spectrum is a commodity that is regulated by governments. The spectrum is used for various purposes which include entertainment (eg. radio and television), communication (telephony and Internet access), military (radars etc.) and, navigation (satellite communication, GPS). Portions of the radio spectrum that are unused or unoccupied at specific locations and times are defined as "white space". TV White space refers to those unused channels, within the range allocated for TV transmission, that can be used without interfering with the primary purpose for which it is allocated.

This document provides an overview of TV white space and describes examples of how a radio system might operate using TV white space spectrum. Not only does it describe the operation of a radio system, but also how the radio system including a white space database enables location based services. The description is high level and generic.

Status of this Memo

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1. Introduction

Wireless spectrum is a commodity that is regulated by governments. The spectrum is used for various purposes which include entertainment (eg. radio and television), communication (telephony and Internet access), military (radars etc.) and, navigation (satellite communication, GPS). Additionally spectrum is allocated for use either on a license basis or for unlicensed use. Television transmission until now has primarily been analog. The switch to digital transmission has begun. As a result the spectrum allocated for television transmission can now be more effectively used. Unused channels and bands between channels can be used as long as they do not interfere with the primary service for which that channel is allocated. While urban areas tend to have dense usage of spectrum and a number of TV channels, the same is not true in rural and semi-urban areas. There can be a number of unused TV channels in such areas that can be used for other services. The figure below shows TV white space within the lower UHF band:

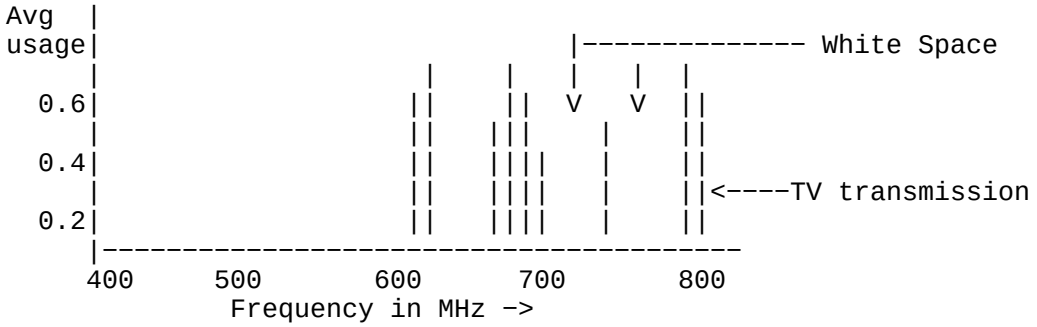

Figure 1: High level view of TV White space

Regulatory entities in several countries including the US, Canada, UK, Finland to quote a few are specifying the regulations for the use of TV white space. The availability of TV white space opens up the potential for its use for various purposes. Regulation may mandate its use for certain specific applications or services.

This document describes an example of how a radio system might operate using TV white space spectrum. Not only does it describe the operation of a radio system for providing Internet access at a hot spot or in a rural area, but also how the radio system including a white space database enables location based services. The

description is high level and generic. It is not meant to be specific to any particular radio technology. The examples described here are however real and based on existing work by the authors.

2. Terminology

Location Based Service

An application or device which provides data, information or service to a user based on their location.

3. White space and cognitive radio technology overview

TV white space is considered the first generation of spectrum access utilizing cognitive radio techniques. Cognitive radio requires a functional entity, namely a database that provides location dependent spectrum availability information for secondary use. The database is required to provide in simple terms an "ask and answer" service to provide secondary use spectrum resources to radio devices. The concept of "white space" in the context of broadband wireless access service is likely to expand to other spectral bands in the future increasing the value and role of databases responsible for determining location dependent spectrum availability. A comprehensive tutorial and introduction to TV white space by IEEE is available at [TV Whitespace Tutorial Intro].

Spectrum is a scarce resource. Current usage model is typically wherein it is allocated for a specific purpose. This results in inefficient use of the resource. The actual usage of the spectrum could vary based on time and location. Better spectrum efficiency could be achieved for example by making available the same spectrum for use during periods when the primary service does not require it or in locations where the service does not apply. Any device or entity that would benefit from available spectrum could potentially verify availability at a given location and time via a database and claim resources for some period of time. Such usage models are beginning to emerge with TV WS being a leading example.

4. TV white space Use cases

There are many potential use cases that could be considered for the TV white space spectrum. Providing broadband internet access in rural and underserved areas is one example. Available channels may also be used by towns and cities to monitor/control traffic lights or read utility meters. Yet another use case could be the ability to

deliver location based services. A couple of these use cases are described in the following sections.

4.1. Hot spot: Internet connectivity service

In this use case a small town could offer Internet connectivity service to local businesses and residents by creating a hot spot using TV white space spectrum. The access point in this example uses IEEE 802.11af air interface technology. The backhaul connectivity to the Internet from the access point to is via microwave or cable. End user devices which are 802.11af capable would access the Internet through the access point. The access point in such a deployment could cover several kilometers and create a fairly large hot spot.

The figure below shows an example deployment of this scenario.

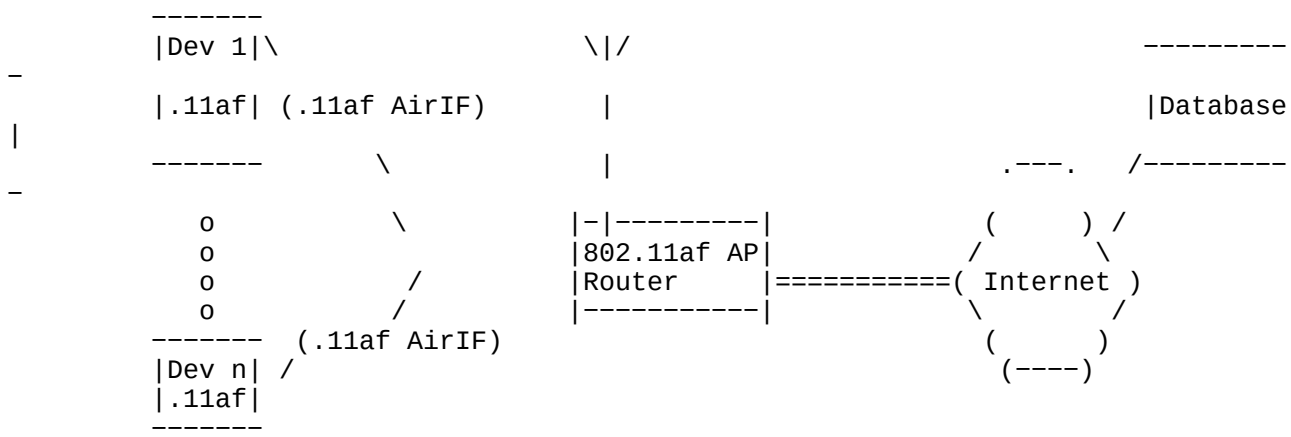

Figure 2: Hot-spot service using TV white space spectrum

Once the rural town has correctly installed and setup the equipment, a simplified power up and operation scenario utilizing TV White Space to provide Internet connectivity service consists of the following steps:

1. The access point (AP) powers up; however its WS radio and all other WS capable devices will power up in idle/listen only mode (No active transmissions on the WS frequency band)

2. The AP which has Internet connectivity via the backhaul establishes a connection to a trusted white space database administrator.

3. The AP (First time) registers its geolocation, address, contact information, etc. associated with the owner/operator of the AP with the trusted database administrator. Meanwhile the DB administrator may be required to store and forward the registration information to the regulatory authority

4. Following the registration process, the AP will send a query to the trusted database requesting a list of available WS channels based upon its geolocation.

5. If the AP has been previously authenticated, the database responds with a list of available white space channels that may be used along with a duration of time.

6. Once the AP authenticates the WS channel list response message from the databaase, the AP selects the available WS channel(s) from the list.

7. The AP acknowledges to the database which of the available WS channels, the AP has selected for its operation.

8. The AP transmits the appropriate control messages to the "listening" peripherals under its control including WS channel numbers for use.

9. Devices can attach to the AP using the channel information provided in the beacon and obtain Internet connectivity.

10. Periodically the AP contacts the database for the purpose of "refreshing" the WS channel availability information.

4.2. Location based service usage scenario

The owner of a shopping mall wants to provide internet access to customers when they are at the shopping mall. His internet service provider (ISP) recommends using access points (APs) in the TV white space frequency band since these radios will have good propagation characteristics, and thus will require fewer APs, and also because the frequency band used by traditional Wi-Fi is crowded with users such as individual stores operating their own Wi-Fi network and also Bluetooth devices. The ISP installs access points in each large store in the mall, and several other APs throughout the mall building. For each AP, the professional installer programs the location (latitude & longitude) of the device. Special tools are required to determine the location, since typical GPS receivers do not function indoors. When each AP is powered on, the radio does not transmit initially. The AP contacts a white space database, using its wired internet connection, via a URL and provides its programmed

location coordinates plus other information required by the database. A reply is received by the AP from the database containing a list of available channels where the AP can operate its transmitter. The AP selects a channel for operation and notifies the database, which records information about the AP including the identity of the AP and its location coordinates. The AP activates its radio and begins to function as a typical wireless AP, providing internet access to connected devices.

A user has a device that is capable of operating in the TV white spaces frequency band. A typical device would be a smartphone with multiple radios, including a cellular radio, a Wi-Fi radio, and TV white space radio. The user arrives at the shopping mall and enters the building. The white space radio in the smartphone is on, and is scanning for an AP. As the user gets near the entrance to the shopping mall, the smartphone locates one of the APs in the building and connects to it. The smartphone begins to use this TVWS radio for internet access. This internet access does not count against the users cellular data cap (the mall owner is providing the internet access) and also the data rates are better than cellular data. As the user walks throughout the mall the smartphone moves between coverage of different APs, and the smartphone connects to a new AP when the user and smartphone move near it.

In order to encourage customers to come to the shopping mall, the mall owner has a loyalty program where members register, build points, and receive coupons and other notices from the shops in the mall. Before installing the internet service in the mall, all loyalty program information was mailed to the user, at an address which was provided by the user when joining the loyalty program.

The ISP provider describes to the mall owner how the loyalty program can be improved using the internet service provided by the APs in the TV white space. A new app is developed for this loyalty program, and promoted to users, asking them to install the app on their smartphone. The app is provisioned with the user’s loyalty program information. When the user comes to the shopping mall, the smartphone locates the AP providing internet service and connects to the AP. The app in the smartphone sees that a radio connection to an AP in the TV white space frequency band is now active. The app registers the identity of the AP and forwards this to the home server for the loyalty program, using the internet connection provided by the AP in the TV white space band. The loyalty program server registers the identity of the user from the loyalty program credentials and also the identity of the AP. Next the loyalty program server contacts the TV white space database and requests the location of the AP having the identity forwarded by the app & smartphone. When the TV white space database replies with the

location coordinates of the AP, the loyalty program server knows the approximate location of the user and smartphone. With this location information, the loyalty program server can now forward loyalty program information to the user. As the user moves through the mall, the smartphone connects to different APs. The process is repeated, allowing the loyalty program to delivery current location based information to the user.

5. Summary and Conclusion

The above are a couple of examples describing the role of the white space database in the operation of a radio network. It also shows an example of a location based service. This is not intended to describe a fully functional deployment, only an example. In a real deployment, there are multiple issues which must be addressed including user privacy.

6. Informative References

[TV Whitespace Tutorial Intro]
IEEE 802 Executive Committee Study Group on TV White Spaces, "TV Whitespace Tutorial Intro; http://grouper.ieee.org/groups/802/802_tutorials/2009-03/2009-03-10%20TV%20Whitespace%20Tutorial%20r0.pdf", March 2009.

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