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B. Patil, Ed.

S. Probasco
G. Bajko
Nokia
B. Rosen
Neustar

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Protocol to Access White Space database: Problem statement and Requirements
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Abstract

Governments around the world continue to search for new pieces of radio spectrum which can be used by the expanding wireless communications industry to provide more services in the usable spectrum. The concept of allowing secondary transmissions (licensed or unlicensed) in frequencies occupied by a primary user is a technique to "unlock" existing spectrum for new use. An obvious requirement is that these secondary transmissions do not interfere with the primary use of the spectrum. One interesting observation is that often, in a given physical location, the primary user(s) may not be using the entire band allocated to them. The available spectrum for a secondary use would then depend on the location of the secondary user. The fundamental issue is how to determine for a specific location and specific time, if any of the primary spectrum is available for secondary use. Academia and Industry have studied multiple cognitive radio mechanisms for use in such a scenario. One simple mechanism is to use a geospatial database that records the primary users occupation, and require the secondary users to check the database prior to selecting what part of the spectrum they use. Such databases could be available on the Internet for query by secondary users. This document discusses the requirements and the problems that need to be addressed for enabling the use of white space spectrum by obtaining information from such a database.

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1. Introduction

Spectrum useable for data communications, especially wireless Internet communications, is scarce. One area which has received much attention globally is the TV white space: portions of the TV band that are not used by broadcasters in a given area. In 2008 the United States regulator took beginning steps when they published their first ruling on use of TV white space, and then followed up with a final ruling in 2010[FCC ruling]. Finland passed an Act in 2009 enabling testing of cognitive radio systems in the TV white space. The ECC has completed Report 159 [ECC Report 159] containing requirements for operation of cognitive radio systems in the TV white space. Ofcom published in 2004 their Spectrum Framework Review [Spectrum Framework Review] and their Digital Dividend Review [DDR] in 2005, and have followed up with a proposal to access TV white space. More countries are expected to provide access to their TV spectrum in similar ways. Any entity holding spectrum that is not densely used may be asked to give it up in one way or another for more intensive use. Providing a mechanism by which secondary users share the spectrum with the primary user is attractive in many bands in many countries.

The concept of allowing secondary transmissions in frequencies occupied by a primary user is a technique to "unlock" existing spectrum for new use. An obvious requirement is that these secondary transmissions do not interfere with the primary use of the spectrum. The fundamental issue is how to determine for a specific location and specific time if of the spectrum are available for secondary use. There are two dimensions of use that may be interesting: space (the area in which a secondary user would not interfere with a primary user, and time: when the secondary use would not interfere with the primary use. In this discussion, we consider the time element to be relatively long term (hours in a day) rather than short term (fractions of a second). Location in this discussion is geolocation: where the transmitters (and sometimes receivers) are located relative to one another. In operation, the database records the existing user’s transmitter (and some times receiver) locations along with basic transmission characteristics such as antenna height, and sometimes power. Using rules established by the regulator, the database calculates an exclusion zone for each authorized primary user, and attaches a time schedule to that use. The secondary user queries the database with it location. The database intersects the exclusion zones with the querier location, and returns the portion of the spectrum not in any exclusion zone. Such methods of geospatial database query to avoid interference have been shown to achieve favorable results, and are thus the basis for rulings by the FCC and reports from ECC and Ofcom. In any country, the rules for which primary entities are entitled to protection, how the exclusion zones

are calculated, and what the limits of use by secondary entities are may vary. However, the fundamental notion of recording primary users, calculating exclusion zones, querying by location and returning available spectrum (and the schedule for that spectrum) are common.

In a typical implementation of geolocation and database to access TV white space, a radio is configured with its location in latitude and longitude. There are multiple ways to configure this location information, e.g. programmed at installation (e.g. for a fixed device) or determined by GPS (e.g. for a or mobile device). At power-on, before the device can transmit in TV white space frequencies, the device must contact a database, provide its geolocation and receive in return a list of unoccupied or "white space" spectrum (for example, in a TV White space implementation, the list of available channels at that location). The device can then select one of the channels from the list (note that it is possible they list is empty; there are no unoccupied channels at the location of the device) and then begins to transmit and receive on the selected channel. The device must query the database again for a list of unoccupied channels based on certain conditions, e.g. a fixed amount of time has passed, the device has changed location beyond a specified threshold. The basic scenario is that before transmitting in TV white space, the device must get permission from the database.

This arrangement assumes that the device querying can complete a query before it transmits, or some other entity is able to query the database. A common arrangement for this kind of service is a fixed tower with a wired infrastructure that provides Internet service to a network of client devices. In this scenario, the tower has Internet access from its upstream service, and can query the database for channels within the tower service area. It can then provide beacon service to its clients, and assign them channels within the list of channels that the tower gets from the database.

Another arrangement might be an ad-hoc mobile network where one or more members of the ad hoc network have an independent radio IP connection (perhaps a commercial cellular wireless data network) which can be used to query the database over the Internet.

A third possibility is a mechanism where the database is accessed on a private IP network.

The low frequencies of the TV bands have good propagation characteristics. At these low frequencies, a radio signal will travel ~3 times further than traditional WLAN at 2.5 GHz, assuming the same transmit power. Because of these characteristics and new cognitive radio techniques, when TV white space becomes available,

this will enable new use cases and new business opportunities. Not only is the capacity of new spectrum needed, but this propagation trait by itself makes TV white space attractive for providing broadband wireless access in rural, sparsely populated areas, as well as for extended range home hot-spot coverage (similar to WLAN today, but with improved coverage). In addition to propagation characteristics, the geolocation database may provide new capabilities for devices that use TV white space. When a device using TV white space registers its location in the database, this simple act makes the location of the device available for location based services.

Other spectrum that might also be available for sharing using white space techniques exist in every country. A great many primary users were allocated space a time when there were many fewer potential users of the space, and the primary users are not making efficient (in geospatial and time aspects) use of the space. In the past, relocating existing primary users was the only feasible alternative. Using white space techniques to share spectrum without imposing burdens on the primary users is more attractive.

This document discusses the requirements for accessing a database on the Internet or a private IP network to obtain information that enables a device to operate/use the available spectrum at a given location. It also identifies various issues that need to be addressed by the protocol between the device and database.

2. Terminology

White Space

Radio spectrum which has been allocated for some primary use, but is not fully occupied by that primary use at a specific location and time.

TV White Space

TV white space refers specifically to radio spectrum which has been allocated for over the air television broadcast, but is not occupied by a TV broadcast, or other licensed user (such as a wireless microphone), at a specific location and time.

White Space Device

A device which is a secondary user of some part of white space spectrum. A white space device can be an access point, base station, a portable device or similar. In this context, a white

space device is required to query a database with its location to obtain information about available spectrum.

TV White Space

TV white space refers specifically to radio spectrum which has been allocated for TV broadcast, but is not occupied by a TV broadcast, or other licensed user (such as a wireless microphone), at a specific location and time.

Database

In the context of white space and cognitive radio technologies, the database is an entity which contains current information about available spectrum at any given location and other types of information.

Protected Entity

A primary user of white space spectrum which is afforded protection against interference by secondary users (white space devices(for its use in a given area and time.

Protected Contour

The exclusion area for a Protected Entity, held in the database and expressed as a polygon with geospatial points as the vertices.

3. Prior Work

3.1. The concept of Cognitive Radio

A cognitive radio uses knowledge of the local radio environment to dynamically adapt its own configuration and function properly in a changing radio environment. Knowledge of the local radio environment can come from various technology mechanisms including sensing (attempting to ascertain primary users by listening for them within the spectrum), location determination and internet connectivity to a database to learn the details of the local radio environment. TV White Space is one implementation of cognitive radio. Because a cognitive radio adapts itself to the available spectrum in a manner that prevents the creation of harmful interference, the spectrum can be shared among different radio users.

3.2. Background information on white space in US

Television transmission in the United States has moved to the use of digital signals as of June 12, 2009. Since June 13, 2009, all full-power U.S. television stations have broadcast over-the-air signals in digital only. An important benefit of the switch to all-digital broadcasting is that it freed up parts of the valuable broadcast spectrum. More information about the switch to digital transmission is at : [DTV].

With the switch to digital transmission for TV, the guard bands that existed to protect the signals between stations can now be used for other purposes. The FCC has made this spectrum available for unlicensed use and this is generally referred to as white space. Please see the details of the FCC ruling and regulations in [FCC ruling]. The spectrum can be used to provide wireless broadband as an example. The term "Super-Wifi" is also used to describe this spectrum and potential for providing wifi type of service.

3.3. Air Interfaces

Efforts are ongoing to specify air-interfaces for use in white space spectrum. IEEEs 802.11af task group is currently working on one such specification. IEEE 802.22 is another example. Other air interfaces could be specified in the future such as LTE.

4. Problem Statement

The use of white space spectrum is enabled via the capability of a device to query a database and obtain information about the availability of spectrum for use at a given location. The databases are reachable via the Internet and the devices querying these databases are expected to have some form of Internet connectivity, directly or indirectly. The databases may be country specific since the available spectrum and regulations may vary, but the fundamental operation of the protocol should be country independent.

An example high-level architecture of the devices and white space databases is shown in the figure below:

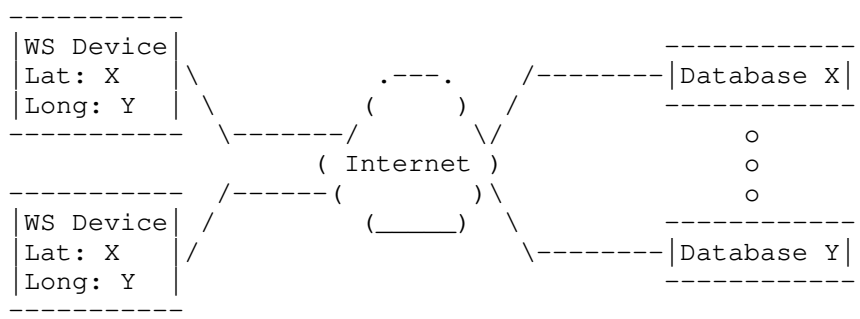

Figure 1: High level view of the White space database architecture

In the figure above, note that there could be multiple databases serving white space devices. The databases are country specific since the regulations and available spectrum may vary. In some countries, for example, the U.S., the regulator has determined that multiple, competing databases may provide service to White Space Devices.

A messaging interface between the white space devices and the database is required for operating a network using the white space spectrum. The following sections discuss various aspects of such an interface and the need for a standard. Other aspects of a solution including provisioning the database, and calculating protected contours are considered out of scope of the initial effort, as there are significant differences between countries and spectrum bands.

4.1. Global applicability

The use of TV white space spectrum is currently approved by the FCC in the United States. However regulatory bodies in other countries are also considering similar use of available spectrum. The principles of cognitive radio usage for such spectrum is generally the same. Some of the regulatory details may vary on a country specific basis. However the need for devices that intend to use the spectrum to communicate with a database remains a common feature. The database provides a known, specifiable Protection Contour for the primary user, not dependent on the characteristics of the White Space Device or it's ability to sense the primary use. It also provides a way to specify a schedule of use, because some primary users (for example, wireless microphones) only operate in limited time slots.

Devices need to be able to query a database, directly or indirectly over the public Internet and/or private IP networks prior to operating in available spectrum. Information about available

spectrum, schedule, power, etc. are provided by the database as a response to the query from a device. The messaging interface needs to be:

1. Radio/air interface agnostic – The radio/air interface technology used by the white space device in available spectrum can be 802.11af, 802.16, 802.22, LTE etc. However the messaging interface between the white space device and the database should be agnostic to the air interface while being cognizant of the characteristics of various air-interface technologies and the need to include relevant attributes in the query to the database.

2. Spectrum agnostic – the spectrum used by primary and secondary users varies by country. Some spectrum has an explicit notion of a "channel" a defined swath of spectrum within a band that has some assigned identifier. Other spectrum bands may be subject to white space sharing, but only have actual frequency low/high parameters to define protected entity use. The protocol should be able to be used in any spectrum band where white space sharing is permitted.

3. Globally applicable – A common messaging interface between white space devices and databases will enable the use of such spectrum for various purposes on a global basis. Devices can operate in any country where such spectrum is available and a common interface ensures uniformity in implementations and deployment. Since the White Space device must know it’s geospatial location to do a query, it is possible to determine which database, and which rules, are applicable, even though they are country specific.

4. Address regulatory requirements – Each country will likely have regulations that are unique to that country. The messaging interface needs to be flexible to accommodate the specific needs of a regulatory body in the country where the white space device is operating and connecting to the relevant database.

4.2. Database discovery

Another aspect of the problem space is the need to discover the database. A white space device needs to find the relevant database to query based on its current location or for another location. Since the spectrum and databases are country specific, the device will need to discover the relevant database. The device needs to obtain the IP address of the specific database to which it can send queries in addition to registering itself for operation and using the available spectrum.

A database discovery mechanism needs to be specified. Reuse of existing mechanisms is an option and could be adapted for meeting the specific needs of cognitive radio technology.

4.3. Data model definition

The contents of the queries and response need to be specified. A data model is required which enables the white space device to query the database while including all the relevant information such as geolocation, radio technology, power characteristics, etc which may be country and spectrum dependent. All databases are able to interpret the data model and respond to the queries using the same data model that is understood by all devices.

Use of XML for specifying a data model is an attractive option. The intent is to evaluate the best option that meets the need for use between white space devices and databases.

4.4. Protocol

The protocol requirements are simple: registration and query transactions are needed. In some circumstances, a registration transaction is required prior to being able to query. The device provides some identifying information, and the database responds with an acknowledgement or error. The query protocol is a simple query/ response action (primarily location in, available spectrum out), with some error conditions.

It may be possible to use existing protocols (e.g. LoST [RFC5222]) or it may be more appropriate to define a new protocol for this purpose. HTTP transport is probably appropriate.

5. IANA Considerations

This document has no requests to IANA.

6. Security Considerations

The messaging interface between the white space device and the database needs to be secured. Both the queries and the responses need to be delivered securely. The device must be certain it is talking to a bona fide database authoritative for the location and spectrum band the device operates on. The database may need to restrict interactions to devices that it has some prior relationship with, or may be restricted from providing service to devices that are not authorized in some manner.

As the device will query with it's location, the location must be protected against eavesdropping. Some regulations include personally identifiable information as required elements of registration and/or query and must similarly be protected.

All communications between the device and the database will require integrity protection.

Man-in-the-middle attacks could modify the content of a response which can cause problems for other networks or devices operating at a given location. Interference as well as total loss of service could result from malicious information being delivered to a white space device.

This document describes the requirements and problems that need to be addressed for a messaging interface between white space devices and databases and does not by itself raise any security concerns.

7. Informative References

[DDR] Ofcom - Independent regulator and competition authority for the UK communications industries, "Digital Dividend Review; http://stakeholders.ofcom.org.uk/spectrum/project-pages/ddr/".

[DTV] "Digital TV Transition; http://www.dtv.gov".

[ECC Report 159] Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT), "TECHNICAL AND OPERATIONAL REQUIREMENTS FOR THE POSSIBLE OPERATION OF COGNITIVE RADIO SYSTEMS IN THE 'WHITE SPACES' OF THE FREQUENCY BAND 470-590 MHZ; http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP159.PDF", January 2011.

[FCC ruling] Federal Communications Commission, "Unlicensed Operation in the TV Broadcast Bands; http://edocket.access.gpo.gov/2010/pdf/2010-30184.pdf", December 2010.

[RFC5222] Hardie, T., Newton, A., Schulzrinne, H., and H. Tschofenig, "LoST: A Location-to-Service Translation Protocol", RFC 5222, August 2008.

[Spectrum Framework Review]

Ofcom - Independent regulator and competition authority for the UK communications industries, "Spectrum Framework Review; http://stakeholders.ofcom.org.uk/consultations/sfr/", February 2005.

Authors' Addresses

Basavaraj Patil (editor)
6021 Connection drive
Irving, TX 75039
USA

Email: basavaraj.patil@nokia.com

Scott Probasco
Nokia
6021 Connection drive
Irving, TX 75039
USA

Email: scott.probasco@nokia.com

Gabor Bajko
Nokia
323 Fairchild drive 6
Mountain view, CA 94043
USA

Email: gabor.bajko@nokia.com

Brian Rosen
Neustar
470 Conrad Dr
Mars, PA 16046
USA

Email: brian.rosen@neustar.biz

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S. Probasco, Ed.

T. Derryberry
B. Patil
Nokia
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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.

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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:

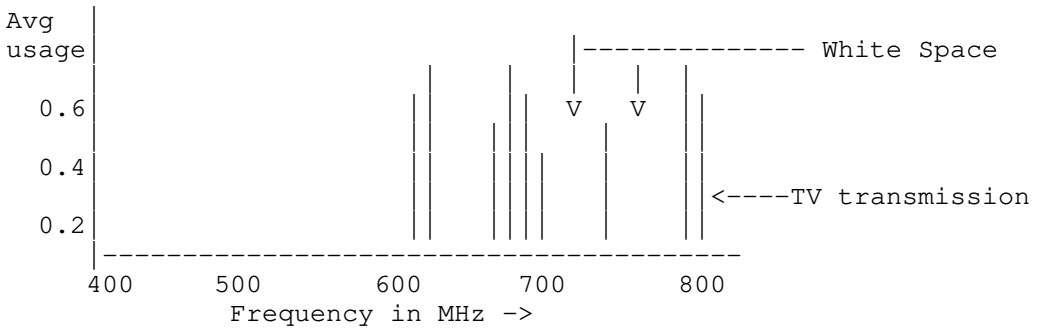

Figure 1: High level view of TV White space

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.

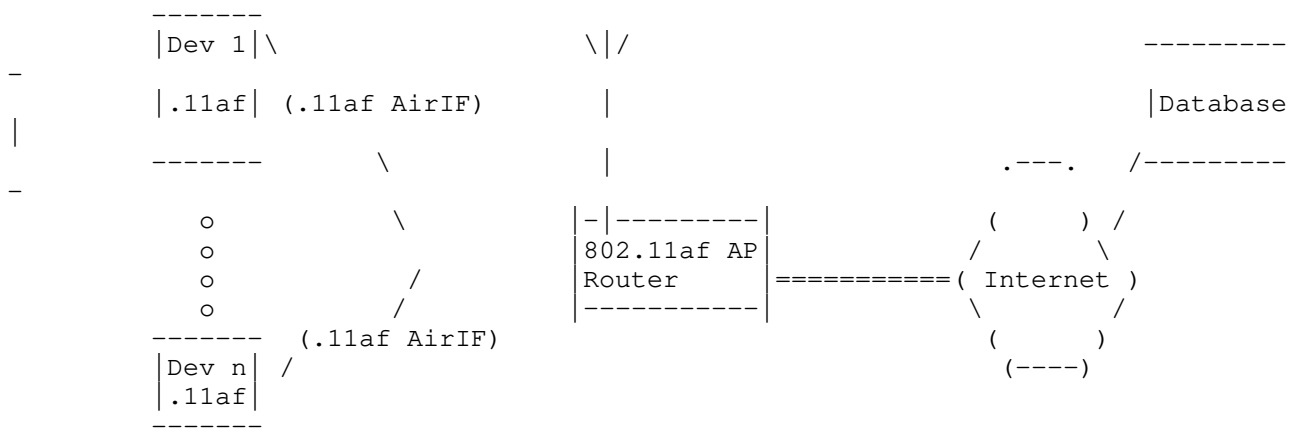

Figure 2: Hot-spot service using TV white space spectrum

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.

Authors' Addresses

Scott Probasco (editor)
6021 Connection drive
Irving, TX 75039
USA

Email: scott.probasco@nokia.com

Tom Derryberry
Nokia
6021 Connection drive
Irving, TX 75039
USA

Email: tom.derryberry@nokia.com

Basavaraj Patil
Nokia
6021 Connection drive
Irving, TX 75039
USA

Email: basavaraj.patil@nokia.com