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Protocol for Communication between White Space Device and White
Space Database
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Abstract

This document defines an application protocol for WSDB services provided to TV Band Devices (TVBDs). The protocol complies with FCC Rules/Requirements [FCC 10-174] and in the context of operating an FCC certified database, it also complies with requirements defined by IETF PAWS [IETF-PAWS-03]. We believe this protocol can be easily extended to include the remaining requirements not already satisfied from the IETF PAWS requirements.

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1. Introduction

This document defines an application protocol for TV Band Devices (TVBDs) to access Whitespace Database (WSDB) services over the Internet. Providing available channel lists to TVBDs is the primary service provided by the WSDB. Several operational requirements are

defined to support this primary function, such as device registration, and FCC ID verification. The protocol allows any TVBD to gain access to the services of the WSDB by communicating over commonly used Internet protocols.

The protocol defined by this document is compliant with FCC Requirements [FCC 10-174] and partially compliant with IETF PAWS requirements [IETF-PAWS-03] where the FCC requirements overlap with IETF PAWS requirements.

A primary goal of the document is to define a protocol between the White Space Database and TVBDs compliant with FCC Requirements [FCC 10-174] and also compliant with relevant overlapping requirements defined by IETF PAWS [IETF-PAWS-03]. The protocol can be easily extended to include the remaining IETF PAWS requirements.

2. Conventions and Terminology

2.1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC-2119 [RFC2119].

In this document, these words will appear with that interpretation only when in ALL CAPS. Lower case uses of these words are not to be interpreted as carrying RFC-2119 significance.

In this document, the characters "{" and "}" surrounding a word indicates a variable to be replaced with an appropriate value as described in the documented section.

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2.2. Terminology

TV Band Device (TVBD, TVWSDB or WSD)

A White Space Device that operates in the TV bands.

White Space Database (WSDB)

In the context of white space and cognitive radio technologies, the database is an entity which contains, but is not limited to, current information about available spectrum at any given location and other types of related (to the white space spectrum) or relevant information.

3. Protocol Stack

The Application Protocol defined in this document utilizes the following protocol stack for communication between the WSDB and TVBD:

Application Layer = HTTPS

Presentation Layer = SSL / XML (or JSON)

Session Layer = Undefined by this standard

Transport Layer = TCP

Network Layer = IP

Data Link Layer = Undefined by this standard

Physical Layer = Undefined by this standard

Many modern applications are successfully utilizing this protocol stack for client-server communications, and most modern network devices already include a TCP/IP stack. Software implementations of these protocols are readily available for use in the development of White Space Databases (WSDB) and Network Devices (TVBD) to support the application standard defined in this document.

HTTPS is a key component used in this protocol, providing a commonly used request-response protocol for a client-server model, where the WSDB is the server and the TVBD is the client. Additionally, HTTPS provides security via SSL to satisfy security requirements.

4. Protocol Definition

This section defines the application protocol that shall be used between the WSDB and TVBD for all services offered by the WSDB. The following sections define the services provided by the WSDB. The services are accessed by the TVBD using HTTPS GET and PUT requests over the Internet. Providing available Channel Lists to TVBDs is the primary service provided by the WSDB.

Operations are only initiated by the TVBD, with a response from the WSDB. This eliminates the necessity of the WSDB initiating communications with the TVBD.

Three services are defined on the interface between the WSDB and TVBD, Registration, Channel List Request, and FCC ID Verification. The services are listed in a logical order representing the steps that a TVBD MUST take to obtain service from the WSDB.

4.1. Registration

A fixed TVBD MUST register with the WSDB prior to operating for the first time, or after changing location, or if any of the registration data changes. Only fixed TVBDs register with the WSDB, personal/portable TVBDs do not.

To successfully register, the FCC ID and Serial Number of the TVBD must be enrolled at the WSDB. Device enrollment is an administration function that is not in the scope of this application protocol definition. WSDB operators may define their own methods for acquiring and maintaining device enrollment data.

To register with the WSDB, the TVBD MUST send a Registration Request Message to the WSDB (see section 4.1.1.).

One of two possible results shall be returned by the WSDB:

1. Successful Registration. The Registration will be valid for RVP and will be extended by subsequent WSDB access by the TVBD.
2. Unsuccessful Registration. The TVBD identifiers (FCC ID and Serial Number) were unrecognized or unsupported by the WSDB.

A successful Registration Reply will be returned to the TVBD only if all of the following are true:

- The FCC identifier and manufacturer's serial number are enrolled at the WSDB
- The device location is within the appropriate regulatory boundaries
- The device type is valid (only Fixed TVBDs may register), and is allowed for the authorized equipment class
- The antenna height is less than or equal to 30 meters

- The HAAT of the device location calculated by the database is less than or equal to 76 meters

A successful registration will overwrite any previous registration information for the same TVBD, as identified by FCC ID and serial number.

The WSDB will retain the TVBD registration for a fixed period (RVP) with no activity. RVP will be extended by every successful registration, and by any subsequent Channel List Request received from the TVBD.

If a TVBD registration expires, Channel List Requests will fail with a reason code of not registered, informing the TVBD of the need to register.

4.1.1. Registration Request Message

A TVBD MUST register with the WSDB by sending an HTTP PUT message in the following format:

HTTPS Method: PUT

URL: `https://{HOST.DOMAIN}/{VERSION}/devices/{FCCID}/{SERIAL}`

XML Body:

```
<RegistrationRequest
xmlns="http://schemas.datacontract.org/2004/07/{NAMESPACE}">
  <AntennaHeight>Decimal</AntennaHeight>
  <ContactCity>String</ContactCity>
  <ContactCountry>String</ContactCountry>
  <ContactEmail>String</ContactEmail>
  <ContactName>String</ContactName>
  <ContactPhone>String</ContactPhone>
  <ContactState>String</ContactState>
  <ContactStreet>String</ContactStreet>
  <ContactZip>String</ContactZip>
  <DeviceOwner>String</DeviceOwner>
  <DeviceType>Byte</DeviceType>
  <Latitude>Decimal</Latitude>
  <Longitude>Decimal</Longitude>
</RegistrationRequest>
```

Where:

{HOST.DOMAIN} is replaced with the host.domain of the WSDB.

{VERSION} is replaced with a valid version number defined by the WSDB.

{FCCID} is the alphanumeric FCC identifier of the device.

{SERIAL} is the manufacturer-assigned alphanumeric serial number of the device.

<AntennaHeight> is the device's antenna height above ground level in meters.

<ContactCity> is the address city for the contact person.

<ContactCountry> is the country for the address of the contact person.

<ContactEmail> is the email address for the contact person.

<ContactName> is the name of the contact person responsible for the device's operation.

<ContactPhone> is the phone number for the contact person

<ContactState> is the state for the address of the contact person.

<ContactState> is the street address for the contact person.

<ContactZip> is the zip code for the address of the contact person.

<DeviceOwner> is the name of the individual or business that is responsible for the device.

<DeviceType> is the numeric device type. TODO: Define enum values!

<Latitude> is the decimal latitude of the device's geographic coordinates (NAD 83) accurate to +/- 50 m.

<Longitude> is the decimal longitude of the device's geographic coordinates (NAD 83) accurate to +/- 50 m.

4.2. Channel List Request

The WSDB will provide, upon request, the available TV channels at the TVBD's location.

There are three possible outcomes to a Channel Request:

1. Successful, with Channel List.
2. Successful, with no Channels Available.
3. Unsuccessful

To successfully receive a channel list, the FCC ID and Serial Number of the TVBD must be enrolled at the WSDB.

A successful Channel List Response will be returned to the TVBD only if all of the following are true:

- The FCC identifier and manufacturer's serial number are enrolled at the WSDB.
- The device location is within the appropriate regulatory boundaries.
- The device type is valid, and allowed for the authorized equipment class.
- For a fixed TVBD, the device is registered and the location matches the values previously registered.

4.2.1. Channel List Request Message

A Fixed or Mode II TVBD needing a channel to operate on can make a Channel List Request to the WSDB by sending an HTTP GET message with the following format:

HTTPS Method: GET

URL:

```
https://{HOST.DOMAIN}/{VERSION}/channels/{LATITUDE}/{LONGITUDE}/?fccid={FCCID}&serial={SERIAL}&type={DEVICETYPE}
```

Where:

{HOST.DOMAIN} is replaced with the host.domain of the WSDB.

{VERSION} is replaced with a valid version number defined by the WSDB.

{LATITUDE} is the decimal latitude of the device.

{LONGITUDE} is the decimal longitude of the device.

{FCCID} is the alphanumeric FCC identifier of the device.

{SERIAL} is the manufacturer-assigned alphanumeric serial number of the device.

{DEVICETYPE} is the numeric device type and antenna configuration.

4.2.2. Channel List Response

Upon receipt of a Channel List Request from a TVDB, the WSDB will return a Channel List Response to the TVDB, using the following sample format:

```
HTTP/1.1 200 OK\r\n
Cache-Control: private\r\n
Content-Length: {LENGTH}\r\n
Content-Type: application/xml; charset=utf-8\r\n
WSDB-Version: 3\r\n
WSDB-Status: {STATUS}\r\n
Date: Fri, 1 Jan 2010 16:00:00 GMT\r\n
\r\n
<ChannelResponse
xmlns="http://schemas.datacontract.org/2004/07/{NAMESPACE}">
<ChannelCount>integer</ChannelCount>
<ChannelList>integer,...,integer</ChannelList>
<RefreshIn>integer</RefreshIn>
```

Where:

{STATUS} provides the status for the Request, 0=valid.

{LENGTH} is the number of characters in the XML body.

<ChannelCount> is the number of channel entries in <ChannelList>.

<ChannelList> is a comma-separated list of channels, an empty list if <ChannelCount> = 0, otherwise <ChannelCount> entries.

<RefreshIn> is the number of hours until the channel list must be refreshed.

4.3. FCC ID Verification Request

The FCC ID Verification Request provides a method for TVBDs to verify the validity of Mode I TVBDs that are dependent upon a master TVBD for channel lists. The WSDB will respond whether a requested FCC ID is valid.

An FCC ID Verification Response will always be returned.

The status returned in the WSDB response is based on whether the FCC ID is found in the authorized list of FCC IDs downloaded from the FCC OET EAS.

The following sequence of events describes the use of this request:

1. A Fixed or Mode II TVBD needs to verify whether a Mode I TVBD is valid, and sends a FCC ID Verification Request Message to the WSDB.
2. The WSDB checks the FCC ID against the authorized FCC IDs and returns a reason code of success (0) only if found, otherwise unknown (not 0) will be returned. As long as the message is decodable, an FCC ID Verification Response will always be returned.

4.3.1. FCC ID Verification Request Message

HTTPS Method: GET

URL:

`https://{HOST.DOMAIN}/{VERSION}/devices/{FCCID}`

Where:

{HOST.DOMAIN} is replaced with the host.domain of the WSDB.

{VERSION} is replaced with a valid version number defined by the WSDB.

{FCCID} is the alphanumeric FCC identifier of the device.

4.3.2. FCC ID Verification Response

Upon receipt of a FCC ID Verification Request from a TVDB, the WSDB will return a status code, using the following sample format:

```
HTTP/1.1 200 OK\r\n
Cache-Control: private\r\n
WSDB-Version: 3\r\n
WSDB-Status: {STATUS}\r\n
Date: Fri, 1 Jan 2010 16:00:00 GMT\r\n
Content-Length: 0\r\n
\r\n
```

Where:

{STATUS} provides the status for the Request, 0=valid.

4.4. Data Objects

This section defines the data objects used in this protocol.

Legend:

Object Name | XML Field Name | Type |

- Description and Valid Values

antenna height | AntennaHeight | float |

- Antenna height above ground level in meters, ignored for personal/portable TVBDs

channel | ChannelList | integer list |

- Comma-separated list of available TV channel numbers, an empty list if ChannelCount=0, otherwise ChannelCount entries
Valid values: 2, 5-20, 21-36, 37-51

channel list count | ChannelCount | integer |

- Number of TV channel numbers in the list
0=no channels available
>0= number of TV channel numbers in ChannelList

contact email | ContactEmail | string(100) |

- email address for the contact person

contact name | ContactName | string(100) |

- name of a contact person responsible for the device's operation

contact phone | ContactPhone | string(50) |

- phone number for the contact person

contact street address | ContactStreet | string(100) |

- street address for the contact person

contact city | ContactCity | string(50) |

- city for the address for the contact person

contact state | ContactState | string(2) |

- state for the address for the contact person

contact postal code | ContactZip | string(20) |

- postal code for the address for the contact person

contact country | ContactCountry | string(2) |

- country for the address for the contact person

country code | CountryCode | string(2) |

- 2-character ISO 3166 country code, used to enforce the regulatory domain

device latitude | Latitude | float |

- decimal latitude of device's geographic coordinates (NAD 83) accurate to +/- 50 m

device longitude | Longitude | float |

- decimal longitude of device's geographic coordinates (NAD 83) accurate to +/- 50 m

device type | DeviceType | integer |

- Numeric TVBD type, used for applying channel availability and separation rules.

0=reserved

1=40 mW Mode I personal/portable (not used)

2=100 mW Mode I personal/portable (not used)

3=40 mW Mode II personal/portable

4=100 mW Mode II personal/portable

5=reserved
 6=reserved
 7=reserved
 8=Fixed

FCC ID | FCCID | string(17) |
 - alphanumeric FCC identifier of the TVBD

owner name | DeviceOwner | string(50) |
 - name of the individual or business that is responsible for the device

serial number | Serial | string(32) |
 - alphanumeric manufacturer's serial number for the TVBD

status | WSDB-Status: (HTTP header) | integer |
 - Status result for the request, see section 4.6. for status code values.

Strings longer than the maximum string length specified in the Type column will be truncated to the maximum string length.

4.5. Timers

The following timers are used by the protocol during operation.

Legend:

Timer Name (Default Value): Description

CLRP (1440 minutes): Channel List Refresh Period. The channel list must be refreshed at least once per day.

CLTO (n/a minutes): Channel List Timeout. If the channel list cannot be refreshed, it times out "tomorrow" at 11:59 pm, local time, relative to when the channel list was originally provided.

CRRP (60 minutes): Channel List Retry Period. If the WSDB returns No Channels Available, the period the TVBD should wait before retrying the request, to prevent overloading the WSDB with requests.

CRT (5 seconds): Channel list Request Timer. Deadman timeout for no response to Channel List Request.

FVRT (5 seconds): FCC ID Verification Request Timer. Deadman timeout for no response to Channel List Request.

RVP (90 days): Registration Valid Period. The WSDB will retain a TVBD registration for this period with no activity. This period is extended for each successful Registration Request and every Channel List Request.

RRRP (60 minutes): Registration Request Retry Period. If the registration request fails, the period the TVBD should wait before retrying the request, to prevent overloading the WSDB.

RRT (5 seconds): Registration Request Timer. Deadman timeout for no response to Registration Request.

4.6. Status Return Codes

The following status return codes are provided by the WSDB on responses to the TVBD to communicate the status of requests made by the TVDB.

Legend:

Status Code, Description, Returned Text

0,	"Successful",	Success
1,	"Malformed Request",	MalformedRequest
2,	"FCC ID is not supported",	FccIdNotSupported
3,	"Reserved",	Reserverd
4,	"Device has not registered",	DeviceNotRegistered
5,	"FCC has disallowed channels",	FccDesignatedNoChannels
6,	"Unknown Country Code",	UnknownCountryCode
7,	"Device is not enrolled",	NotEnrolled
8,	"Device is not enrolled in specified country",	NotEnrolledInCountry
9,	"Location is outside the regulatory domain",	LocatedOutsideRegulatoryDomain
10,	"Antenna Height cannot be above 30 meters",	AntennaHeightAbove30m
11,	"Height Above Average Terrain cannot be above 76 meters",	HaatAbove76m
12,	"FCC ID is invalid",	InvalidFccId
13,	"Device Type is invalid",	UnknownDeviceType
14,	"Request does not match previous registration",	RequestDoesNotMatchRegistration
15,	"Device Type does not match the equipment class",	DeviceTypeDoesNotMatchEquipmentClass
255,	"No Value",	None
254,	"Unknown Error",	UnknownError

5. Formal Syntax

While this specification uses an XML message structure, JSON may provide an acceptable option for encoding messages.

6. IANA Considerations

None

7. Security Considerations

In the protocol defined in this document, the use of HTTPS is essential for satisfying FCC and IETF-PAWS security requirements related to message integrity.

8. Conclusions

This document defines an application protocol for WSDB services provided to TVBDs. The protocol complies with FCC Rules/Requirements [FCC 10-174] and in the context of operating an FCC certified database, it also complies with requirements defined by IETF PAWS. We believe this protocol can be easily extended to include the remaining requirements not already satisfied from the IETF PAWS requirements.

9. Acknowledgments

This document was prepared using 2-Word-v2.0.template.dot.

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10.1. Normative References

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