



Key Bridge Global LLC
1600 Tysons Blvd., Suite 450
McLean, VA 22102
Tel: 703 414 3500
Fax: 703 414 3501

TV Bands Database

System Architecture & Interface Descriptions

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Rules, Interpretations and Implementation

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Document Information

Document Purpose	To capture and document industry consensus relating to the TV bands database (15.713) and TV bands database administrator (15.715) in the context of architecture, public interfaces and operation of a TV bands database.
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Author/Editor	Jesse Caulfield <jesse.caulfield@keybridgeglobal.com>
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Document History

Date	Author/Editor	Edit Summary	Doc Version
03/15	Jesse Caulfield	First draft – high level architecture and data model	0.1
04/29	Jesse Caulfield	Second draft – added requirements	0.2
06/29	Jesse Caulfield	Updated interpretation + Methods and Practice, Converted all transaction formats to JSON	0.3
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08/13	Jesse Caulfield	Incorporated industry comments and requested edits Added Executive summary	0.8

Document Notes

Because the proceeding remains under consideration the requirements may change. Where we believe this may occur we have tried to accommodate by adding flexibility and options to the interface and session design.

Where explicitly stated in the current Rules (as published in the Federal Register) the terms MUST and SHALL are used. Where there may be room for interpretation or discretion is explicitly granted, this document attempts to enumerate possible options and weigh their cost/benefit to advise commercial policy.

Executive Summary

A basic functional TV bands database system architecture is presented which includes nine interfaces and completely fulfils the Commission's requirements.

Each respective Database interface is a collection of web service functions that may be accessed by authorized parties (TV band devices and end-users) to transact information with the Database.

Nine interfaces are defined and two interfaces which accommodate communication with the public Internet are described in detail:

- INT-TVBDx to support interactions with TV band devices
- INT-SYNC-DB to support synchronization with other Databases

Various essential transactions across those two external interfaces are described including:

- TVBD channel list inquiries
- FCC auditing & enforcement
- TVBD status reporting
- Database synchronization

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Overview: Database Objectives and Desired Functionality

Title 47: Telecommunication

PART 15—RADIO FREQUENCY DEVICES

Subpart H—Television Band Devices

§ 15.713 TV bands database.

(a) Purpose. The TV bands database serves the following functions:

- (1) To determine and provide to a TVBD, upon request, the available TV channels at the TVBD's location. Available channels are determined based on the interference protection requirements in §15.712.
- (2) To register the identification information and location of fixed TVBDs.
- (3) To register protected locations and channels as specified in paragraph (b)(2) of this section, that are not otherwise recorded in Commission licensing databases.

§ 15.715 TV bands database administrator.

The Commission will designate one or more entities to administer a TV bands database. Each database administrator shall:

- (a) Maintain a database that contains the information described in §15.713.
- (b) Establish a process for acquiring and storing in the database necessary and appropriate information from the Commission's databases and synchronizing the database with the current Commission databases at least once a week to include newly licensed facilities or any changes to licensed facilities.
- (c) Establish a process for registering fixed TVBDs and registering and including in the database facilities entitled to protection but not contained in a Commission database, including cable head ends and TV translator receiver sites.
- (d) Establish a process for registering facilities where part 74 low power auxiliary devices are used on a regular basis.
- (e) Provide lists of available channels to fixed and personal/portable TVBDs that submit to it the information required under §15.713(f) based on their geographic location.
- (f) Make its services available to all unlicensed TV band device users on a non-discriminatory basis.
- (g) Provide service for a five-year term. This term can be renewed at the Commission's discretion.
- (h) Respond in a timely manner to verify, correct and/or remove, as appropriate, data in the event that the Commission or a party brings claim of inaccuracies in the database to its attention.
- (i) Transfer its database along with the IP addresses and URLs used to access the database and list of registered Fixed TVBDs, to another designated entity in the event it does not continue as the database administrator at the end of its term. It may charge a reasonable price for such conveyance.
- (j) The database must have functionality such that upon request from the Commission it can indicate that no channels are available when queried by a specific TVBD or model of TVBDs.
- (k) If more than one database is developed, the database administrators shall cooperate to develop a standardized process for providing on a daily basis or more often, as appropriate, the data collected for the facilities listed in §15.713(b)(2) to all other TV bands databases to ensure consistency in the records of protected facilities.

Interpretation

Section 15.713 of the Rules detail the minimum information a TV bands database system (“Database”) must contain and describes in general terms several transactions between the Database and various external systems that must occur. These transactions includes supporting providing channel lists for TV band device (“TVBD”) operation, registration and verification of protected services records and the support of FCC auditing and enforcement activities.

Appendix C of the Rules explains the purpose of the TV bands database as to allow “low power unlicensed transmitters to operate in the TV broadcast bands at locations where spectrum is not ... used by authorized services.”

Section 15.713 further explains the commercial function of a TV bands database is to provide, subject to certain restrictions, a list of TV channels available at a requesting TVBD’s geographic location.

For purposes of interference avoidance the Database is required to collect from the Commission and maintain an accurate working copy of records locating incumbent fixed transmitters, to calculate their geographic protected contours, and to provide TVBDs with correct channel information based on their location at the time of inquiry.¹

The Database must enable the Commission to enforce incumbent protection from interference where necessary.

Lastly, the Database must accommodate synchronization of certain information with other licensed TV bands databases.

¹ Protected contours are detailed in 15.712

The TV Bands Database System Architecture

In general, the Order describes a straightforward information storage and processing system and implies nine interfaces:

- Three interfaces to retrieve raw data from the Commission
- One interface to enable oversight, reporting and enforcement by the Commission
- Four interfaces to provide services for various enumerated Database “Clients”
- One interface to allow enforcement against Mode-I TVBDs

Of the nine interfaces, six describe Database internal operations while three describe interaction between the Database and third parties which must be well defined and standardized if possible.

A high level schematic interpretation of the Order’s text, its implied functional architecture plus interfaces are illustrated in Figure 1, where external interfaces and system functions are outlined in red.

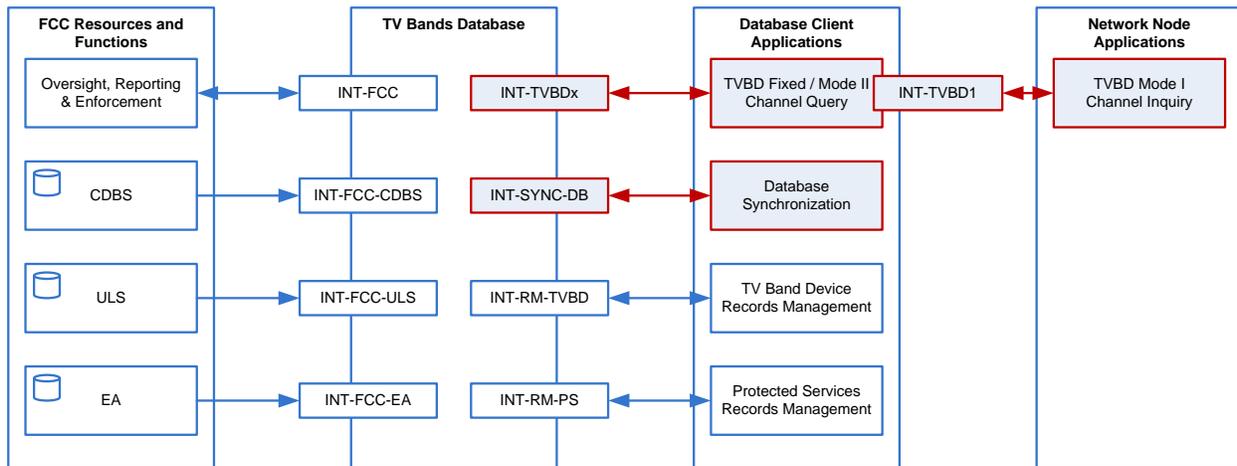


Figure 1 High-level system block diagram illustrating the nine interfaces described in the Order and their relationships

All Database, communications are expected to be Internet web services using open communication standards. The various information services which the Database must provide are built upon web services and delivered as functions incorporated into an Interface. An Interface is defined as a web service which implements a security model and makes available a defined set of functions. Communication interfaces to the Database are grouped by their scope of availability:

- External Interface

External interfaces are two-way, machine readable communications resources available to authorized devices and persons. External interfaces provide machine discoverable and readable one or two-way communication resources that the Database administrator or third parties may use to build network-based applications which use the Database as an Internet information resource.

The Database architecture includes two key external interfaces that support two-way machine-to-machine data exchange: an interface for TVBDs and one for other Database administrators.

- Internal Interface

Database interfaces are considered internal if they may not be directly accessed by third parties but rather exist only to support Database provided information services.

Examples of an internal interfaces are those that support the various web services and web portals for protected services registration, record review and FCC oversight.

- Internal Interface, Receive-only

Internal, receive only interfaces are used for automated machine-to-machine communication and database synchronization.

Three internal interfaces are required to provide Database synchronization with FCC databases. Their function is straightforward: to retrieve an exactly copy of external data objects and to make it available for local processing.

All nine defined Database interfaces are listed and described in the following table.

Class	Interface Label	Interface Description
External	INT-TVBDx	Class of functionally similar external interfaces that support connections from TV Band devices. Their primary function is to accept and reply to channel inquiries. Acceptable values for 'x' are 'F' for Fixed, '2' for Mode-II, and '1' for Mode-I devices. The interface may be extended in the future to accommodate new feature sets or device types.
External	INT-SYNC-DB	External interface to enable for the synchronization of independently operated TV band database systems
<i>Internal</i>	<i>INT-RM-TVBD</i>	<i>Internal record management interface to allow for the creation of new, and the review or modification of existing, TV Band device records</i>
<i>Internal</i>	<i>INT-RM-PS</i>	<i>Internal record management interfaces to allow for the creation of new, and the review or modification of, various protected services records</i>
<i>Internal</i>	<i>INT-FCC</i>	<i>Internal interface to enable manual or automated oversight, reporting and enforcement by authorized Commission staff</i>
<i>Internal</i>	<i>INT-FCC-CDBS</i>	<i>Collector to retrieve and process CDBS tables, whole or in part, from the FCC</i>
<i>Internal</i>	<i>INT-FCC-ULS</i>	<i>Collector to retrieve and process ULS tables, whole or in part, from the FCC</i>
<i>Internal</i>	<i>INT-FCC-EA</i>	<i>Collector to retrieve and process Equipment Authorization tables and/or specific EA record details, whole or in part, from the FCC</i>

System Interface Descriptions

TVBD Connection Interface

INT-TVBDx

Requirements

Title 47: Telecommunication

PART 15—RADIO FREQUENCY DEVICES

Subpart H—Television Band Devices

§ 15.713 TV bands database.

(e) TVBD initialization.

- (1) Fixed and Mode II TVBDs must provide their location and required identifying information to the TV bands database in accordance with the provisions of paragraph (b) of this section.
- (2) Fixed and Mode II TVBDs shall not transmit unless they receive, from the TV bands database, a list of available channels.

(f) Fixed TVBD registration.

- (1) Prior to operating for the first time or after changing location, a fixed TVBD must register with the TV bands database by providing the information listed in paragraph (f)(3) of this section.
- (2) The party responsible for a fixed TVBD must ensure that the TVBD registration database has the most current, up-to-date information for that device.
- (3) The TVBD registration database shall contain the following information for fixed TVBDs:
 - (i) FCC identifier (FCC ID) of the device.
 - (ii) Manufacturer's serial number of the device.
 - (iii) Device's geographic coordinates (latitude and longitude (NAD 83) accurate to ± 50 m).
 - (iv) Name of the individual or business that is responsible for the device.
 - (v) Name of a contact person responsible for the device's operation.
 - (vi) Address for the contact person.
 - (vii) E-mail address for the contact person.
 - (viii) Phone number for the contact person.

(g) A personal/portable device operating in Mode II shall provide the database its FCC Identifier (as required by §2.926 of this chapter), serial number as assigned by the manufacturer, and the device's geographic coordinates (latitude and longitude (NAD 83) accurate to ± 50 m)

Title 47: Telecommunication

PART 15—RADIO FREQUENCY DEVICES

Subpart H—Television Band Devices

§ 15.715 TV bands database administrator.

(j) The database must have functionality such that upon request from the Commission it can indicate that no channels are available when queried by a specific TVBD or model of TVBDs.

Interpretation

Only Fixed and Mode-II devices may request channel lists from the Database. There are four possible states for Fixed and Mode-II TV band devices with regard to their operation:

State	Device Status	Database Status	Transmit Status
1	Unregistered and inactive	No database record	Not able to transmit
2	Registered and inactive	Database record but no valid channel list	Not able to transmit
3	Registered and active	Database record plus valid channel list	Able to transmit
4	In Service	Possibly not connected	Transmitting

TVBD Registration is beyond the scope of this document.^{2,3}

TVBD Initialization describes a process through which a registered device establishes a session with the Database to exchange information. In most instances this will be to inquire and receive a valid channel list.

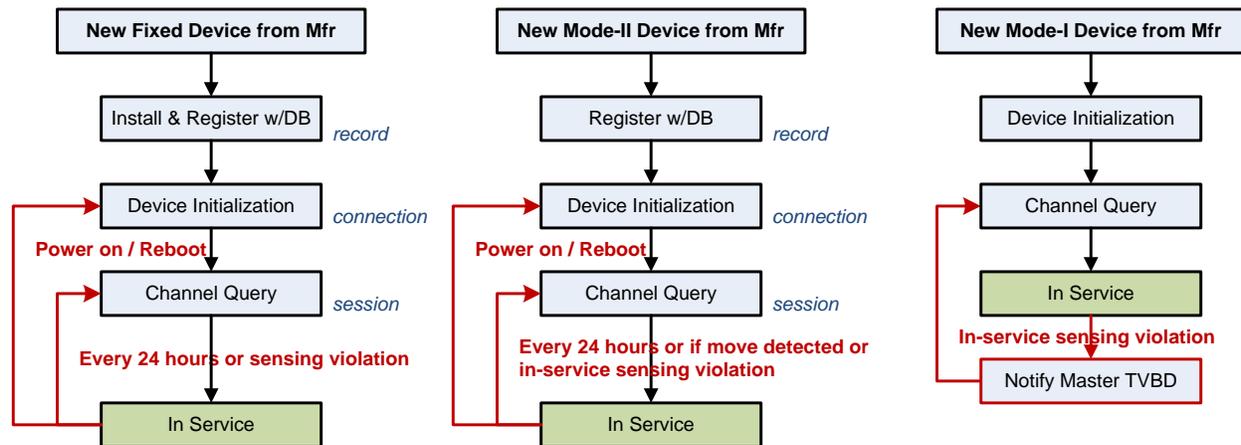


Figure 2: State diagrams for Fixed, Mode-II and Mode-I TV band devices indicating device state plus Fixed and Mode-II device status with the TV bands database labeled in blue.

Prior to beginning transmission (“In Service”), all devices must sense, or ‘listen’, for 30 seconds to ensure their selected channel is not occupied by a protected service the Database may be unaware of. Once in service devices must continue to sense once every 60 seconds. If a protected service is detected, the device must cease transmitting on that channel. Mode-I devices differ in that they must also notify their Master TVBD of any in-service sensing violation. In practice, it’s expected that such notifications will likely be made over an existing TV bands data link and immediately prior to transitioning from ‘In Service’ to ‘Channel Query’.

The Commission reserves the ability to deny service to any individual or class of TV band device (Fixed, Mode-II and Mode-I). Enforcement against Mode-I devices is implemented by the Database via proxy through Fixed and Mode-II devices.

² Fixed device Registration requires both a record of the device’s identifying information as defined in 15.713 (f)(3) and a commercial account. Mode-II devices are not required to maintain a relationship with the database but may be required to establish a commercial account with the Database administrator for the settlement of fees.

³ See the Key Bridge document *Registration, Authentication and Security* for additional details.

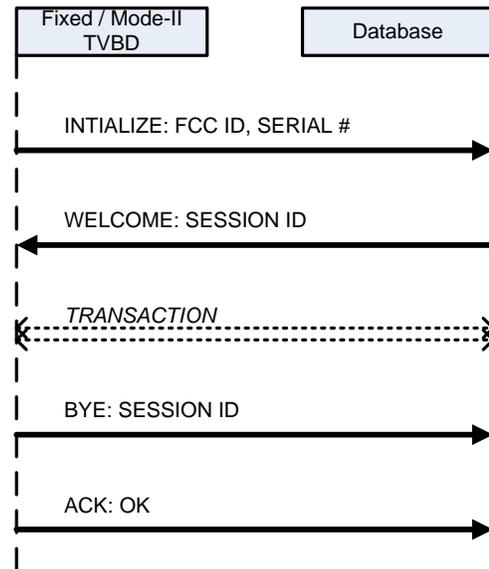
Discussion of Connections and Sessions

Communication between the Database and TVBDs occurs across a Connection, which is a point-to-point TCP/IP link between two IP hosts. A connection is established at either the Network layer (OSI 3) or Transport layer (OSI 4) and should be authenticated and encrypted. Typical examples of connections are a point-to-point VPN or TCP/IP socket.

Software applications communicate with other applications via sessions across a connection. Sessions are established at the Application layer (OSI 7) and enable the exchange of useful information.⁴ Once a session is established the application may begin to initiate transactions.

If desired, multiple sessions may be instantiated across a single connection to allow for parallel or non-blocking operation of transactions.

In summary: connections allow IP hosts to securely exchange network packets while sessions allow applications to transact useful information.



Sessions may be created and destroyed with the INITIALIZE and BYE commands, respectively. A Fixed or Mode-II device creates a session by sending an INITIALIZE command to the Database containing the device's identifying information. If the TVBD's identifying information is authorized the Database will create a session and respond with a new session's ID. If the device is not authorized, the session is rejected with an error code.

The Database may also initiate new sessions with a TVBD. In this case the INITIALIZE command originates with the Database and contains a new session ID instead of identifying information.

The following commands are enabled on all interfaces to enable session management.

Command Description & Context

INITIALIZE	Request to create a session between a Fixed or Mode-II TVBD and the Database. Message must include the requesting device's identifying information. Either a TVBD or the Database may initialize a session across an established connection. When a session is initialized by the database, message content is a session ID instead of TVBD identifying information. TVBD Antenna Height Above Ground (HAG) must be indicated by Mode-II devices during session initialization when it is above 3 meters and may be omitted where it is not.
WELCOME	Acknowledgement and establishment of an open session through which either end-point may execute subsequent transactions. Message must include session identifier.
ERROR	Acknowledgement of request and notification that a session cannot be established. Message must include error codes or explanatory details for end-user resolution.
BYE	Command to destroy a session. Message must include a session identifier.
ACK	General acknowledgement. When responding to a BYE message the content is 'OK'

All session communications described in this document employ the hypertext transfer protocol (HTTP) via TCP/IP sockets unless otherwise noted. Interface authentication and security are described in a separate document.⁵

⁴ See ISO/IEC standard 7498-1:1994 *Open Systems Interconnection Basic Reference Model*

⁵ See Key Bridge document *TV Bands Database: Security and Authentication*

Channel Query Session for Fixed / Mode-II Devices

INT-TVBD[F, 2]

The Database will provide a machine readable web service to accept and process incoming session initialization requests and respond to authorized channel inquiries. The INT-TVBDx interface supports the setup, modification and termination of sessions between the Database and TVBD clients. Fixed and Mode-II devices have similar initialization and channel inquiry requirements and are served by the same query response engine.

Note that all transactions require an existing connection between the TVBD and Database. Sessions are established across connections.⁶

A channel inquiry transaction across the INT-TVBD1 and INT-TVBD2 interfaces is illustrated below in Figure 3. The transaction requires an exchange of two messages and may be followed by several optional notifications.

- (1) CHANNEL QUERY: The TVBD may now request a channel list by referencing the session ID and specifying its location.
- (2) CHANNEL LIST: The database will respond with a calculated list of channels plus a time stamp. It will also confirm the TVBD's location.

If desired, the TVBD may now terminate the session with the Database if desired. The following exchange is currently optional.

- (3) NOTIFY: Once a channel is selected the TVBD may issue a notify message indicating the active, transmitting channel it has selected.
- (4) ACK: The Database will acknowledge and confirm any notification messages by echoing the content back to the sender.

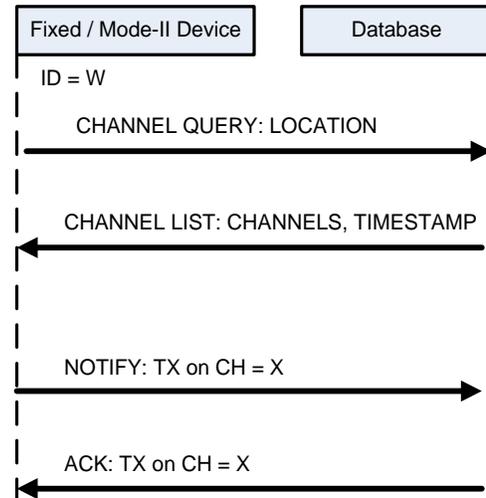


Figure 3: Channel inquiry transaction between a Fixed / Mode-II device and the TV bands database.

⁶ For more information see Discussion of Connections and Sessions and Key Bridge: *Registration, Authentication and Security*.

Following are the minimum set of required commands necessary to provide channel lists to TVBDs across the INT-TVBDx interface:

Command	Description & Context				
CHANNEL QUERY	<p>Command to request a list of available channels from the Database. A CHANNEL QUERY message must reference an established session and include the TVBDs geographic location.</p> <p>Location must be a numeric pair ordered as LATITUDE, LONGITUDE, in decimal format, containing up to 5 significant digits, in the NAD-83 datum.</p>				
CHANNEL LIST	<p>Database response to a valid CHANNEL QUERY command, which includes a list of channel values. For verification, CHANNEL LIST messages include an echoed copy of the CHANNEL QUERY location which must exactly match the TVBD's submitted value. In the event of a location value mismatch the TVBD must notify an error to the database and issue a new CHANNEL QUERY.</p> <p>CHANNEL LIST includes a Database generated time stamp plus duration which the TVBD should use to calculate channel list expiration and to schedule a refresh event. The time stamp is formatted according to RFC 3339 while the time interval is encoded in ISO 8601:2004(E) format.⁷</p>				
NOTIFY	<p>Command to submit unsolicited information to the Database. The Database accepts many types of NOTIFY messages, which must be formatted as key-value pairs and are sent to the database without solicitation. (Query responses use the INFO message type.) The Database will accept at a minimum the following key-value pairs within a NOTIFY message:</p> <table border="1"> <thead> <tr> <th>Key</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>TX</td> <td>Indicates the presently active transmitting channel. TX must be followed either by an integer channel or a fully qualified frequency value ending in zero in units of Megahertz. Valid examples include: '15' or '476.0' but not '476.' or '476'.</td> </tr> </tbody> </table>	Key	Value	TX	Indicates the presently active transmitting channel. TX must be followed either by an integer channel or a fully qualified frequency value ending in zero in units of Megahertz. Valid examples include: '15' or '476.0' but not '476.' or '476'.
Key	Value				
TX	Indicates the presently active transmitting channel. TX must be followed either by an integer channel or a fully qualified frequency value ending in zero in units of Megahertz. Valid examples include: '15' or '476.0' but not '476.' or '476'.				
ACK	General acknowledgement. When responding to NOTIFY messages the submitted information is echoed back to the user.				

⁷ See IETF RFC 3339, *Date and Time on the Internet: Timestamps* at <http://www.ietf.org/rfc/rfc3339.txt> and ISO 8601:2004(E) *Representation of dates and times*, section 4.4 *Time Interval* at http://isotc.iso.org/livelink/livelink/4021199/ISO_8601_2004_E.zip?func=doc.Fetch&nodeid=4021199

The UNIX command to generate a sample timestamp is: `date --rfc-3339=seconds -u`

The 'Channel Query' Message

Through an established session TVBDs need only present their location to request a channel list. The Database will have already established the TVBD type (Fixed, Mode-II) and Antenna Height Above Ground (HAG) during session initialization.

The 'Channel List' Message

The Database provides three useful sets of data for TVBDs in a CHANNEL LIST message. Of most interest to the TVBD are the actual channels, which are formatted as simple list of integer values.

Also included in a CHANNEL LIST is a timestamp and a duration. The timestamp value should be used by the TVBD to calculate when it must retrieve a new channel list. A shorter duration than 24 hours (one day) will be marked if protected events are scheduled with the Database that could affect the TVBDs operation on one of the indicated channels during the next 24 hours.

Timestamp duration is included as a courtesy and will never be greater than 1 day. Year and Month values must always be zero, and any non-zero values must be ignored by the TVBD.

Example Transaction

An example channel inquiry transaction is presented below using JSON encoding with the text formatted for readability. In this example the TVBD indicates its antenna is 4 meters above ground while the Database timestamp of one day implies no known events within the next 24 hours for the listed channels.

Message	Message Content
INITIALIZE	{FCC_ID:"BDJ6AUME57A" ,SERIAL:"33451AB" ,HAG:4}
WELCOME	{SESSION_ID:"ADF781023"}
CHANNEL QUERY	{SESSION_ID:"ADF781023" ,LOCATION:{{37.18654,-79.54623}} }
CHANNEL LIST	{SESSION_ID:"ADF781023" ,LOCATION:{LAT:37.18654,LON:79.54623} ,TIMESTAMP:2009-08-02 14:36:04+00:00 ,DURATION:P0Y0M1DT0H0M ,CHANNELS:[3,5,7,9,11,13,15] }
NOTIFY	{SESSION_ID:"ADF781023" ,TX:15}
ACK	{SESSION_ID:"ADF781023" ,ACTION:"NOTIFY" ,TX:15 }

Channel Query Session for Mode-I Devices

INT-TVBD[1]

To comply with §15.715(j), the Database must support authorization of Mode-I device channel assignments by proxy through Fixed or Mode-II devices. The actual interface, protocol and mechanics of communication between Mode-I and Fixed or Mode-II devices are beyond the scope of this document except for basic functionality and requirements make by the Rules.⁸

When a Fixed or Mode-II (Master) device receives a channel inquiry from a Mode-I (Client) device, the Master must relay the Client's identifying information to the Database for validation and wait for a response prior to issuing a channel list or allowing the Client to transmit.

The Database will check the Client's identifying information against a list of devices, provided by the Commission, for which the Commission wishes to deny operation. This list has been colloquially called a TV bands device 'black list'. The Database will reply to the Master device with either positive confirmation or an ERROR message indicating that the Master must deny operation to the specific Client device. Errors will include supplementary or explanatory information to facilitate end-user resolution directly with the Commission.

If the Mode-I Client is validated the Master device may then freely assign channels to the Client from its own existing valid channel list.

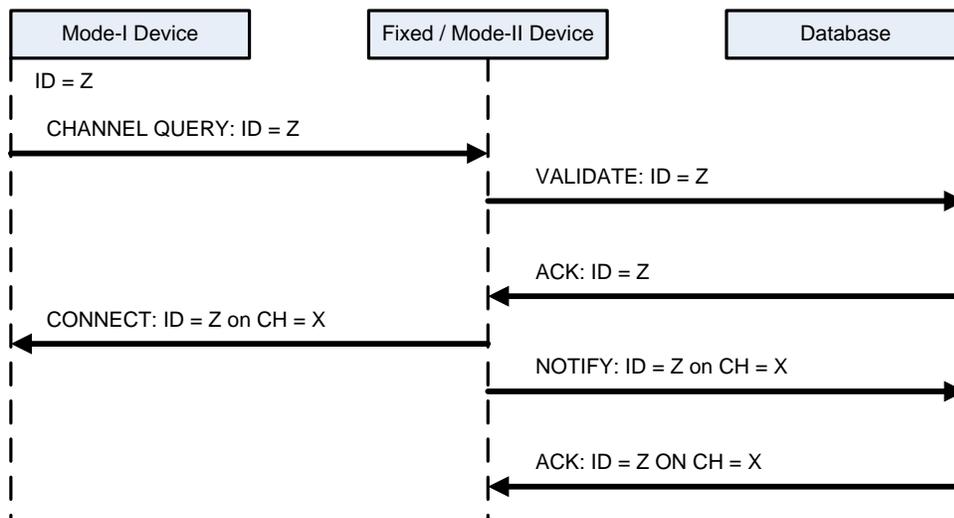


Figure 4: Mode-I channel assignment transactions allowing the Commission to deny transmitting capability to unauthorized Mode-I devices with positive confirmation

The following command is added to INT-TVBDx interface to support authentication of Mode-I TVBD devices:

Command	Description & Context
VALIDATE	Command issued by a Fixed or Mode-II device to the Database requesting confirmation of a Mode-I device's authorization to transmit. VALIDATE messages must reference a valid session ID and include the Mode-I device's identifying information (FCC ID + serial number).

⁸ See Key Bridge documents for additional information: *Interference Protection Requirements, System Architecture & Interface Descriptions, Registration, Authentication & Security*

FCC Auditing and Enforcement Sessions

INT-TVBD[F, 2, 1]

The Commission may wish to know the location and operating status of devices or channels prior to making an enforcement action. To enable the Commission to conduct TVBD audits and enforcement the following methods are added to the INT-TVBDx interface.

Command	Description & Context
DETAIL	Database originated command to a Fixed or Mode-II device to provide operational details of a specified device (possibly including the queried device) or an occupied channel. DETAIL messages must reference a session ID and include either: <ul style="list-style-type: none"> • A specific device's identifying information (FCC ID + serial number) or • A class of device's identifying information (FCC ID) or • A broadcast channel number
INFO	Response message containing the requested information. INFO messages must reference the session identifier and indicate an error when no matching devices are found.
DISCONNECT	Database command to a Fixed or Mode-II TVBD to disconnect either a specific TV band device, a class of devices, or all devices on a specified channel (possibly including the instructed device). Message must reference a session ID and include either a specific device's identifying information (FCC ID + serial number), a class of device's identifying information (FCC ID), or a broadcast channel number. DISCOMMENT messages include a cryptographic signature for authentication by the receiving TVBD.

Device Auditing and Detail Inquiry

The Database may query Fixed or Mode-II devices for the operational status of any type of TV band device (Fixed, Mode-II or Mode-I). A device detail transaction requires the exchange of two messages and is illustrated in **Error! Reference source not found.** The transaction begins with a DETAIL command indicating the desired device's identifying information. The TVBD responds with either an ERROR message if no match is found or an INFO message that must contain, at minimum, the specified device's transmitting and, if different, its receiving channel.

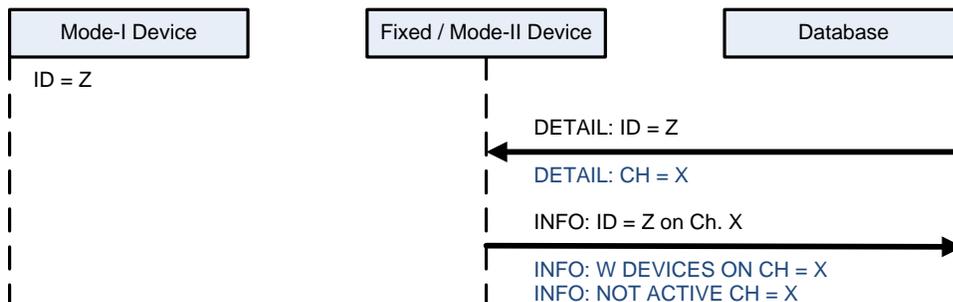


Figure 5: Audit transaction illustrating the collection of device and channel operating status information (blue text). Device auditing messages may be sent to Fixed and Mode-II but not Mode-I devices.

An example device audit transaction is presented below using JSON encoding with the text formatted for readability. In this exchange, the Database requests the operational status of a specific device.

```

DETAIL      {SESSION_ID:"ADF781024"
            ,FCC_ID:"BDJ6AUME57A"
            ,SERIAL:"33451AB"
            ,TX:"*"}

INFO       {SESSION_ID:"ADF781024"
            ,FCC_ID:"BDJ6AUME57A"
            ,SERIAL:"33451AB"
            ,TX:15
            ,RX:19
            ,POWER:-55}

```

Channel Auditing and Detail Inquiry

A channel status transaction is similar but with a differently formatted INFO message response. A channel detail audit also begins with a properly formatted DETAIL command, and the TVBD response is an INFO message containing either an error notification that there are NO active transmitters on the requested channel or a list containing the identifying information of all active devices (including the responding device) known to be actively transmitting on the requested channel.

The following example illustrates a transaction to query the operational status of an entire channel. The responding TVBD returns a list containing the identifying information and operating detail for four devices.

```

DETAIL      {SESSION_ID:"ADF781025"
            ,FCC_ID:"*"
            ,SERIAL:"*"
            ,TX:15}

INFO       {SESSION_ID:"ADF781025"
            ,TX:15
            ,DEVICES:[ { FCC_ID:"BDJ6AUME57A",SERIAL:"33451AB",RX:19, POWER:-55}
                       ,{ FCC_ID:"BDJ6AUME57A",SERIAL:"33452AB",RX:19, POWER:-53}
                       { FCC_ID:"BDJ6AUME57A",SERIAL:"33453AB",RX:19, POWER:-31}
                       { FCC_ID:"BDJ6AUME57A",SERIAL:"33454AB",RX:19, POWER:-60}
                       ]}

```

Device and Channel Enforcement

The Database and all TVBDs will support the Commission's enforcement requirement with a transaction to disconnect a specific device, class of devices, or all devices on a specific channel.

To ensure the validity and authenticity of Commission enforcement instructions, the enforcement message will be cryptographically signed by the Database and readable only with the private keys held by the receiving TVBD.

If the target TVBD is not connected or the indicated channel is unoccupied the receiving Fixed or Mode-II device will respond with an INFO message. Otherwise, the DISCONNECT message will be forwarded to its final recipient and appropriate action taken.

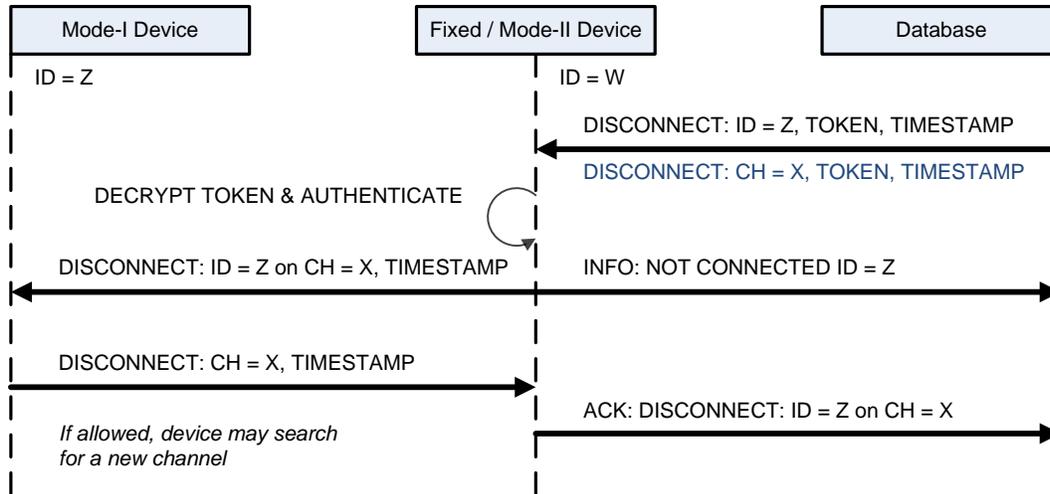


Figure 6: Enforcement transaction illustrating methods to disconnect individual devices or the evacuation of channels (blue text)

To enable Commission enforcement actions the following command is added to the INT-TVBDx interface:

Command	Description & Context
DISCONNECT	Command from the Database to a Fixed or Mode-II device instructing the TVBD to disconnect a specific TV band device (including itself), a class of devices, or all devices on a specified channel. DISCONNECT messages must reference a session ID and include either a specific device's identifying information (FCC ID + serial number), a class of device's identifying information (FCC ID), or a broadcast channel number. DISCONNECT messages are cryptographically signed for authentication and action only by the intended recipient.

Enforcement Duration

For device specific or channel-wide enforcement there are two types of action the Commission may implement: those with temporary duration or indefinite. Temporary enforcements are indicated by a timestamp with a non-zero duration. After a temporary enforcement has expired all affected device(s) may re-initialize.

For temporary enforcement action, the timestamp duration may be set. For indefinite enforcement requiring end-user resolution, the timestamp duration is set to zero.

Device Specific Enforcement

The Commission, via the Database, may prevent a single device or an entire class of TV band devices from transmitting. Device enforcement transactions require the exchange of two messages between the Database and the controlling Fixed or Mode-II device. If the targeted device is Mode-I, the Disconnect command may trigger separate transactions with other IP end points.

As with INT-TVBD1, the actual interface, protocol and mechanics of communicating between a Mode-I and Fixed or Mode-II device are beyond the scope of this document except for the basic functionality described herein.

An enforcement transaction begins with a properly formatted DISCONNECT command. If the token is confirmed to be valid the Fixed or Mode-II TVBD will issue appropriate terminating commands and cease transmitting to all matching devices (including itself if appropriate) and acknowledge details of the action taken back to the Database.

To disconnect a specific device the Database must specify that device's identifying information. To disconnect a class of device the Database may use a wildcard '*' in the serial number field. For single or multiple device enforcement, the TVBD response follows a similar format.

In the following example transaction note the timestamp field value of zero, indicating a class of devices is instructed to cease operation on channels 15, 16, and 17 until further notice.

```
DISCONNECT      {SESSION_ID:"ADF781027"
                 ,FCC_ID:"BDJ6AUME57A"
                 ,SERIAL:"*"
                 ,TX:[15,16,17]
                 ,TOKEN:"cIZjxGTli1Ug3HJtQ9aWD+9q08gTVGtqzWV1VXjCTsHbsy732Fw/jdFBAs"
                 ,TIMESTAMP:2009-08-03 14:34:17+00:00
                 ,DURATION:POYOM0DTHOM }

ACK             { SESSION_ID:"ADF781027"
                 ,ACTION:"DISCONNECT"
                 ,DEVICES:[ { FCC_ID:"BDJ6AUME57A",SERIAL:"33451AB"}
                             ,{ FCC_ID:"BDJ6AUME57A",SERIAL:"33452AB"}
                             { FCC_ID:"BDJ6AUME57A",SERIAL:"33453AB"}
                             { FCC_ID:"BDJ6AUME57A",SERIAL:"33454AB"} ] }
```

Channel Vacation Enforcement

The Commission, via the Database, may also disconnect all devices on a specific transmitting channel for a fixed duration or indefinitely. Channel enforcement is similar to device enforcement except for the extent of actions required by the receiving Fixed or Mode-II TVBD.

For channel enforcement the Fixed or Mode-II TVBD must disconnect all client devices and cease transmitting on the indicated channel. The acknowledgement should include details of the action taken.

To disconnect all devices on a specific channel, the DISCONNECT message will contain a wildcard for 'FCC_ID' and 'SERIAL', while specifying a channel 'TX' value. The TVBD will respond using the same format described for specific devices but only indicate the count of devices affected by the action and not their identifying information.

```
DISCONNECT      {SESSION_ID:"ADF781028"  
                ,FCC_ID:"*" "  
                ,SERIAL:"*" "  
                ,TX:"15"  
                ,TOKEN:"cIZjxGTli1Ug3HJtQ9aWD+9q08gTVGtqzWV1VXjCTsHbsy732Fw/jdFBAs"  
                ,TIMESTAMP:2009-08-03 15:34:17+00:00  
                ,DURATION:POYOMODT6HOM }  
ACK             { SESSION_ID:"ADF781028"  
                ,ACTION:"DISCONNECT"  
                ,DEVICES:4 }
```

Status and Information Reporting Session (Optional)

INT-TVBD[F, 2]

Requirement

Title 47: Telecommunication

PART 15—RADIO FREQUENCY DEVICES

Subpart H—Television Band Devices

§ 15.711 Interference avoidance mechanisms.

(c) Spectrum sensing

- (1) Detection threshold. (i) All fixed and personal/portable TVBDs must be capable of detecting ATSC digital TV, NTSC analog TV and wireless microphone signals using analog or digital modulation methods....*
- (2) Low power auxiliary device channel availability check time. A TVBD may start operating on a TV channel if no wireless microphone or other low power auxiliary device signals above the detection threshold are detected within a minimum time interval of 30 seconds.*
- (3) TV channel availability check time. A TVBD is required to check for TV signals for a minimum time interval of 30 seconds. If a TV signal is detected on a channel indicated as available for use by the database system, the device will provide a notice of that detection to the operator of the device and a means for the operator to optionally remove the channel from the device's list of available channels.*
- (4) In-service monitoring. A TVBD must perform in-service monitoring of an operating channel a minimum of once every 60 seconds. There is no minimum channel availability check time for in-service monitoring.*
- (5) Channel move time. After a wireless microphone or other low power auxiliary device signal is detected on a TVBD operating channel, all transmissions by the TVBD must cease within two seconds.*
- (6) Personal/portable devices operating in the client mode shall identify to the fixed or Mode II personal/portable device those television channels on which it senses any signals above the detection threshold. The fixed or Mode II device shall respond in accordance with the provisions of this paragraph as if it had detected the signal itself.*
- (7) TVBDs communicating either directly with one another or linked through a base station must share information on channel occupancy determined by sensing. If any device in a local area group or network determines that a channel is occupied, all other linked devices will also be required to respond in accordance with the provisions of this paragraph as if it had detected the signal itself.*

Interpretation

End users and service providers may elect to configure certain of their devices to report operational status and sensing information back to the Database. This information may help the Database to improve the accuracy and quality of channel query responses plus help the Commission to better understand TV band frequency use and occupancy.

TVBDs of all types may report detected signals at their discretion directly the Database by sending a **DETAIL** message through the **NOTIFY** interface command.

Mode-I devices may also report operating information to the Database via proxy through their upstream Fixed or Mode-II Master device.

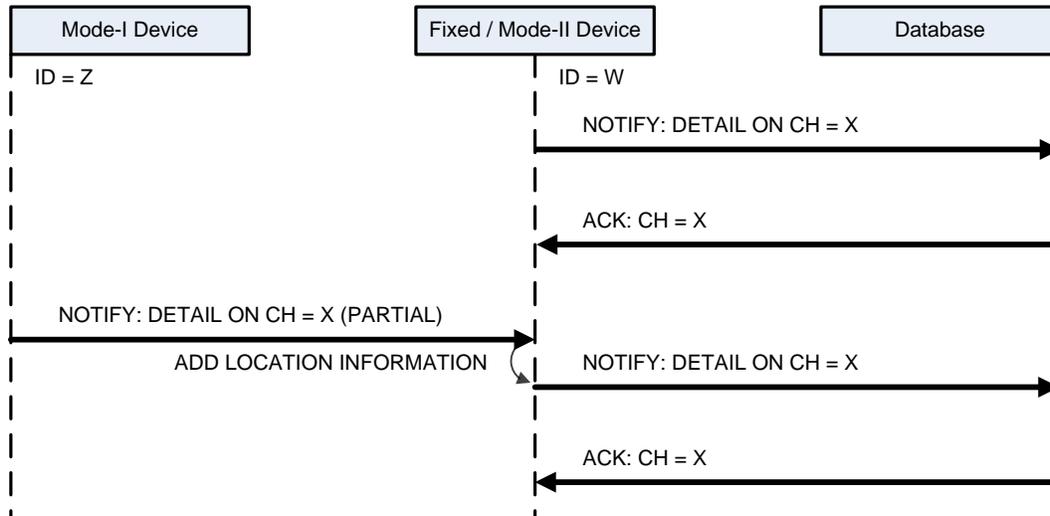


Figure 7: Receipt by the Database of status and reporting methods are supported for all TV band devices by sending a **DETAIL message through the **NOTIFY** command.**

The **DETAIL** message is explained below.

Message content: the DETAIL object

Unlicensed TV band devices are presently required to sense for two classes of incumbent transmitter on a channel that is indicated as available by the Database

- Television signals and
- Low power auxiliary devices (microphones).

Operational status notifications messages must have their content formatted as a DETAIL object, which may contain the following defined key-value pairs:

Key	Value description
CLASS	Class of detected transmitter. Allowed values are: <ul style="list-style-type: none"> • 'LPAUX' for microphones or other similar devices • 'TV' for any type of television signal
TX	The detected transmitting channel
TYPE	The type of sensing notification: acceptable values are either <ul style="list-style-type: none"> • 'INFORMATION' indicating expected or not significant in-service monitoring data • 'VIOLATION' indicating the channel was cleared by the Database for unlicensed operation and the sensed signal was not expected
POWER	The detected power level in dBm units
LOCATION	The location where the detection occurred (typically the submitting TVBD's location)
TIMESTAMP	When the detection occurred. By default, the duration is set to zero. However, if the TVBD is configured to record detection event start and stop times the duration may be set accordingly.

As an example, the following message reports a detected microphone signal that lasted for four minutes on a channel that the Database indicated was available for unlicensed operation:

```

NOTIFY      {SESSION_ID:"ADF781029"
            CLASS:"LPAUX"
            ,TX:15
            ,TYPE:"VIOLATION"
            ,POWER:-63
            ,LOCATION:{ LAT:37.18654, LON:-79.54623 }
            ,TIMESTAMP:2009-08-03 17:34:17+00:00
            ,DURATION:P0Y0M0DT0H4M }

ACK        {SESSION_ID:"ADF781029"
            ,ACTION:"NOTIFY"
            ,TX:15}
  
```

Database Synchronization Interface

INT-SYNC-DB

Requirement

§ 15.715 TV bands database administrator.

(k) If more than one database is developed, the database administrators shall cooperate to develop a standardized process for providing on a daily basis or more often, as appropriate, the data collected for the facilities listed in §15.713(b)(2) to all other TV bands databases to ensure consistency in the records of protected facilities.

Interpretation

Independently operated Databases may diverge greatly over 24 hours during the normal course of operation. A mechanism is required for Databases to synchronize on-demand and to assure required content is properly mirrored.

It is each Database's responsibility to synchronize itself with other Database systems but not to assure that other systems are synchronized with it. Synchronization is a client-server transaction whereby the client Database synchronizes itself with the Server.

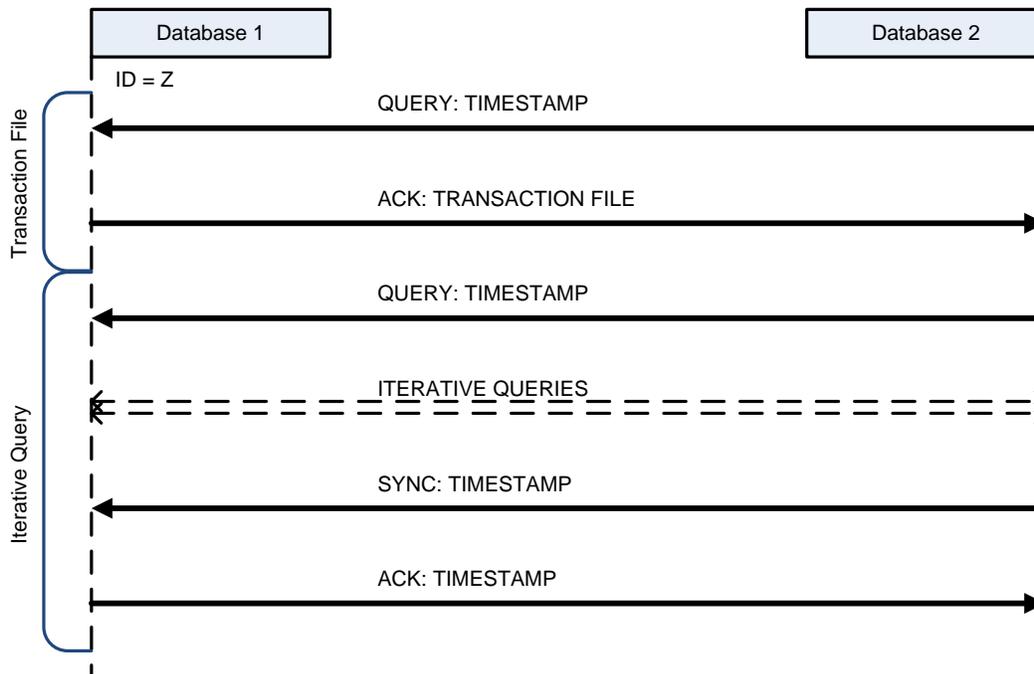
To facilitate this, each Database must support time stamped tracking of all modifications to its own contents and at minimum the following functionality:

- Respond to a set of queries to identify all unsynchronized records (add/delete/change) since the indicated timestamp
- Provide a mechanism to positively confirm all records are synchronized and contain identical information

Databases may also opt to remain synchronized and exchange incremental updates as they occur. In this case individual Database records should not diverge and it is not necessary to exchange updates from a given snapshot or time stamped baseline. Instead it may be necessary from time-to-time to positively confirm that all records are matched and then only to synchronize those records that are not.

Time Stamped Synchronization

A Database may synchronize itself with another Database by establishing a connection, then a session, across which the initiating Database may execute various transactions.



Time stamped synchronization is a method whereby one Database may either receive all modifications in a bulk transaction or iteratively query and retrieve modifications from another Database between the time of inquiry and a specified timestamp in the past.

Bulk transfer often involves database-specific, and sometimes proprietary, binary transaction files. Details about the bulk transfer of transaction files are left to the respective Database administrators.

An iterative query may occur across a standard web interface and is described below.

Iterative synchronization begins when the requesting Database (Client) issues a QUERY command to another Database (Server) and indicates a timestamp for when the Server should begin to relay unsynchronized records.

The Server responds with an information message indicating the number of records for each class of device that require synchronization.

The Client may then iteratively query records for each class of device.

Optionally, after all records are retrieved both systems (Client + Server) may establish a new timestamp or snapshot to record the most recent successful synchronization event.

Example Iterative Query

An brief excerpt of an example iterative query session is shown below. In this example the foreign Database shows four classes of record require synchronization and indicates how many records for each class should be updated.

The synchronizing database then enters a double iterative loop, first for each class of device, then for each record that should be updated for that device class.

```
QUERY          {SESSION_ID:"ADF781030"
                ,TIMESTAMP:2009-08-03 21:34:17+00:00
                ,DURATION:POYOMODTOHOM}

INFO           {SESSION_ID:"ADF781030"
                ,TYPE:"RECORD COUNTS BY CLASS"
                ,[{CABLE:15 }, {TXTX:105 }, {LPAUX:65 }, {TVBDF:301 } ] }

QUERY          { SESSION_ID:"ADF781030"
                ,CLASS:"CABLE"}

INFO           {CABLE RECORD}

QUERY          { SESSION_ID:"ADF781030"
                ,CLASS:"CABLE"
                ,FUNCTION:"NEXT"}

INFO           {CABLE RECORD}

...

ERROR          (NO RECORDS AVAILABLE)

QUERY          { SESSION_ID:"ADF781030"
                ,CLASS:"TVTX"}

....
```

The minimum contents of each record class (CABLE RECORD, TVTX RECORD, etc.) are defined in the Rules. Each RECORD must also contain the type of synchronization required. For example: CREATE, UPDATE, DELETE.

As an example, a record describing a Cable head end that receives two protected television channels (15 and 36) from the same TV transmitting facility is shown below:

```
CABLE RECORD {TYPE:"CREATE"  
              ,NAME:"Cable Communications"  
              ,ADDRESS:{STREET:"1001 Binary Blvd."  
                        ,CITY:"Booleam"  
                        ,STATE:"IO"  
                        ,ZIP:"10101"}  
              ,RX LOCATION:{LAT: 45.12500, LON:-83.45601}  
              ,TVRX:{ {TX:15, CALLSIGN:"W15-DT", TX LOCATION: {LAT: 44.6700, LON:-83.9021}  
                      {TX:36, CALLSIGN:"W36-DT", TX LOCATION: {LAT: 44.6700, LON:-83.9021} }  
              }
```

If desired additional information may be included in a record detail. Establishing a standard message exchange and database record format is left to the Database administrators.

Continuous, Incremental Synchronization

Synchronization of geographically distributed databases is a common requirement for Enterprise information technology systems, and most commercial database systems provide robust, proprietary solutions.

Details for the implementation of continuous and near real-time synchronization of independently operated Databases are left to their respective administrators.

Appendix: Questions & To Do List

- **Add adjacent channel indicators**

INT-TVBD[F, 2]: Channel lists should accommodate an adjacent-channel indicator for Mode-II devices. The 'CHANNEL LIST' message cited in this document (v 0.8) must be extended.

Requirement citation has special Mode-II accommodation (red text):

Title 47: Telecommunication

PART 15—RADIO FREQUENCY DEVICES

Subpart H—Television Band Devices

§ 15.712 Interference protection requirements.

(a) Digital television stations, and digital and analog Class A TV, low power TV, TV translator and TV booster stations:

(2) Required separation distance . Fixed TVBDs and personal/portable TVBDs operating in Mode II must be located outside the contours indicated in paragraph (a)(1) of this section of co-channel and adjacent channel stations by at least the minimum distances specified in the following table. Personal/portable TVBDs operating in Mode II must comply with the separation distances specified for an unlicensed device with an antenna height of less than 3 meters. Alternatively, Mode II personal/portable TVBDs may operate at closer separation distances, including inside the contour of adjacent channel stations, provided the power level is reduced as specified in §15.709(a)(2).

- **Mode-II antenna height above ground – Translating GPS coordinates**

The height displayed on most consumer handheld GPS receivers is orthometric height, or the height above mean sea level (MSL). Mode-II devices may provides its height in MSL. The Database will use SRTM-1 (1 arc-second resolution) digital elevation model data to calculate height above ground.

- **Backup plan for EA database content**

INT-FCC-EA: If the Commission does not make EA content available on a machine-readable basis the Database cannot verify FCC ID and Serial Number. In this case the CHANNEL QUERY command must be extended:

- TVBDs must indicate their device type (Fixed or Mode-II)
- Database must implement more robust (blind) checks to verify the FCC ID and Serial Number to the extent possible.