TESTING DATA BROADCAST AND MULTIMEDIA HOME PLATFORM (MHP) SERVICES WITHIN THE DVB MULTIPLEX

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ABSTRACT

Conventional broadcast television, either analogue or digital, may be thought of as the transmission of video and associated audio. The advent of digital broadcasting has created the opportunity for broadcasters to augment this with a rich array of data related services. These other services range from the digital encoding and transmission of Teletext and subtitles through to internet exploration and fully interactive gaming and advertising applications. As more broadcasters move to digital transmission the competition to attract viewers will increase. Programme content will remain a key differentiator, however, the role of these other interactive services in attracting viewers should not be underestimated.

The initial standardisation work was done by the MPEG committee and has subsequently being built upon by the DVB, particularly with the development and standardisation on the Multimedia Home platform (MHP) and its adoption by Open Cable (OCAP) in the US cable arena. As with the digital transmission of video and audio programmes, it is vital to the success of these other services that all authored material and transmissions can be correctly accessed and viewed by the target audience. The only reliable way to achieve this is to test for adherence to the relevant Application Programming Interface (API) standards.

This paper will outline the technology that enables these data services to be broadcast. It also highlights the measures which are being undertaken to ensure that new platforms which receive this entertainment are compliant to the standard API's and become as successful as conventional digital television.

COMMERCIAL DRIVERS FOR DATA BROADCAST AND MHP

The MHP specified by the DVB as ETR TS 101 812 V1.1.2 (1) offers the consumer a data rich new viewing experience of combined video, audio, enhanced broadcast and interactive services. From the broadcasters perspective it offers a tool for both greater advertising revenue generation and an enhanced viewing experience.

Key to both these opportunities is flawless systems interoperability and invisibility of any "technology" issues associated with a very complex delivery mechanism. To the end viewer data broadcast needs to be entirely transparent in operation, literally the press of a few buttons on a set top box remote control.

The broadcast industry has addressed these issues early in the development phase of MHP through the DVB MHP Experts Group (MEG). Its mission is to develop a test strategy for the MHP API which sits between the set top box firmware and the downloaded interactive application. This test strategy is designed to ensure that all MHP set top boxes which have passed a suite of interoperability tests at the API level will be conformant with the MHP specification.

Ensuring compliance is a technically complex and demanding procedure that has to date entailed passing approximately 7,000 individual MHP test cases.

Clearly the other side of this coin is to ensure that the authored and downloaded applications are also fully compliant with the API. Ensuring this is the responsibility of the content authors and the broadcasters who have tools to ensure compliance to the DVB data broadcast syntax and protocol and test carousel generation systems.

WHAT IS DATA BROADCASTING ?

DVB Transport Streams were initially developed as means of delivering compressed audio and video services to an end user form a central service provider via a variety of different third party delivery networks. It was very quickly realised that the same streams and networks could also be used to provide more than just video or audio and a number of different ways are defined in the MPEG-2 specification (ISO13818-6) (2) to carry that data according to the type of application.

Typical examples quoted for data broadcast applications include

- STB firmware updates to the STB operating system
- STB Application software downloads e.g. games
- Picture or text data e.g. extended advertising information
- Extended service information and programme guides
- Internet services
- Proprietary data e.g. price lists,

These applications all have different requirements therefore a number of fundamentally different methods are available to broadcast the different data types. Each of these different methods have several slightly different implementations e.g. DVB and DTG carousels, and OpenTV for example.

The DVB specification for data broadcasting (3) identifies a number of application areas and associates a data broadcasting profile for each application area. These application areas range from the download of software, interactive television, to the delivery of Internet services over broadcast channels. The data broadcasting profiles are as follows

- Data Piping
- Data Streaming
- Multiprotocol Encapsulation
- Data Carousels
- Object Carousels

A description of data and object carousel transmission relevant to MHP is provided in this paper.

PSI and SI

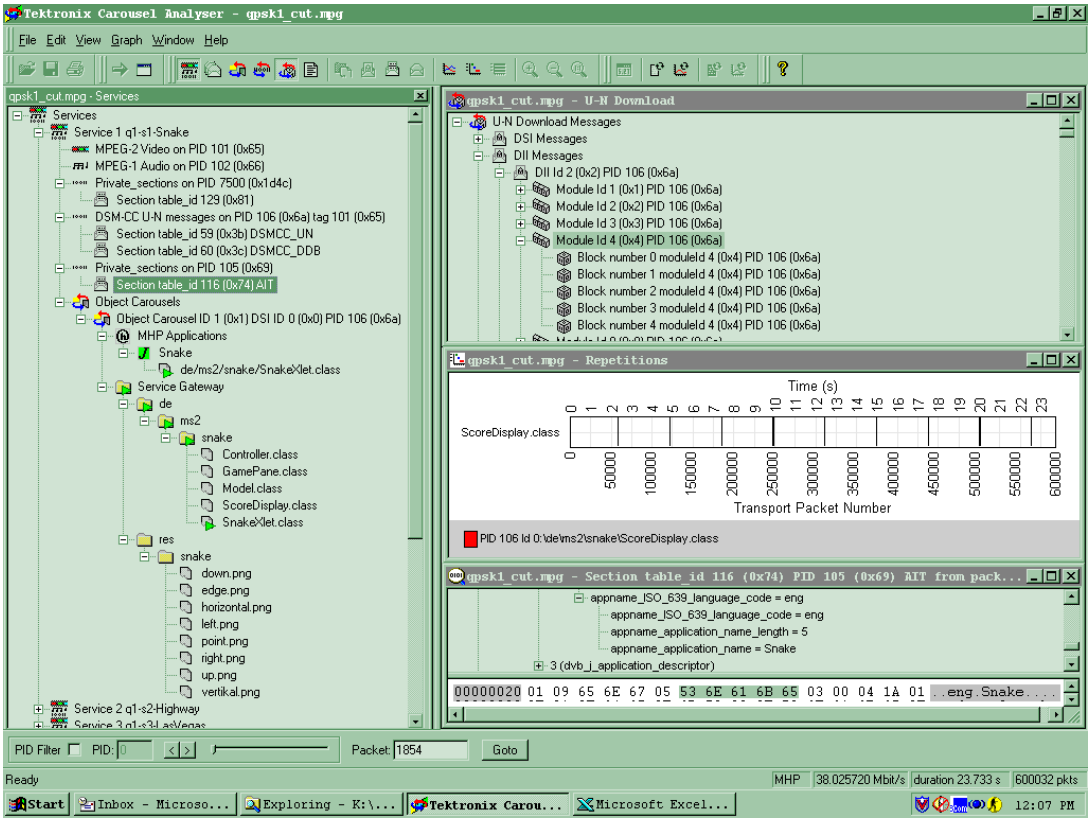

Figure 1 - SI/PSI Linkage

The MPEG systems standard, ISO 13818-1 (4) defines the mechanism by which encoded video, audio and data services which together form a single “program” is multiplexed, with other programs, into a transport stream. The transport stream multiplex is a packetised data stream, with fixed length packets of 188 bytes. Each packet has a 4 byte header which contains a 13 bit PID (Packet IDentifier). The individual elements of a program, audio and video are each carried within packets having a unique PID. To enable a decoder to successfully locate the constituent parts of a particular program within the transport stream the MPEG committee specified Program Specific Information (PSI) which is embedded into the transport stream in 3 tables. These are the Program Association Table (PAT), the Program Map Table (PMT) and the Conditional Access Table (CAT). The PAT is always allocated the PID value 0 and defines the PID on which each PMT can be found within the transport stream multiplex. A separate PMT section must exist for each of the programs within the transport multiplex. It defines the PIDs for the video, audio and data services which comprise the program. The identification of the components for each service is specified via a stream_type descriptor. For each of the data broadcasting profiles the DVB has defined the use of the stream_type descriptor.

To complement the MPEG defined PSI the DVB has defined additional Service Information (SI) (3) which is incorporated into the transport stream in a set of tables adhering to the MPEG private section syntax. From a data broadcast perspective two of the SI tables, the Service Description Table (SDT) and the Event Information Table (EIT) can be used to locate and identify the data broadcast profile. This enables the receiver to correctly process the data contained within the transport stream.

In addition for Digital Terrestrial Television (DTT) DVB have defined a table specific to MHP, the Application Information Table AIT (1) linked from the PMT. This provides the set top box with information on the interactive application carried in a data broadcast and allows the broadcaster to request a change in the activation state of the target set top box. The AIT also identifies the source of the application, its transport mechanism as IP encapsulation or carousel and formats as HTML or DVB Java. It also controls an applications life cycle once broadcast and loaded on the set top box.

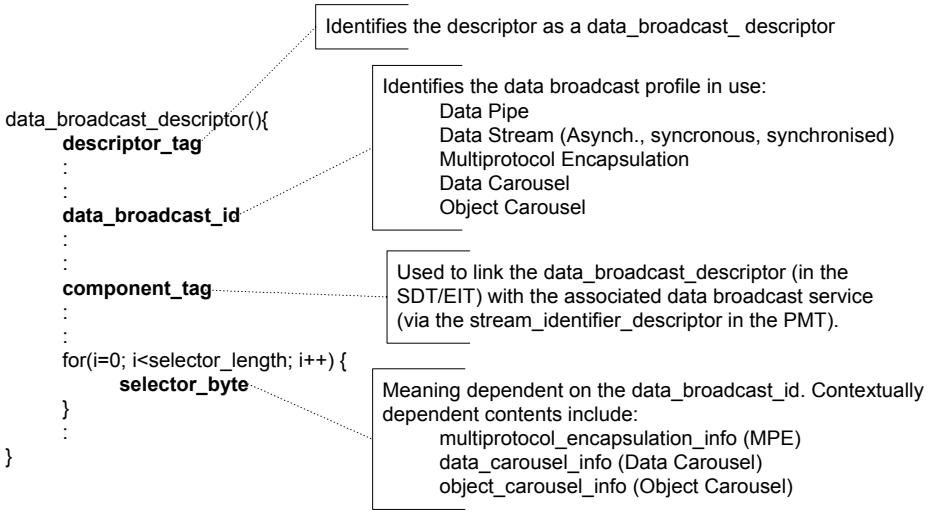

Figure 2 - Data Broadcast Descriptor

MHP Object and Data Carousels

Carousels are intended for the periodic transmission of information over a transport stream. Although the content of a carousel can be changed in response to a request from a target, it is more usual for the carousel to be regularly repeated regardless of whether any target is listening or needs that data at that moment. In practice a target that needs a specific data item is expected to simply wait until it is re-transmitted and collect the data on the fly.

The main difference between Object and Data carousels is :_

- Data carousels contain modules of data of **unspecified** content; it is up to the target to know what to do with the data it receives
- Object carousels contain **identifiable** data objects such as .jpg or .txt files and even the application software needed to use other objects. A directory structure enables any set top box to find an object, extract and download its associated application software and then use the object.

Data carousels are often used for downloading new system software to a set top box whereas an object carousel is typically used for game delivery, shopping services and Electronic Program Guides (EPG).

Both data and object items are repeated at periodic intervals though typically the repetition rate will vary from item to item. For example the EPG for the next hours viewing will repeat far more often than that for next month or the football results more often than that for a minority sport. The service provider will normally make commercial decisions about repetition rates.

Both Object and Data carousels are based upon the Digital Storage Media Command and

Control protocol (DSM-CC) extensions to the MPEG2 specification ISO13818-6, object carousels building on the structure defined for data carousels.

The contents of carousels are defined in the various User-User (UU) and User-Network (UN) messages and carried in modules or groups of files on one or more PIDs. A carousel may occupy multiple PIDs.

What is DSM-CC?

DSM-CC, Digital Storage Media Command and Control protocol was originally envisaged as a way of supporting Video on Demand (VOD) delivery of program material across a network on a transport stream.

In the simple generic case a program would be stored on a digital storage medium – i.e. a server – and DSM-CC messages are then used :

- By the target to request a program.
- By the server to tell the target where to find the program.
- By the target for VCR like control (Start, pause rewind etc.) of the stream.

The protocol has been extended to be able to cope with both on-demand as well as periodic delivery of program and data across multiple network providers.

User - User (UU) and User - Network (UN) Messages

In a typical broadcast system there will be service provider e.g. in the UK the BBC or Channel 4, a network carrier e.g. BSkyB, NTL or Telewest and target viewers using terrestrial, cable or satellite set top boxes.

In DSM-CC terms the network carrier is the Network whilst the service provide is a Server User and the target viewer is a Client User; usually both providers and targets are simply called Users.

A UN message is either from a User to a Network or from the Network to a User. This includes messages about where to find data/object carousels provided by the service provider.

A UU message is a direct communication between Users. For example a request for VOD service from a STB to the service provider, the VOD service itself from the service provider to the viewer or the actual files in an object carousel.

CORBA, IOR and BIOP

CORBA is widely used in IT areas that are unrelated to digital television, having been developed as a means to allow interoperability of components. Essentially all the information needed to identify, find and make use of an item can be transmitted or located using information in these messages.

- **CORBA** is Common Object Request Broker Architecture, a generic system for exchanging information about objects.
- **IOR** is Interoperable Object Reference or loosely a unique reference to an object.
- **BIOP** is Broadcast Inter ORB Protocol which defines a way of exchanging information in a broadcast carousel environment about an object, including directory and broadcast file systems and information on the object itself.
- **ORB** is Object Request Broker i.e. that which controls objects.

BIOP message contains an internationally agreed method to exchange information about an object being broadcast in the carousel; the rest is just parts of that method. The BIOP may also indicate how to use the object, including possibly providing the application software.

Data Carousels

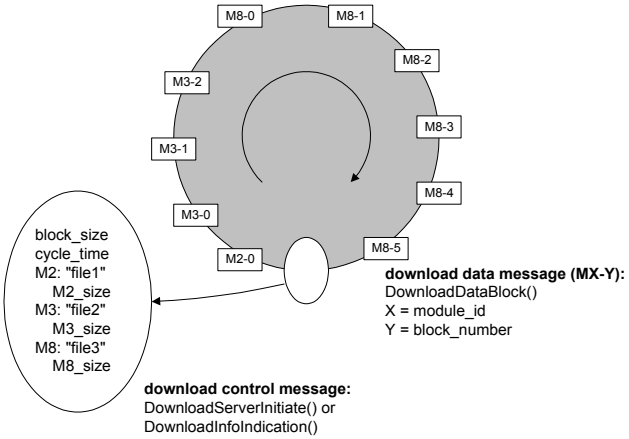

Figure 3 - Data Carousel

A data carousel does not contain a directory style structure or BIOP messages but monolithic blocks of data.

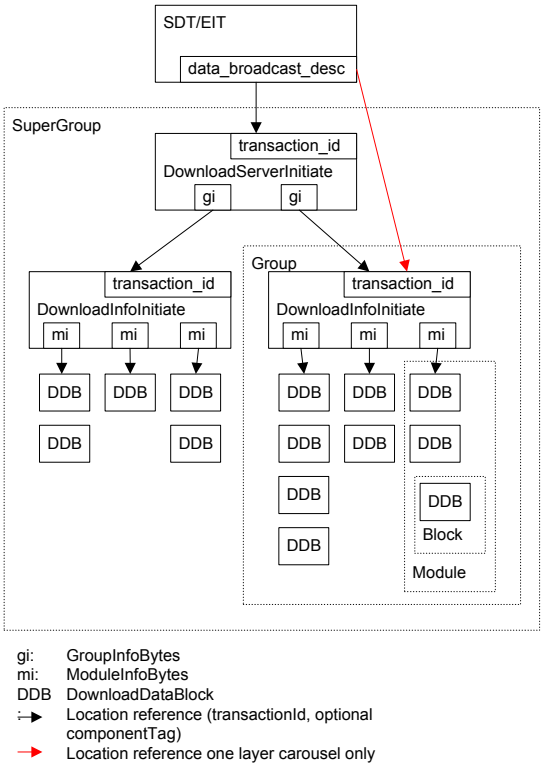

Figure 4 - Data Carousel Structure

A complete single item of data is defined as a “module”, this is generally a group of files. For transmission modules are split up into one or more blocks. Each block is sent as a section in the payload of a **DownloadDataBlock (DDB)** message. DDB messages can be sent in any order or at any periodicity; hence a mechanism is needed to identify which DDBs belong to what modules.

A **DownloadInfoIndication (DII)** message is used to group modules into logical groups. The information for more than one module can be in a single DII message; this forms a **Group**. Usually a group will contain logically related data modules.

If there are more related modules than can be grouped together into a single DII message then a **Supergroup** can be formed from multiple DII messages. Supergroup syntax is carried as the payload of a **DownloadServerInitiate (DSI)** message.

Note that modules and hence DDBs can be logically contained in many different groups or carousels in a broadcast. This reduces the need to waste bandwidth repeating common data items in different applications. Generally modules in a group are related.

A **one layer data carousel** contains a small number of modules referenced in a single DII. A **two layer data carousel** contains DSI messages referencing one or more DII messages.

Test Issues

For a development test tool the parameters which are likely to be examined for a data carousel are:

- Test the consistency and syntax of the PSI/SI e.g. Stream type and data broadcast descriptor.
- Test the consistency and syntax of the DSM-CC messages.
- Ensure that version information is consistent.
- Enable retrieval of the data.
- Adherence to the Data service decoder model where applicable.
- Measurement of bit and repetition rates for DSIs, DIIs, DDBs and modules.

OBJECT CAROUSEL

Transmitted in a Broadcast Inter ORB Protocol (BIOP) message format, a DVB Object Carousels uses the DSM-CC User to User Object Carousel specified by MPEG (2). The transmission of a structured group of objects using the Object Carousel protocol enables the client to build a mirror of the directory and file structure of the client as depicted in figure 5.

The data and attributes of an object are contained in a BIOP message which is transmitted in a Data Carousel.

A detailed description of the way in which objects are linked is beyond the scope of this paper, a good description may be found in DVB Implementation guidelines for data broadcasting (5).

Object carousels are used to broadcast items of identified data from a server to a receiver. These items are called objects and may be pictures, text files, and programs together with a directory listing ("**Service Gateway**") of the contents of the carousel. Related objects grouped and sent together as a single carousel form a **Service Domain**.

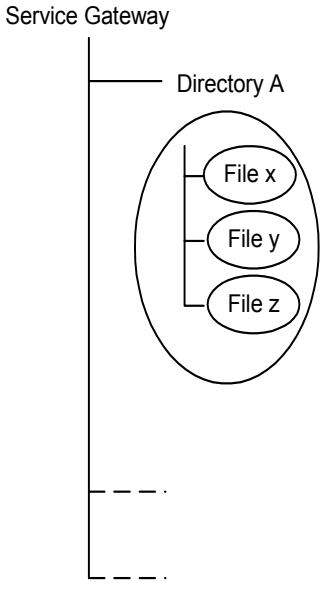

Figure 5 -
Object Carousel Hierarchy

Object carousels are like data carousels in that groups of objects are combined into a block of data, and then a variant of the data carousel methodology is used to transmit it. i.e. it still uses blocks, modules, DII and DSIs. As one module may contain many different objects the main extension is therefore the mechanism used to identify individual object within the modules of data. Basically the DSI enables the service gateway object to be quickly found; the service gateway being the top level directory.

The types of data sent are:-

- Directory Objects – e.g. the service gateway
- File Objects – e.g. text, picture, executable program files etc.
- Stream Objects – references to data/audio/video streams on other PIDS via a **Tap** (see below)
- Stream Events – Used to indicate a point in a Stream Object, usually a program start or stop time.

Taps are used to solve the problem that the actual PIDs used to broadcast DIIs, DDBs and video/audio streams are not known until the live broadcast time and even then PIDs may change if services are remuxed. Within the carousel therefore all references to PIDS are only made in terms of a tap; the association between a tap and a real PID is made via the PSI, in the association tag descriptor or stream identifier descriptor. Without taps a multiplexor would need to be modify a potentially large number of embedded BIOP messages.

Note that modules may be compressed to minimise transmission time. This should be transparent to the user

Application Example

To put this in context consider an interactive advertising application. Following a generic advert by a car manufacturer the user wants to know more about, say, a sports car. After the user selects “more info” the set top box downloads and runs a file object containing the Java application pointed at by the advert. The Java application will then download the directory object to present a list of all car datasheets for the user to choose from.

When the user selects the sports car datasheet the Java app will then download the datasheet and display it. The Java app may also specify that a stream object is associated with datasheets. Loading the specific datasheet might also cause the STB to access a stream object as well. For example a small viewing window might open in a corner of the display and a video advert –sent on another PID referenced by the stream object – will play about the selected car as the user reads the datasheet.

Broadcasting Object Carousels

The following is a simplified overview of Object Carousel Broadcast :-

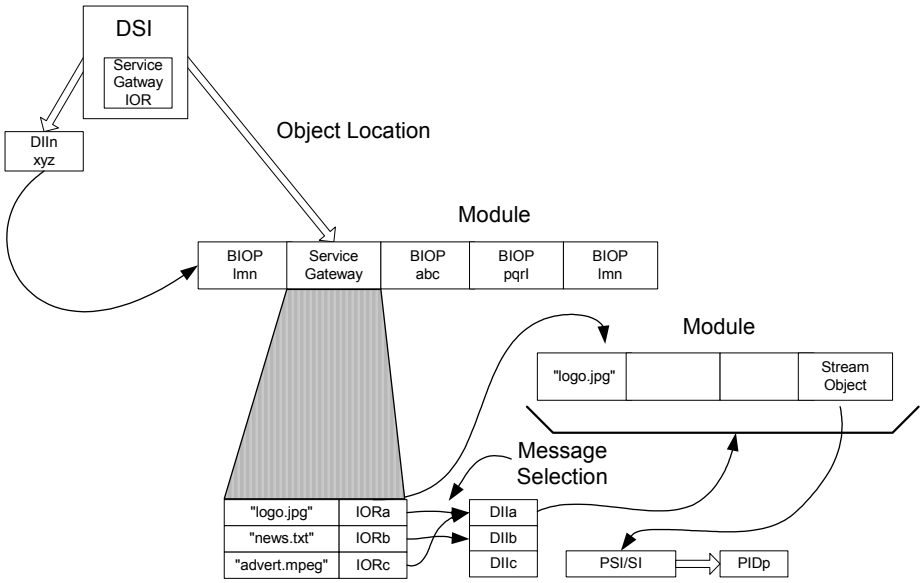

Figure 6 - Object carousel Broadcast

Directory, file and stream objects are sent in the same method as data carousels i.e. in modules split into blocks sent as sections in the payload of **DownloadDataBlocks** (DDBs). Objects are sent as BIOP messages and an integral number of complete BIOPs are combined together to form a modules. For ease of access each BIOP's header contains an "identifier key" and the length of the BIOP, enabling a parser to quickly skip search through the module. Often used BIOPs may be repeated.

A **DownloadServerInitiate (DSI)** message contains the IOR of the service gateway and is referred to in the PMT so forming the starting point to work out the contents of a specific object carousel.

Objects are referenced in a directory object using **IOR**s (Inter operable Object References). This contains all the information needed to access an object in the same service domain or on another object carousel (including those broadcast on other transport streams and/or PIDs). A name is associated with each IOR; this is called a *Binding.* IORs reference DIIs and contain object location structures.

The name given to the structure in the IOR that describes the location of an object is called a **Profile Body** which come in two types:

- **BIOP Profile Body** – used only for objects within this service domain
- **Lite Options Profile Body** – used for objects on other servers.

An IOR can contain more than one Profile Body if the object is available on more than one carousel and the set top box can choose the easiest/quickest one to access.

Test Issues

Object carousel test issues include:

- Set Top Box access times for complete or partial carousel access.
- Detection of unresolved object references.
- Recreation of expected directory structure as Figure 5.
- Measurement of object bit and repetition rates.

MHP RECEIVER PLATFORM CONFORMANCE AND INTEROPERABILITY

The test system shown below has been used to automate the validation of target MHP set top boxes, enabling both faster testing and automatic logging of test results. Set top boxes are tested as black box entities, with RF and infra red input interfaces and picture and Ethernet outputs. To enable testing the set top box has to be placed in a special test mode to enable Reponses to a test stimulus to be generated via the Ethernet port.

Test cases generated and stored on the test controller are used to play stored test streams from the AD991 MPEG signal source. These streams are modulated and fed directly to the set top box. The response to the stream is monitored by the output video screen sampling system or via a message passed back to the test controller via Ethernet.

Compliance to the expected response is logged by the test controller for later analysis.

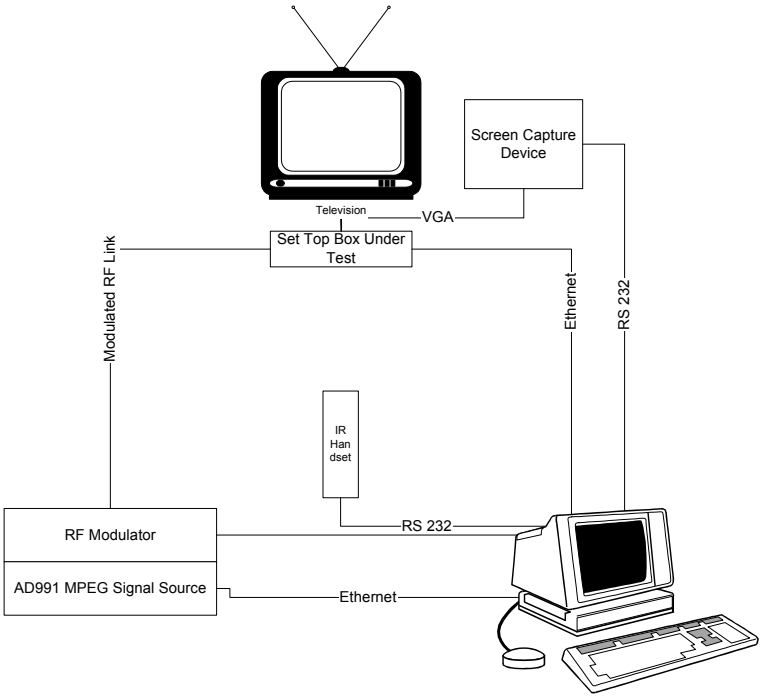

Figure 7 - Automated MHP Set Top Box Verification

For a set top box or application development test tool the parameters which are likely to be examined for a data carousel are :

- Test the consistency and syntax of the PSI/SI e.g. Stream type, data broadcast descriptor.

- Test the consistency and syntax of the DSM-CC messages.
- Enable retrieval of the data and the reconstruction of the objects from the carousel.
- Test consistency of the AIT with object carousel contents.
- Adherence to the Data service decoder model where applicable.

In addition a MHP compliant test carousel generator tool proves to be a useful test tool for application development and verification.

CONCLUSIONS

The capability to enhance programming with interactive elements as well as offering pure data based applications will enable broadcasters to increase the differentiation of their services. In order for this to be successful the whole population of viewer set top boxes have to be able to successfully decode and correctly run all of the applications which are broadcast. Given the complexity of the digital broadcast it is impossible to guarantee that every application will run on all set top boxes, however by ensuring that the set top box compliance regime is used and that broadcast content authors adhere to the MHP specifications extremely high degrees of interoperability are ensured.

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