

# **A Visual Compositing Syntax for Ancillary Data Broadcasting**

Craig Birkmaier  
PCUBE LABS  
Gainesville, Florida

## **Abstract:**

Ancillary data transmission using the MPEG transport layer of the ATSC Digital Television standard can enable a wide range of new services for television broadcasters, and other distribution channels that carry DTV bit streams. This paper analyzes the data broadcast opportunity, and requirements for standards to support the local display of information carried as ancillary data.

Managing the program multiplex to optimize the utilization of MPEG transport packets presents a variety of opportunities and challenges to broadcasters. The paper will examine three types of data that will be carried in the multiplex: programmed; periodic; and opportunistic. Programming opportunities for each data type will be identified and the technical requirements examined. The ability to create local raster representations from ancillary data is a basic requirement for DTV receivers in applications that include: closed captioning for the hearing impaired; emergency messaging; and electronic program guides. A visualization and compositing syntax for ancillary data will be proposed and relationships to other standards such as HTML-based web browsers will be examined.

## Introduction

After years of debate, development and testing, more debate, re-development and re-testing, it appears that the era of digital television is finally upon us. Direct broadcast satellite (DBS) services, based on MPEG-2 digital video compression, have become an instant success story in the United States. In Europe, satellite, terrestrial broadcast and cable versions of the Digital Video Broadcast (DVB) standard will be deployed over the next 2-5 years.

While these developments are significant, in that they prove the viability of the underlying technology for digital television services, 1996 may well be remembered for what *was not* decided about the future of digital television. Facing opposition to the proposed Advanced Television Systems Committee (ATSC) standard from the computer industry and Hollywood, terrestrial broadcasters in the United States came to the bargaining table. On November 25th, representatives of the computer industry, television broadcasters, and manufacturers of television receivers agreed to resolve their differences about video formats to the marketplace. The agreement acknowledged that the future of digital television broadcasting involves more than just sharper pictures and 3D sound.

On December 24th, the Federal Communications Commission ratified the ATSC digital television standard, with exceptions, based upon the November 25th agreement. These exceptions remove the video formats proposed by the ATSC, allowing the marketplace to influence the evolutionary path, for what is likely to become an entirely new medium.

The implications of this decision are just beginning to be understood. In the place of mandated formats for standard and high definition television (SDTV and HDTV), industries with a potential stake in the DTV decision are now free to offer alternatives to the formats proposed by the ATSC. The agreement also acknowledges the fact that broadcasters will have a powerful new tool in their arsenal—the ability to broadcast data in addition to traditional video programming.

This paper examines the implications of the recent decisions about the future of DTV, providing a framework for further discussions about standards and recommended practices for data broadcasting. Within this context the paper examines the implications that data broadcast standards may have on the architecture of DTV receivers, and other information appliances that will process data carried in digital broadcasts. These architectural implications extend into the area of MPEG-2 video decoding, and thus may influence decisions about the video formats that will be used to launch the new digital television broadcast service.

## Defining the Opportunity

When the advanced television process began in the late '80s, it was expected that the business model for terrestrial television broadcasting would not change radically with the introduction of HDTV. When the target shifted from analog (ATV) to digital (DTV), however, the prospects for a fundamental restructuring of the business of television broadcasting began to surface. Interested stakeholders in the rapidly evolving computer industry began to question the business model assumptions upon which the advanced television process was based. This led to discussions about interoperability with personal computers and a formal interoperability review of the proponent systems.

At the same time, the Internet phenomenon surfaced—millions of consumers began to connect their personal computers to the Internet, to exchange e-mail and join Usenet discussion groups. The development of HTML proved to be the enabling technology for an entirely new form of electronic publishing, the World Wide Web. At a fundamental level, HTML provides our first glimpse at several important concepts, which are now beginning to impact expectations for DTV:

- The ability to link a variety of media objects in a manner that permits these objects to be delivered and composed at the viewer's location, as they are consumed—the flexible nature of HTML permits the local information appliance to present these objects in a manner appropriate for the local display and viewing conditions;
- The ability to continuously extend the capabilities of the standard and devices that support it, to facilitate new features and services.

In recent years the Java programming language has emerged as a model for interoperability and extensibility of services that will be delivered via the Internet. The Java concepts can be extended to what may become an important component of the Internet...digital television. Java is based on two critical concepts:

- The virtual machine;
- The ability to deliver data and the program required to consume it, by compiling the program to run on the local virtual machine.

In the past year, the Internet and World Wide Web have begun to challenge the entrenched position of television broadcasting and cable as a medium to deliver information and entertainment to the masses. Even more significant, the Web is rapidly emerging as a new medium for advertiser supported services, and as a virtual storefront that can bring manufacturers, and the people who buy their products, together. A web page provides a unique new vehicle to deliver information about products to consumers, and to facilitate transactions that enable the consumer to purchase these products.

This emerging model for electronic commerce threatens the business models, upon which many traditional media industries are based, including radio, television, newspapers, catalogs, and direct mail. A wide range of businesses have moved rapidly to embrace the Internet concepts, even without a clear understanding of an underlying economic model for this new medium. Many television broadcasters are now publishing Web pages, and by so doing are developing an important component of the infrastructure that will eventually feed their DTV channels.

While current bandwidth limitations inhibit the ability to deliver media rich services such as audio and video over the Internet, it is already clear that, in time, it will be possible to provide a viewing experience that will equal or exceed that of the television broadcast medium that has existed for the past fifty years. Perhaps the most important factor in the rapid growth of the Internet and the World Wide Web relates to the ability to empower the consumer of the information. Rather than being a passive viewer, they become an integral part of the experience, exercising the ability to navigate and interact with information. Furthermore, the individual is also empowered to become a content creator, publishing information that others can consume.

The implications of this shift in empowerment should not be underestimated, especially by television broadcasters. Already it is obvious that the Internet is a strong competitor for eyeballs, enticing a very important group of viewers away from the television set in the family room. So obvious in fact, that in 1996, Sony and Phillips, in partnership with Web-TV, brought the World Wide Web to the TV in the family room. And this is just the tip of the iceberg.

Virtually every consumer electronics manufacturer is developing television receivers, or add on boxes that integrate traditional television functions with the ability to surf the Internet. Broadcasters such as NBC have entered partnerships with companies such as Microsoft and Intel to deliver data in the vertical interval of NTSC television transmissions, permitting web type services to be delivered as an enhancement to traditional television programs. And DBS systems, which are already delivering data for features such as electronic program guides, are now expanding into the delivery of Internet services through ventures such as DirectPC.

All of these products rely on an critical feature in the boxes that feed video to the attached television receiver--a modem that connects to a telephone line, to provide the back channel data path for interactive data transactions. Some of these boxes connect directly to the Internet.

The traditional assumption that television broadcasting is a one-way medium, incapable of delivering interactive services is been rendered meaningless by the shift to digital technology. Consumers may have several back channel options for interacting with television broadcasts--telco, cable and wireless. More important, however, they may not need or want any back channel to consume interactive services delivered as data through the DTV channel. The ability to store broadcast data locally, in an information appliance, makes it possible to deliver interactive applications in much the same way that the Internet currently broadcasts data to servers all over the world.

For example, using the full bandwidth of a 6 MHz DTV channel, a broadcaster can deliver 72 megabytes of data in thirty seconds. This data may include audio, video and graphic objects that are combined in the receiver to create a traditional linear television commercial—it may also include the elements of a web page to provide an interactive experience for the viewer, such as an electronic brochure. In other words, the digital broadcaster can provide virtually any service that can be delivered by any other data network; and a wired back channel can be used to support transactions, including on-demand data broadcast services.

Perhaps the most important implication, however, is that broadcasters have sufficient bandwidth to deliver high quality audio and video along with these new interactive services. Equally important, they can do this in a totally non-invasive manner. The viewer can choose whether they want to send any information back, essentially building a privacy firewall between the viewer and the service provider. This level of privacy does not exist when a consumer connects to an Internet Web site, as a record of the visit can be recorded by the web server.

The bottom line is that DTV is likely to evolve into an entirely new medium. As with the transition from radio to television, this medium will require a new business model. A business model that leverages the ability to broadcast data.

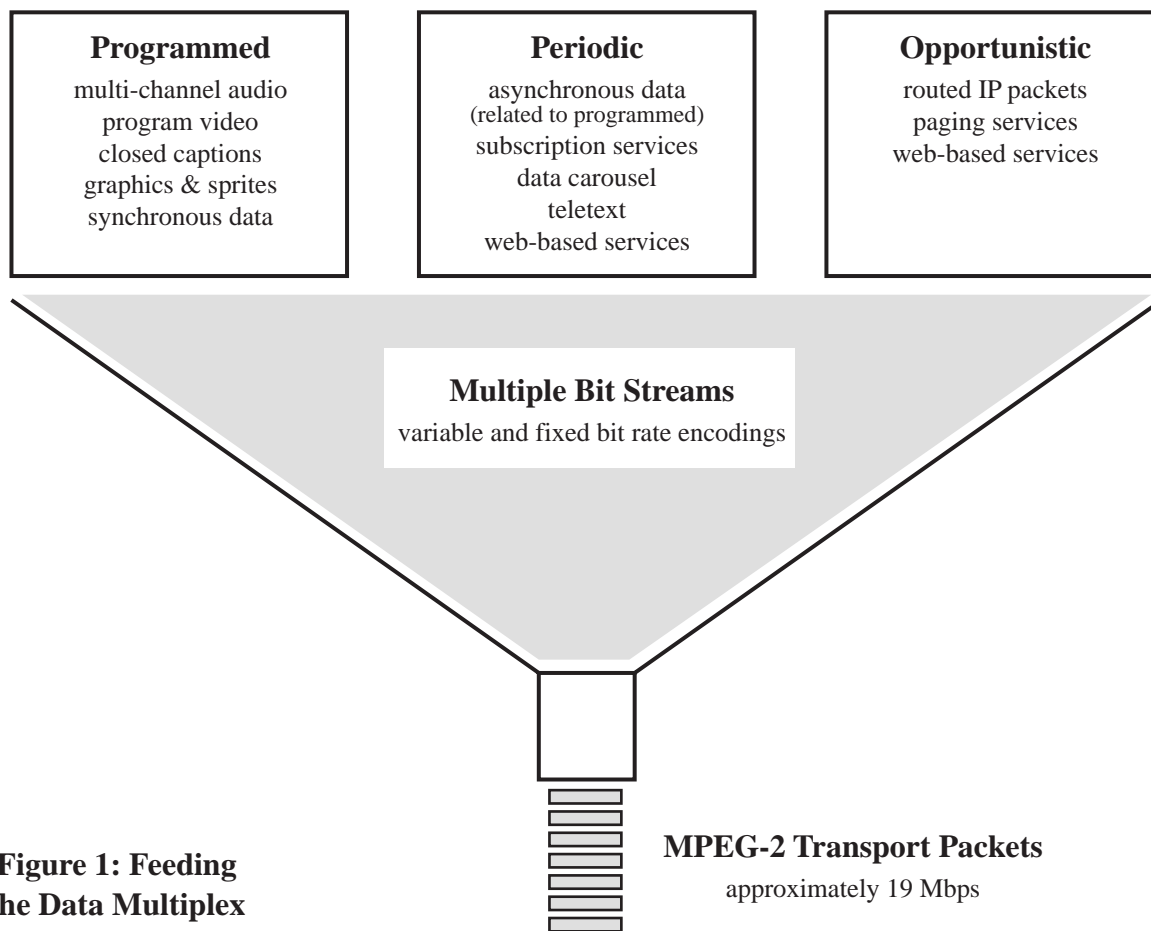
*The business of digital television broadcasting is the management of the data multiplex that feeds the 19 megabit per second channel, so as to maximize the revenue that can be produced at any given moment in time.*

The new DTV standard allows broadcasters to deliver packets of data using a transport protocol optimized for the delivery of one or multiple MPEG-2 encoded television programs, each with multiple audio channels, and *ancillary data*. Each program will consist of multiple video and audio bit streams, identified by headers in the data packets, along with ancillary streams for closed captions and program related data.

Managing the multiplexing of all of these streams is clearly an important technical consideration for the operation of a DTV channel. If the total data rate exceeds the roughly 19 megabits/second (Mbps) that can be squeezed into a 6 MHz channel, broadcasters have a problem--something is going to break. If the total data rate falls short of the 19 Mbps available, broadcasters have another problem; they are leaving bits--i.e. money--on the table.

## Managing the Data Multiplex

To better understand the data broadcasting opportunity, we must first understand the potential sources of data that will feed the DTV channel multiplex. There are three general categories of data that will feed the multiplex, as illustrated in Figure 1.



**Figure 1: Feeding the Data Multiplex**

Programmed data looks the most familiar. These are bits that a broadcaster contracts to deliver at a given point in time—for example, a free & clear program, perhaps simulcast on an NTSC channel, provided to meet the broadcaster's public service commitment. Programmed data is *isochronous* or real-time. These packets must arrive on-time or they are useless.

There are two variations on MPEG-2 encoding of real-time video/audio programs; fixed bit rate and variable bit rate. The choice can have a significant impact on quality of the video that is delivered and the management of your data multiplex.

Entropy coding techniques, such as those used in MPEG-2, produce a variable amount of data, based on the information content of the pictures that are being encoded. With fixed bit rate encoding, as the name implies, the encoder attempts to maintain a constant bit rate. It achieves this by varying the level of quantization, sometimes producing visible compression artifacts when the information content of the pictures is high.

Variable bit-rate coding attempts to maintain a constant level of picture quality by keeping the level of quantization fixed, and letting the bit rate increase with pictures of increased coding complexity. Typically the encoder is set to operate with an average and peak bit rate in mind.

Encoding video for release using the new Digital Video Disc (DVD) formats provides a good example. The average bit rate is typically determined by the length of the program or movie

being encoded--total capacity divided by total duration determines the average bit rate target. Peak bit rate is established by the peak transfer rate for the DVD disc--rates vary with single and dual layer discs. In digital broadcasting, an example of peak bit rate would be 19 Mbps peaks in HDTV programs encoded for a DTV channel.

In DTV applications, variable bit rate coding offers a potential quality-of-service advantage by delivering consistent picture quality. It also offers a potential business advantage by maximizing the revenue produced by a DTV data multiplex. For example, a broadcaster that carries two programmed services can set the peak bit rates for each so that they do not exceed the 19 Mbps available. When they operate below these peaks--which is most of the time--any data packets left over can be used for periodic and opportunistic services.

Unlike the isochronous nature of video programs, periodic data can be delivered in an *asynchronous* manner--when it can be fit in. A good example of periodic data is the Teletext service that is delivered in the vertical interval of PAL broadcasts in France.

Assume a broadcaster chooses to provide advertiser supported news headlines, sports scores, weather maps and forecasts to viewers through a web site and their DTV channel. When a DTV receiver tunes to the channel it will receive a program map that indicates all of the services feeding the data multiplex. The receiver can set up a memory buffer to accept periodic data identified in this program map. This data is inserted in the multiplex periodically to update information and serve new customers who are acquiring the channel. Once in memory, this information will be available to viewers on demand (full screen), or it can be displayed continuously on an unused portion of the screen (a window), or as a program overlay.

The rate of update for periodic data becomes a variable, which is factored into the software managing the data multiplex. For example, weather maps may only change every hour and be refreshed every five to ten minutes for new viewers. Sports scores may be updated as they are received for games in progress.

Periodic data can also be used to provide other new revenue streams. For example, a broadcaster could deliver movie guides for local theaters, restaurant guides and printable coupons. Like programmed data, periodic data can be sold and scheduled, however, due to its asynchronous nature there is some flexibility in delivery time.

Opportunistic data has similar characteristics to periodic data. The major difference is that it may not be something that can be scheduled, or it may be data with a lower priority and thus may be sold at a lower rate. In either case it will be delivered on a space available basis.

A good example of opportunistic data would be a paging service. The message size is small and thus easy to squeeze into the limited residual packets that are left over; and there is some latitude in delivery time. Another good example is the delivery of routed data packets to wireless information appliances, for Internet type services--an appliance of this type may use a back channel to request data packets, or it may simply filter the data carried in a DTV channel, looking for information to which it subscribes.

### **Error Correction**

A new business model for digital broadcasting can be supported using the concepts outlined previously. Clearly, the broadcaster can deliver almost any type of service, by delivering bits to a data broadcast enabled DTV receiver. There are, however, some problems with using terrestrial broadcast channels for applications where the integrity of the data is critical.

The absence of a back channel to request retransmission of packets that are lost, or packets that contain errors, makes it difficult to guarantee the integrity of data in applications that depend on error free transmission. For example a Java applet that will be compiled and run on the local processor. The MPEG-2 transport protocol, upon which the new DTV is based, does not assume error free transmission. Instead, it depends on error concealment to hide the effects of lost data packets.

There are several ways to deal with this limitation in data broadcast applications.

- Add an error correction layer to the data transmissions, at the expense of a portion of the available bandwidth;
- Use periodic data updates to recover from earlier errors.
- Transmit data on multiple channels with time offsets.

Improved error correction may prove to be a viable option for certain applications. This issue has been examined by the ATSC T3/S13 Specialist Group on Data Broadcasting, in which the author has been an active participant. The nature of the errors that have been measured in field tests of the DTV modulation system tend to be of short duration, often the result of impulse noise. Error correction routines designed to deal with these burst errors could be implemented at the expense of channel bandwidth.

Periodic updates may provide a viable error correction solution in applications where data is being stored in the receiver for demand based information services. If a packet is lost, it can be refreshed at the next periodic update.

In applications where streams of data require error free delivery, time offsets within the same channel or on two channels can be used to provide error correction, at the obvious expense of channel bandwidth.

In certain applications, the service provider may want to deliver a data service to multiple channels within the same market, so as reach the maximum number of viewers. The data can be delivered to different channels with time offsets; information in the packet headers can indicate when this data will be delivered again and on what channel(s). Assuming that a digital media server in the home might be equipped with two or more demodulators, it could tune to another channel to capture packets lost in the original transmission.

This technique might also prove viable for applications where DTV channels are used to deliver large amounts of data to consumers or businesses in time periods when DTV channels might otherwise be underutilized (e.g. 1-6 a.m.). Dual channel broadcasts with a small time offset could provide nearly real-time error correction.

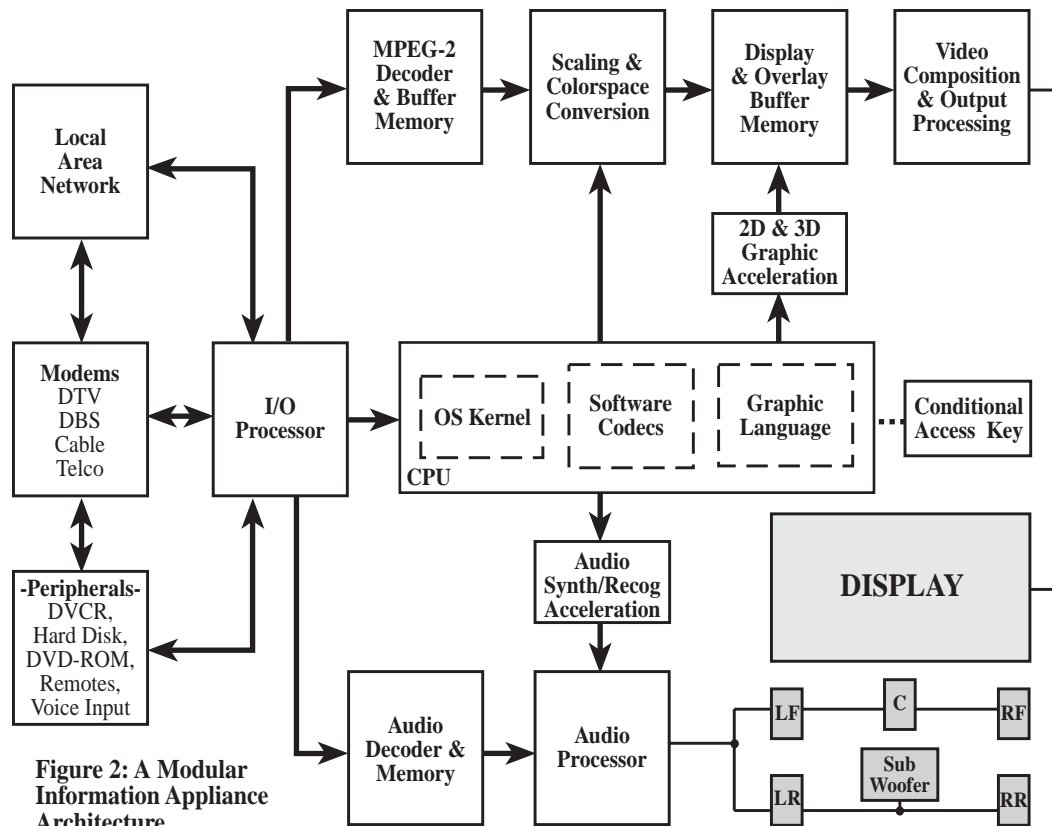
### **Multiplexing Objects for Local Composition**

For a number of years, this author and others have suggested that digital media content will be delivered in a variety of new ways, once we make the transition to digital broadcasting.<sup>1,2,3</sup> Several papers have been delivered by this author at recent SMPTE Conferences, related to the delivery of visual objects to a digital television receiver, and the ability to compose these objects for local display. These techniques provide potential solutions to deal with the realities of accommodating program content with variable aspect ratios—including 4:3 and 16:9—as well as a variety of new services, which can be delivered using data broadcasting techniques.

This work has been taken up by various international standards organization, working in the areas of multimedia and television standards, including the SMPTE. Recent announcements from participants in MPEG-4 standards activities, indicate that work is now underway within this process to develop standards for object based data broadcasts, using a framework based on MPEG encoding tools and other imaging standards emerging from the computer industry and the Internet.

With the introduction of set-top computers optimized for the presentation of Internet web-based services, it is clear that capabilities for local, object-based, image composition will be desirable in many of the information appliances that will exist in the future. This includes PCs and DTV receivers that will display video programs and information from data broadcasts. In the author's opinion, it is appropriate to think of these appliances as being nearly identical with respect to image and data processing components, but optimized for the applications and viewing environments in which they are used.

Figure 2 provides a generalized view of the modular components that are likely to be found in these information appliances:



Appliances that offer the kinds of processing capabilities identified in Figure 2 are likely to emerge in the next generation of multimedia PCs and in set-top boxes designed for DTV, DBS and digital cable applications. Appliances of this type will be capable of processing digital media files that may contain some or all of the following information tracks:

- a raster image background;
- raster image inserts--for graphic sprites, picture-in-picture and picture-out-of-picture;
- ancillary data for locally synthesized text, graphics, 3D objects and print output;
- natural sound and music;
- dialog and narration.

Appropriate tracks may be selected from a broadcast transmission or in an interactive network transaction. As described in Figure 2, modular appliances may support a variety of techniques for decoding, synthesis, and display of these tracks:

- packets are routed to the appropriate processing components after demodulation;
- the MPEG-2 decoder buffer can be used for the program raster(s) and to decode visual objects. These images rasters and sprites can be scaled in an appropriate fashion to facilitate presentation on the local display--colorspace conversion can also be applied as the pixels are input to the display memory;
- objects carried in more compact representations such as 2D and 3D vector based graphic formats can be processed by the CPU or dedicated acceleration hardware and input to the display buffer;
- the display and overlay buffer memory supports double buffering of decoded image streams to permit synchronization with the local display refresh rate; these buffers can be used to facilitate local composition by feeding blocks of pixels to the image composition module;
- similar capabilities exist for the audio processing modules of the appliance or media server;
- finally, a composition syntax is required to put all the pieces together.

The video modules can be designed to support a single display refresh rate, or to vary the rate when being used with a multi-synchronous display. In addition, the display buffer can have multiple outputs, making it possible to simultaneously feed both an existing interlaced television receiver and new displays that provide higher levels of resolution.

Using memory addressing techniques visual objects can be moved within a composition to support simple path based animation and the scrolling of text. Positions can be updated on a frame-by-frame basis to support motion path scripting. Color replacement and alpha channel blending techniques can be offered to provide high quality overlays with full support for antialiasing and transparency.

All of these features can be enabled by defining the system architecture in terms of the raster into which digital data is decoded or synthesized and a simple toolbox for the minimal implementation of the standard. Such an approach does not preclude the development of single function information appliances that are optimized for the decoding of certain types of data streams. It does, however, enhance the value of programmable devices that can support the entire toolbox and extensions to enhance features and performance. Programmability is a critical enabling technology for device independence, allowing a media file and the instructions (program) for decoding it to be transported together over any type of digital communications channel. As mentioned previously, the Java language is emerging as one approach to device independent programmability.

### **Considerations for Container Formats and Header/Descriptors of Track Contents**

A media file *master* may be a collection of many tracks. The tracks may include multiple representations of the same information to support localization of the content's presentation. Elements of the media file can be selected by a content distributor to localize the presentation, they may be selected from multiple tracks in a DTV broadcast, or in interactive server based applications the client could select only the required tracks for transmission and local presentation.

Headers and descriptors may exist in the context of the media file, and in the packetized data streams that are transported over a digital transmission channel. Two type of header/descriptors are required to implement such a compositing syntax: *function labels* and *format labels*.

*Function labels* are related to a media file; they are stored with the file and used by a decoder to identify the available tracks and decoding methodology. In a broadcast application they are transmitted at the beginning of the program and periodically thereafter. *Function headers* will typically utilize a shorthand notation to minimize transmission overhead, identifying track types and decoding methodologies using codecs registered with an international standards authority.

*Function descriptors* provide addition information related to the content; this may include a track description or a downloadable program for decoding the track.

In addition to time-based tracks—i.e. programmed data—that require synchronization during transmission of the content, the media file may include ancillary data tracks that occur only once for the program such as: an index to the available tracks; a program synopsis; information about the cast; copyright information; and instructions for navigation and interactivity with the program content. These tracks should be accessible by the client at any time during the transmission. In broadcast applications these descriptors may be downloaded at the beginning of the transmission and updated periodically to update the decoders of receivers that join a transmission in progress. This data should be stored locally for instant access by the viewer.

*Format labels* are related to the process of packetizing the data for transmission. *Format headers* identify the content of the data packets that are being transmitted, carry the formula for reconstructing the packets into the bit streams for each track, and may include periodic synchronization information. MPEG utilizes the concept of labels to provide these services.

*Format descriptors* carry instantaneous information that may be necessary to support decoding and real-time interactivity; this permits interactivity with information that is broadcast, such as the answers in interactive game shows, statistics during sports programming, and response information within commercials and new forms of interactive advertising. These descriptors may include ancillary data such as closed captions that require synchronization with the program content, and localization information for commercial tagging.

Digital television broadcasts may also require mechanisms for the encryption of data and authorization of services. Thus descriptors may be further classified as *public* or *private*. *Public descriptors* would be accessible to every client; *Private descriptors* would be encrypted and thus accessible only to those clients with the necessary hardware or software keys for decryption.

The use of a time-based media file structure with header/descriptors is the foundation for future digital media systems, including digital broadcasts. It provides the mechanism for media independence—the ability to send both the data and the recipe for decoding and composition. This is a critical requirement for extensibility of the system with advancements in both the hardware and software components of the system.

As we begin the transition to digital transmissions systems such as DTV, DBS, and digital cable, and new forms of digital media distribution through the Internet and DVD, there are concerns that a proliferation of proprietary decoders and operating systems could lead to market chaos, inhibiting the development of new electronic publishing markets and interoperability of the content developed to proprietary specifications. On the other hand, regulating the design of *open architecture* information appliances might stifle innovation and lead to rapid obsolescence of the standard.

The recent DTV compromise leaves us with the market driven approach, and the potential for chaos. To take full advantage of the market driven approach to DTV we should define minimum standards for local image synthesis to support local image composition, interactivity, and navigation. These features can be implemented on receiving devices at an appropriate level of performance. Low cost receivers may provide minimal capabilities and no options for extensibility, while digital media servers may provide higher levels of performance and the ability to upgrade modules as standards evolve.

These enabling standards may define:

- the minimum MPEG-2 decoder performance and buffer memory required for various quality of service levels;
- a minimum display memory buffer to support rasterization of multiple visual objects with positioning coordinates relative to origin coordinates;
- extensible support for both hardware and software decoders for raster images and motion image streams (JPEG, MPEG, Wavelets, etc.);
- minimal standards for the local synthesis of text and graphics; these standards may be extended by allowing programs for local navigation, graphic and text synthesis to be resident in an information appliance or downloaded with the content;
- minimal standards for video overlay with extensible support for the synthesis of image and overlay information at multiple color depths, color replacement keying, alpha channel keying, etc.

One way to support these capabilities at the system level without placing unnecessary restrictions on the manufacturer of the information appliance is to define the architecture in terms of the display buffer memory required to support a particular level of a spatial resolution hierarchy. This buffer memory becomes the *standard* rather than the various image formats that can be decoded and presented within it. Formats become a profile that specifies the subset of the available raster that is being used for the main program. Portions of the buffer memory not being used by this profile are available for the rasterization of additional tracks (inserts and overlays) or other media files

Manufacturers can offer display components that deliver various aspect ratio subsets of the raster for a particular level of the standard. It is important to note that all of the program content would be delivered (regardless of aspect ratio) to the information appliance. With the addition of image scaling capabilities, a video processing subsystem could provide the viewer with a choice of letterbox or pan & scan presentation of a program. For the delivery of stills and documents, the entire buffer could be loaded with the image; the viewer could then scroll around the image viewing it through the display aperture.

By establishing only the minimal requirements for compatibility with the standard, consumers and manufacturers could choose the level of performance desirable for specific applications. For example, a caption might be included in a media file or broadcast transmission as ASCII text data with timing references to link the caption to the program content. In a similar manner a localized commercial tag could be transmitted as ASCII text data referenced to specific zip codes; the address of the decoder would be used to select the appropriate tag from the text file.

A minimal implementation would include the ability to rasterize the text and insert it over the program. An information appliance that implemented a software based graphics language and user interface might allow the viewer to specify a particular font and size, position the text within or outside of the program—if the display aperture is larger than the program—and overlay (key) the text on the program content. A fully programmable system would allow the graphics language, fonts and user interface to be downloaded with the data, so that the content creator could control every aspect of the composition.

## Conclusions

The business model for digital television broadcasting is about to undergo many profound changes. In the author's opinion these changes will benefit both broadcasters and the communities they serve.

Broadcasting started as a medium to deliver audio to the masses. When television came along people tried to do radio with pictures...but not for long. They quickly discovered that this was a new medium with new opportunities. It would be unreasonable to believe that DTV, with its inherent ability to radiate bits, will continue to be defined in terms linear television entertainment and information programming.

Imagine viewers watching a commercial on the large screen display component of the digital media server in their family room. The video, audio, animation and graphic components of the linear commercial are also components of the 72 megabyte web site just delivered via the DTV channel.

These sites will become interactive brochures where viewers can manipulate photorealistic 3D renderings of products. For example, they could custom configure that new sports utility vehicle, then link to the Web to have a dealer bring one by for a test drive, set up financing, or deliver it. If broadcasters adopt this business model, they might even get a commission on the sale or at least a bonus for the back channel *responses* they deliver.

The social implications of the shift to digital television will be far more profound than a sharper image and 3D sound. This is an entirely new medium. It will leverage other communications infrastructures to provide the consumer with something that was missing from our first attempt at a visual mass medium. The ability to control the vision, rather than being manipulated by it.

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<sup>1</sup> "An Open Architecture for Digital Communications Systems," Craig J. Birkmaier, IEEE Multimedia, Fall 1994, pp. 77-83.

<sup>2</sup> "An Open Architecture for Digital Communications Systems, Part 2" Craig J. Birkmaier, IEEE Multimedia, Winter 1994, pp. 79-84.

<sup>3</sup> "Object Oriented Television," V.M. Bove, Jr., SMPTE Journal, 104, Dec. 1995, pp. 803-807.