TRANSPORT B FOR BROADCASTERS: 
BOON OR BANE?
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Delivery of enhanced television content via DTV data broadcasting offers significant advantages. However, implementation within networks and stations presents major problems. Two distinct solutions are described.

INTRODUCTION

The ATVEF specification for enhanced television receivers provides two methods for delivery of enhancement content. “Transport A” uses the Internet. “Transport B” broadcasts the content along with the video and offers significant advantages of speed, scalability and reach, especially when delivered digitally. Broadcasters in North America are attracted to the advantages of ATVEF Transport B as a way to increase the value of DTV services. However, many system-wide hurdles must be overcome for its successful deployment throughout networks and stations. Two approaches for system-wide implementation of Transport B are described. These considerations are also applicable to the DVB-MHP enhanced television standard and the similar evolving DASE standard within the ATSC.

ATVEF

The Advanced Television Enhancement Forum (ATVEF) developed an open specification for minimum features of “enhanced” set-top boxes and televisions to enable interactive television. During a game show, a user can select an icon that causes clickable graphics to appear over the video, allowing them to play along with the game using their remote control, perhaps in competition with other viewers. During a public-affairs documentary, the interactive content instructions can cause the video image to be reduced in size, allowing access to related text and graphical information through buttons placed alongside the ongoing program. Onscreen interactivity related to the program or promotion being broadcast will make it possible to order products or public television memberships. Availability of this “converged” experience will also change the nature of television programs, making them more conducive to interactivity.

Since a set-top-box or television with these interactive features can not be upgraded as easily as a personal computer, it is important to provide a clear and long-lasting specification for these devices and related content. The ATVEF specification was created to fill this need and has been brought to SMPTE for standardization within the Committee on Data Essence Technology (D27).

Triggers

In order to alert the user that interactive content is available and for timed activation of subsequent events, a short “trigger” is sent with a syntax proscribed by EIA-746A. Each trigger includes a Universal Reference Locator (URL) for the HTML content appropriate to the
particular moment in the television program. In analog broadcasts, the trigger is placed within the closed-caption channel, insuring that it will remain intact as it passes through the thousands of possible production, network, station, cable and satellite processes – even low-grade home VCRs.

Content

The format of the interactive content is a slight modification of existing Hypertext Markup Language (HTML) practices, with extensions to allow placement and control of the television image as if it is a normal HTML graphic element. Selected image, animation and audio formats are also supported.

The ATVEF specification provides two methods for delivery of this content – Transport A and Transport B. Either one or both of these transports can be used in a given program, at the option of the content producer.

TRANSPORT A – INTERNET

Transport A requires that the ATVEF-enabled device have an Internet connection during the interactive experience. Each content element is retrieved from a web server as specified by the URL within a trigger, or the URL assigned to an on-screen button by previously loaded HTML content. This approach of retrieving content from a server when the user requests it is referred to as a “pull” method.

Since Transport A content travels via the Internet and triggers pass through the existing closed-caption channel, producers can add enhancements to a program with no change to any of the existing network, broadcast or cable infrastructure and operating agreements. This is the advantage of Transport A.

TRANSPORT B – BROADCAST

Transport B delivers interactive content via the program broadcast instead of the Internet. Within an analog NTSC broadcast, low-speed data (=15 Kbps/line) can be placed in the vertical interval per the EIA-516 NABTS standard. Within a digital broadcast, high-speed data (hundreds or thousands of Kbps) can be placed within the ATSC-encoded stream. By delivering the interactive content simultaneously to all users whether they request it or not (the “push” method), three advantages appear, compared to Transport A.

Speed

Many home users continue to access the Internet over dial-up connections for reasons of cost or the lack of DSL and cable-modem availability in their area. Transport B via a digital broadcast makes it possible to deliver interactive content at a speed perhaps one-hundred times faster than a dial-up connection, depending upon the amount of digital bandwidth dedicated to this use.

The apparent speed of Transport B is even greater, since the content can be delivered to the receiver cache memory before the user is given the chance to request it. As a result, the access speed can be made to seem near infinite, higher than the fastest broadband connection. This cache pre-load approach is not possible using Transport A without creating massive if not catastrophic server demand. (Imagine a popular show where millions of enhanced receivers automatically and
simultaneously ask for every new program enhancement through individual requests to a single web server, whether the viewers want the enhancement or not.)

**Scalability**

Popular shows with millions of viewers will place unrealistic demands upon the related web server if only Transport A is used. If the “most-clicked” content is instead delivered via Transport B, server overload can be eliminated.

**Reach**

Transport B will be *required* in situations where a continuous Internet connection is not available for any of a variety of reasons:

Busy Modem Line - Even if a home has a dedicated “modem” line, it may be in use by a computer or additional ATVEF receiver.

Single Phone Line - Many home users continue to share one telephone line for both voice calls and Internet access. Keeping this line busy during all interactive television viewing may be unrealistic.

No Connection – Users will be attracted to enhanced features for which they don’t have to provide any Internet connection. (However, users will then not be able to select those enhancements that require an Internet “back-channel” for transaction processing.)

**CHALLENGES OF TRANSPORT B**

Although the advantages of Transport B are notable and may become more dramatic as the popularity of ATVEF increases, many hurdles must be overcome for Transport B to be successfully deployed by broadcast stations. Challenges exist with analog Transport B, content authoring and content synchronization. Within each area of challenge, insurmountable disadvantages exist along with challenges that can be overcome through coordinated efforts of the industry.

**ANALOG TRANSPORT B**

Three primary factors will likely continue to discourage the deployment of analog Transport B (EIA-516 NABTS VBI data).

1 – Analog Transport B is restricted to a low data rate (=15 Kbps per/line), leaving it without the advantage of speed over dial-up Internet connections and at a speed *disadvantage* for users with broadband Internet access.

2 – The use of analog Transport B would likely require that content be authored with two sets of Transport B content – one at a low rate for analog and the other at a higher rate for digital. Producers will likely not think it worth this effort.

3 – Many cable systems routinely blank the VBI, thereby blocking analog Transport B. By contrast, at least one major cable system seems inclined to allow digital program-related
enhancements to pass intact while they control the use of ancillary data through digital carriage agreements instead of blanking efforts.

4 – Many broadcasters have committed multiple VBI lines for other data services, making it difficult to agree upon lines that might be universally dedicated to ATVEF Transport B.

For these reasons, we will drop analog Transport B from further consideration and focus solely on Transport B via digital broadcasts.

OFF-LINE AUTHORING

ATVEF using just Transport A presents new and challenging steps to the off-line production process. Interactive content must be authored in parallel with the video. Triggers must be carefully inserted at appropriate points in the time-line. The ability of the user to choose many different paths of navigation must be taken into account, adding complexity to the required testing.

Transport B adds an additional layer of complexity. The actions of the users must be anticipated and the interactive content must be completely delivered before any user requests it. This can only be successfully accomplished if the producer knows in advance what bandwidth will be available for the data broadcast. Authoring tools will need this information in order to manage the timing of the data broadcast, as they manage the content of the user cache.

In the case of networks of stations, reserving bandwidth for Transport B requires the agreement of all stations carrying the program. Providing the desired bandwidth might require some stations to reduce the number of channels being broadcast or the quality of the video in those channels. It might require them to forgo the sale of bandwidth for ancillary data-broadcast applications.

Naturally, stations will want to maximize the number and quality of services. Naturally, the producers of enhanced television content and commissioning networks will want to maximize the interactive experience for the viewers and the bandwidth for Transport B. The television industry has little experience with the kinds of compromises that will be required.

LIVE AUTHORING

For live events, limited knowledge exists regarding the timing of interactive events. Even so, it is possible to use Transport B to send elements early in the program that will be needed at a later time, up the size limit of the user cache memory (specified by ATVEF to be at least 1MB). However, this method will not work for users who tune to the program after the enhancement elements have been broadcast.

Some interactive elements may be small enough and the data bandwidth high enough to make them appear in time, even if their broadcast does not begin until they are needed.

STATION SYNCRONIZATION

There are two methods for the synchronization of Transport B content with the broadcast. Each has relative advantages. Both have significant challenges for implementation.
In the “Station Synchronization” approach (Figure 1), a Transport B data server resides at every station, closely coupled to the station traffic, automation and MPEG encoding systems. The dashed line indicates the interface between network and station.

The network delivers the video and audio to the station using traditional methods.

The traffic system receives data from the network to alert it and in turn the automation system when enhanced data exists for an upcoming program. Prior to airing the program, the automation system instructs the data server to access a specific directory on the producer or network’s data server. From this directory, the data server retrieves all enhancement elements and a schedule describing when each element should be broadcast, relative to the timeline of the program.

The automation system controls the data server to synchronize the Transport B broadcast with the television program. It does so regardless of any delay in the program start time or interruption due to commercials. For programs carried direct from the network feed (very common with commercial broadcasters), a delay in the start time makes synchronization more difficult.

Bandwidth allocation for the Transport B data is accomplished in one of two ways. In the first approach, an interface between the data server and encoder requests bandwidth, perhaps in advance. Alternately, the encoder has statistical multiplexing features that respond to the Transport B data received, giving priority to this data over the needs of the encoded video.

Live programs present a unique challenge. A live enhancement data channel must be established by the automation system from the distributor, through the data server, to the encoder.

Multiple channels of video within the DTV broadcast requires multiple data servers or one able to support multiple data streams and control interfaces.

![Figure 1 - Station Synchronization](image)

**Advantages**

1 – No change is needed in the video/audio portion of the multiple station “master control” infrastructures of delivery, routing and storage devices.

2 – The required data server can also be used for enhancement of local programs.

3 – Interactive content can be changed after the program itself has been delivered to the stations. Subsequent airings of a previously recorded show always have the most current enhancements.
4 – It is conceptually possible to begin transmission of Transport B data before the program itself begins, insuring that the data arrives in time for early interaction. (However, this would necessitate a mutual requirement that no programs or commercials contain data broadcasts near their end. Also, a user’s Transport B-equipped VCR or PVR could easily miss these "early enhancements" when starting a recording or playback right at the beginning of the program.)

Disadvantages

1 – A complex system is required at every station, resulting in many chances for system or operational error, especially for live events.

2 – The cost of equipment and training is significant, especially when considering broadcaster’s need for redundancy when systems are complex.

3 – A program’s interactive features cannot be viewed at the station without the availability of a data server.

Challenges

1 – Standards must be developed for the exchange of enhancement data files and schedules, and the automation control of Transport B data servers and MPEG encoders.

2 – Every station must install a data server and may need to install a new automation system. (Many stations do not have an automation system. For those that do, it may not offer Transport B server control.)

PRODUCER SYNCRONIZATION

In the “Producer Synchronization” approach (Figure 2), enhancement data is synchronized during the post-production process or at the network upon distribution. It is carried through a data path in parallel with the video and audio through station reception, storage, routing and processing until combined within the MPEG stream for digital broadcast.

The main advantage of this approach is that only a few data servers are needed – at the point of post-production.

The main disadvantage is the need to somehow keep the Transport B data intact as its associated video passes through thousands of video devices of various types, makes and models. Two aspects of this challenge might seem at first glance to be overwhelming. First, the thought of adding separate data switching channels in parallel with every video path in every station. Second, the lack of data channel ports on video servers and tape machines.

Bypass

PBS stations have solved this problem temporarily by feeding DTV programs over the satellite in their final ATSC form, allowing stations to simply patch the satellite receiver direct to the transmitter. Not only does this eliminate the need for a DTV encoder at the station, data broadcasting bits pass through as well, as notable national PBS demonstrations of Enhanced Television have shown. However, as all stations must legally localize their content with ID's and EAS alerts, this is not a long-term solution.
A better solution would be to connect the satellite receiver data output to the encoder/multiplexer data input. However, this becomes complex if the encoder input is commonly switched between video sources. More importantly, this approach will not work for time-shifting or local repeats of network programs.

**VANC**

Fortunately, the capability of digital equipment to support data within the digital vertical interval makes the producer-synchronization approach possible, with complete ability to store and forward. Most of the digital equipment currently in use by television stations already has this capability thanks to the far-sighted standards efforts within SMPTE and the efforts of manufacturers to provide support for VANC in their digital products.

The standards for interconnection of serial digital video use the same timing as analog video, even though the long horizontal and vertical synchronizing intervals are unnecessary. The use of these “empty” intervals for data is optional but standardized. All digital routing equipment passes this optional data intact.

The horizontal blanking interval ancillary bits (HANC) are commonly used for embedding multiple channels of digital audio within the serial signal, eliminating the need for separate audio cabling and routing equipment. However, support for recording the HANC signals within tape machines and servers is limited to the related support provided for recording audio signals, and is sometimes compressed before recording with the presumption that it is audio. The number of channels recorded is sometimes just two, commonly four and only rarely more. Hence, HANC is not a viable contender for Transport B data, as the channels are usually all dedicated to stereo, second language and descriptive audio.

Fortunately, most of the common digital video tape recorders and video servers provide support for recording the vertical blanking interval ancillary data (VANC). The mapping of VANC within the digital interface is defined in SMPTE 334M. Most standard definition equipment records 720 samples of 8 bit luminance and 8 bit color (360 samples each of Cr and Cb) for a total of over 300 Kbps in just one line per frame. Some equipment supports more than one line per frame. Current and planned high definition VTRs support even more data.

Embedders and de-embedders for this purpose have already been developed for use with high definition programming. Support for standard definition requires a minor change to existing low-cost products from a variety of manufacturers. Only one de-embedder will be required per enhanced broadcast channel at each station.

**Advantages**

1 – The expense and complexity of interconnected automation and data servers at every station is avoided.

2 – Once embedded, the enhancement data will always accompany compatible digital copies of the program. The enhancements can always be viewed in the future, without a need to keep the content available on a central server.
Disadvantages

1 – The data rate must be limited to the minimum capacity of common digital tape formats, roughly 300 Kbps. This does not seem like a burden, however, and may serve a useful purpose of keeping the wishes of producers under control.

Challenges

1 – Standards must be developed that define a VANC line for Transport B data and the format and interface for Transport B data with the required embedding and de-embedding equipment.

2 – Serial digital infrastructures must be implemented at every station desiring to carry program enhancements.

![Network & Station Master Control Diagram]

**Figure 2 - Producer Synchronization**

LOCALIZATION

In the ultimate implementation of ATVEF, nationally enhanced content will be localized for each region in which it is broadcast.

This might be as simple as adding local station logos to enhanced content. Perhaps links will be provided to local station or community web sites. Advertising within the enhancements will be customized for each market.

The traditional approach of web site localization through the use of cookies is problematic within ATVEF. In this approach, a user is asked to specify what station they are watching. Their answer is registered in a central server database, identifying their unique receiver by a "cookie" stored in local memory. This approach does not work if only Transport B is available, since there is no return-path over which to perform this transaction.

Even if Transport A is available, localization of Transport B content using cookies might create catastrophic server demand if every reference to local content causes every receiver to request localization URLs from the central server. Also, localization will be more effective if the user does not need to take an active part in localizing their content. Two solutions are possible. Either requires deliberate coordination between producers and stations.
Localized Triggers

It is possible to insert local triggers at each station in such a way that national content is linked to local content, without modification of the Transport B content. However, this will require receivers to have a Transport A Internet connection to access the local content. Local servers must also be capable of supporting the demand of simultaneous access from all the receivers in their market. These may or may not be reasonable requirements.

Localized Transport B

By reserving bandwidth for local content, it is conceptually possible that a local data server could be programmed to insert local content within the national Transport B data stream. Perhaps a token within the Transport B data would activate local insertion. Perhaps careful scheduling would facilitate the coordination of insertion. Accomplishing this will require standards that are beyond the scope of this paper.

SECONDARY ISSUES

There is no consumer video tape format in the market that can record Transport B enhancement content. Although the D-VHS format is so capable, piracy concerns within the content industry have seemed to stall the offering of consumer D-VHS VCRs and the requisite digital interface on associated receivers.

CONCLUSIONS

The use of Transport B over a digital broadcast offers significant advantages to creators, distributors and viewers of enhanced television. In order for Transport B to be successful, cross-industry efforts are required. Additional standards must be created. Enhanced TV authoring tools must be developed with features to support content broadcasts and receiver cache management. Producers must make the extra effort in content authoring. Networks and stations must come to agreement on the amount of bandwidth reserved for Transport B. Stations and networks must agree upon which synchronization approach to use and must make the requisite infrastructure investment. The use of the vertical ancillary data capability within digital systems offers promise for implementation of Transport B and should be explored.

1 www.dvb.org
2 www.atsc.org
3 www.atvef.com
4 www.smpte.org
5 www.eia.org
6 VTRs supporting at least one uncompressed line of VANC include JVC Digital S, Panasonic DVC-Pro, Sony BetaCam SX and Sony IMX. Video servers supporting at least one uncompressed line of VANC include all Sony servers and the Pinnacle servers formerly manufactured by Hewlett Packard.