

A Phased Approach to Implementing DTV

By Mark Magee

There are many paths that can be taken during the transition from analog to digital television. Broadcasters must weigh the delivery of new services, such as high definition, multiplexed standard definition, pay television, and data broadcasting, versus budgetary and logistics constraints. Rather than jumping into a full-featured digital television (DTV) broadcast system, broadcasters may wish to consider the upgrade in phases. This paper discusses an upgrade path to delivery of new digital services that can be taken over four phases. At each phase, the broadcaster must build and install only a portion of the full DTV broadcast system; yet each phase also represents a milestone at which the broadcaster can deliver meaningful services.

The transition from the current analog television plant to the future full-featured DTV broadcast plant involves many significant shifts. There will be many new pieces of equipment in the facility, and just as many shifts in mindset. Digital broadcasting is not just about digitizing current services; it is about the ability to deliver new digital services whose implications are not yet fully explored.

Fortunately, broadcasters need not change everything at once. Station engineers can add equipment here and there, gradually adding to and replacing infrastructure. But as the plant investment increases, it will be important to have commensurate increases in the scope of services.

The first phase with any DTV conversion is getting a signal on the air. This initial phase, described below, is a minimalist approach that may appeal to some. The second phase adds multiplexed standard definition to the digital system—multiplexing is an opportunity to offer new services, which may be a priority for some broadcasters. The third phase adds high-definition (HD) pass-through. This yields a higher quality of service yet requires a minimum of local investment. The final phase is conversion to a fully HD capable facility.

Phase 1: Dawn of Digital Services

Although some broadcasters may wish to jump directly into high definition, some may wish to take a more conservative approach to launching digital services. The most conservative first step is to simply simulcast the existing analog service in digital. Even

with this approach, there are a number of complex and potentially expensive upgrades to perform.

Perhaps the most expensive upgrades will occur at the transmitter site. Conversion to digital may require physical upgrades to the existing antenna; building a second antenna; or worse yet, finding another antenna site. In addition, there is the need for a new digital transmitter, with new power requirements, and an upgrade to the station-to-transmitter link (STL).

Faced with all these challenges at the transmitter site, the broadcaster may wish to minimize initial investment at the station itself. What will the minimum system look like? Figure 1 depicts a bare-boned, but fully operational DTV system. Remarkably few new pieces of equipment or changes in operation are required.

Just before the analog STL, the signal is split to also feed an ATSC-compliant MPEG-2 encoder. This video feed is most likely available in either analog NTSC or serial digital (SMPTE 259). Either of these formats can be accepted directly at the encoder. The audio feed is most likely available in differential analog or AES/EBU. Again, either format can be accepted at the encoder.

If the audio and video feeds are in proper lip sync, no special synchronizing considerations are required. Although the internal processing

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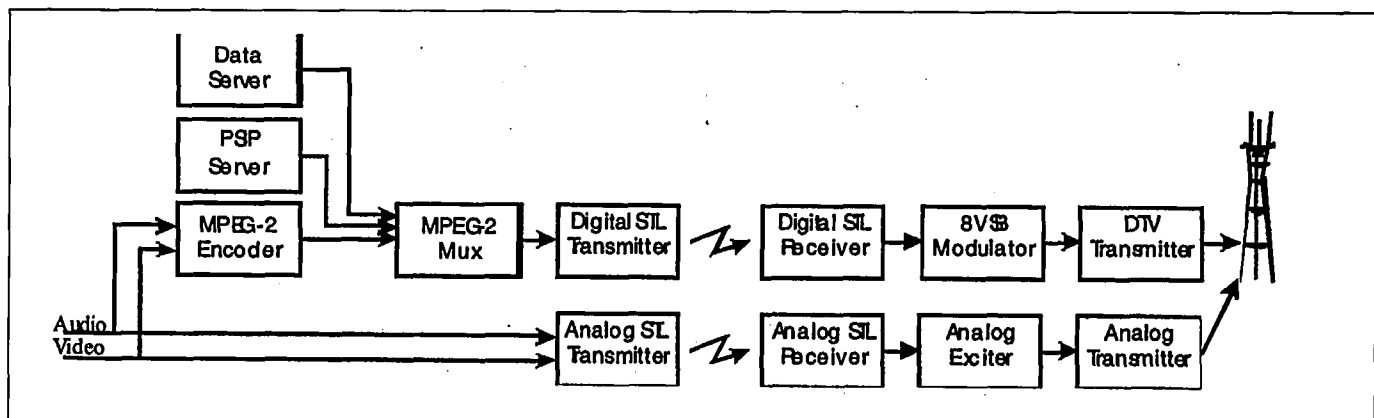


Figure 1. Minimal DTV system.

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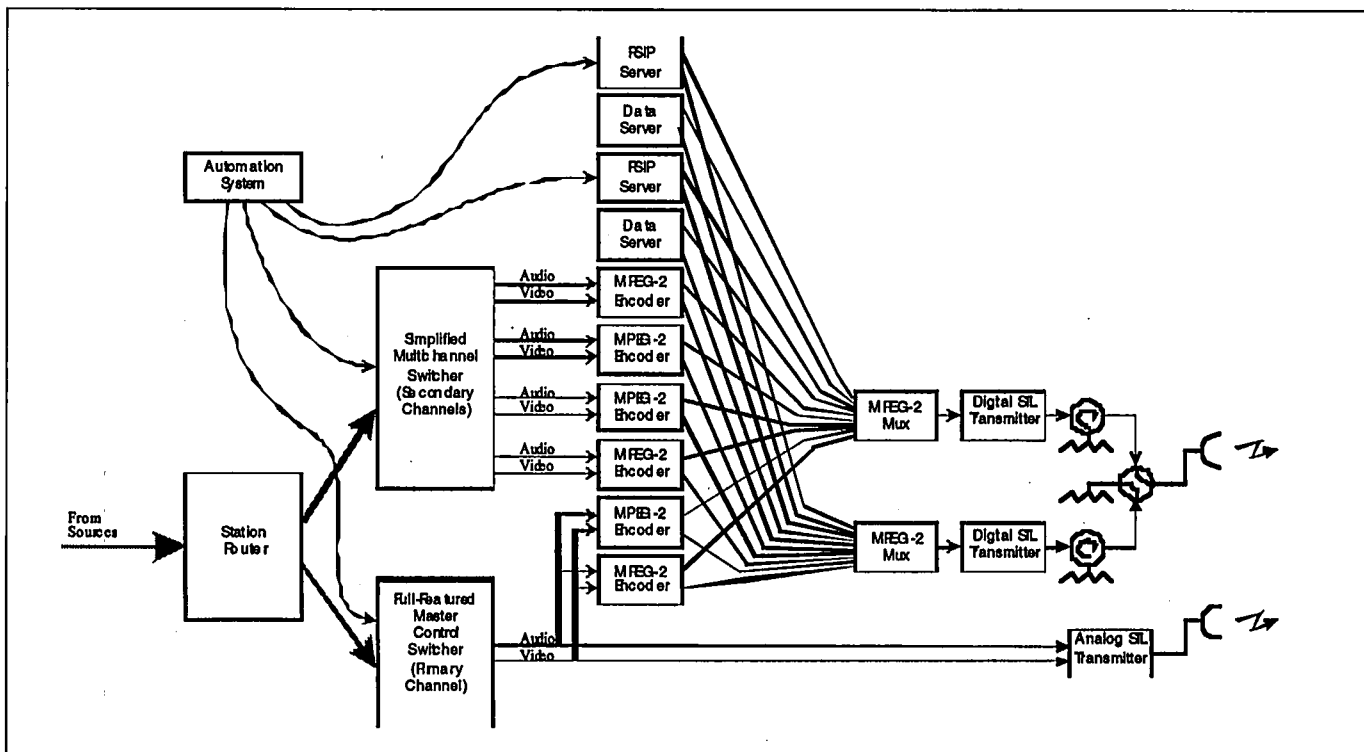


Figure 2. Multiplexed DTV system, studio system.

delays for audio and video are different, the encoder compensates for these internal differences and outputs a fully synchronized multiplexed stream.

Because the standard definition signal requires only a fraction of the 19.4 Mbits/sec available, it may be desirable to use the remainder of the bandwidth to broadcast data services for business or home applications. The data server in the diagram provides the capability to broadcast data within the multiplexed MPEG stream. The applications for data delivery may include transmission of a variety of public and private services:

- Digitized local, national, or international newspapers.
- Sports and entertainment listings.
- Financial data and news for brokers or individual investors.
- Private database updates for retail or financial businesses.

Initially, these services could be completely standalone. Eventually, data services may be tied to program or advertisement content.

In addition, service information is required as part of the digital stream. This "information about the information" allows the decoder to navigate the different services in the stream. The formats specified by the ATSC is

called Program and System Information Protocol (PSIP). The PSIP server provides this information to the multiplexer. Initially, PSIP could be supported with a standalone computer, but at some point the PSIP server should be tied into the station automation system.

Phase 2: Multiplexed Standard Definition

To get on the air with a DTV signal, there are a number of hurdles at the transmitter site, and a few at the station. To put a multiplexed DTV signal on the air, the situation gets more complicated at the station, but this complexity allows a wider range of services.

Broadcasters may use multiplexed DTV in a variety of ways. They may have a flagship channel that is used in much the same way as their current signal, but they can have a few additional channels that are used in different ways. Examples include:

- Local or regional news channel (e.g., Bay TV in the San Francisco market).
- Cable channels (to complement or compete with local cable).
- Additional syndicated programming.

- Additional broadcast slots for popular programming.
- More infomercials.
- Pay-per-view movies.

DTV multiplexing leads to a change in master control. Today a broadcast station is focused on making one channel of video as good as possible. There is a high demand for sophisticated video manipulation features as well as reliability in the video path through the plant. This approach may remain for a primary broadcast channel.

For secondary channels, the video path may be simplified considerably. In any case, the video compression path for any of the signals looks about the same. Figure 2 depicts the station diagram for a multiplexed DTV broadcast system with one primary channel and up to three secondary channels.

The diagram indicates the use of a simplified switcher for the secondary channels. For these channels, it may be possible to forgo digital video effects and other features commonly used to give a distinctive look to a station. The primary channel retains the fully featured master control switcher used today. Once multiplexing is in use, the broadcaster should consider an automation system that is designed for managing multiple channels. This

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automation system should be tied into the PSIP server.

The MPEG system in Fig. 2 is expanded to handle the additional channels of video. Beyond the additional capacity, the MPEG system also features full redundancy. The diagram depicts one backup encoder for three active encoders on the secondary

channels. The primary channel has one-for-one encoder redundancy. The data server, PSIP server, mux, and STL transmitter also have one-for-one redundancy.

Statistical multiplexing (statmux) is an important consideration in multi-channel broadcasting. Statmux improves video quality by allowing a

set of channels to dynamically share a bandwidth pool. Over time, video material varies in compression difficulty. Statmux allows a channel with difficult video to increase its bit rate, whereas another channel with easy video lowers its bit rate. If all channels have difficult video simultaneously, there is no spare bandwidth to share.

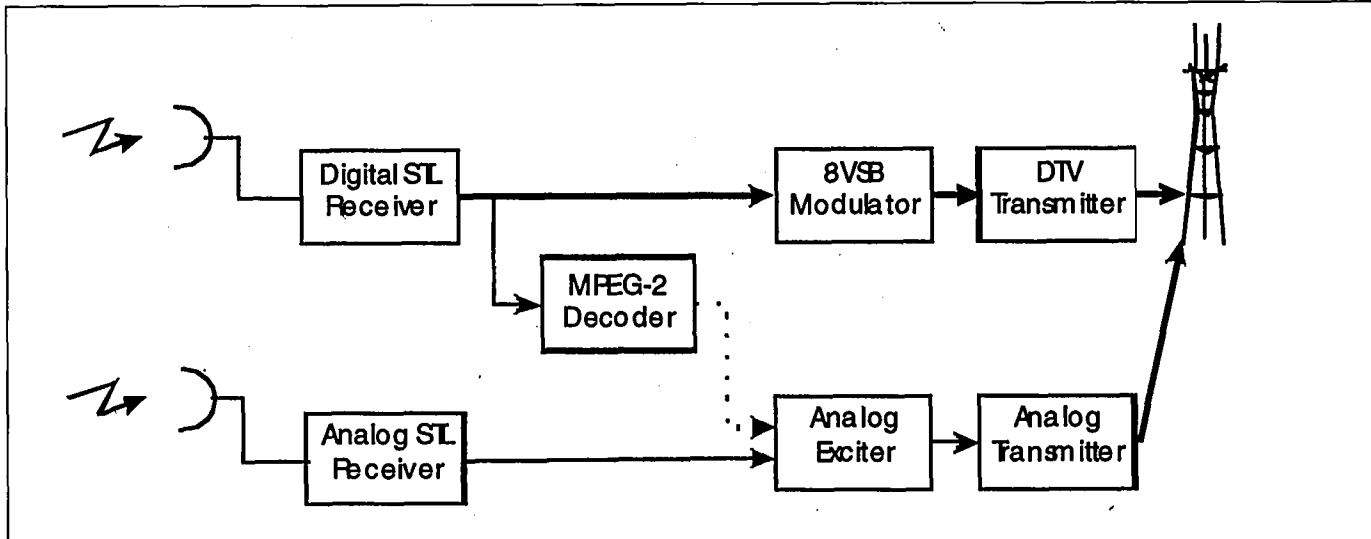


Figure 3. Multiplexed DTV system, transmitter site.

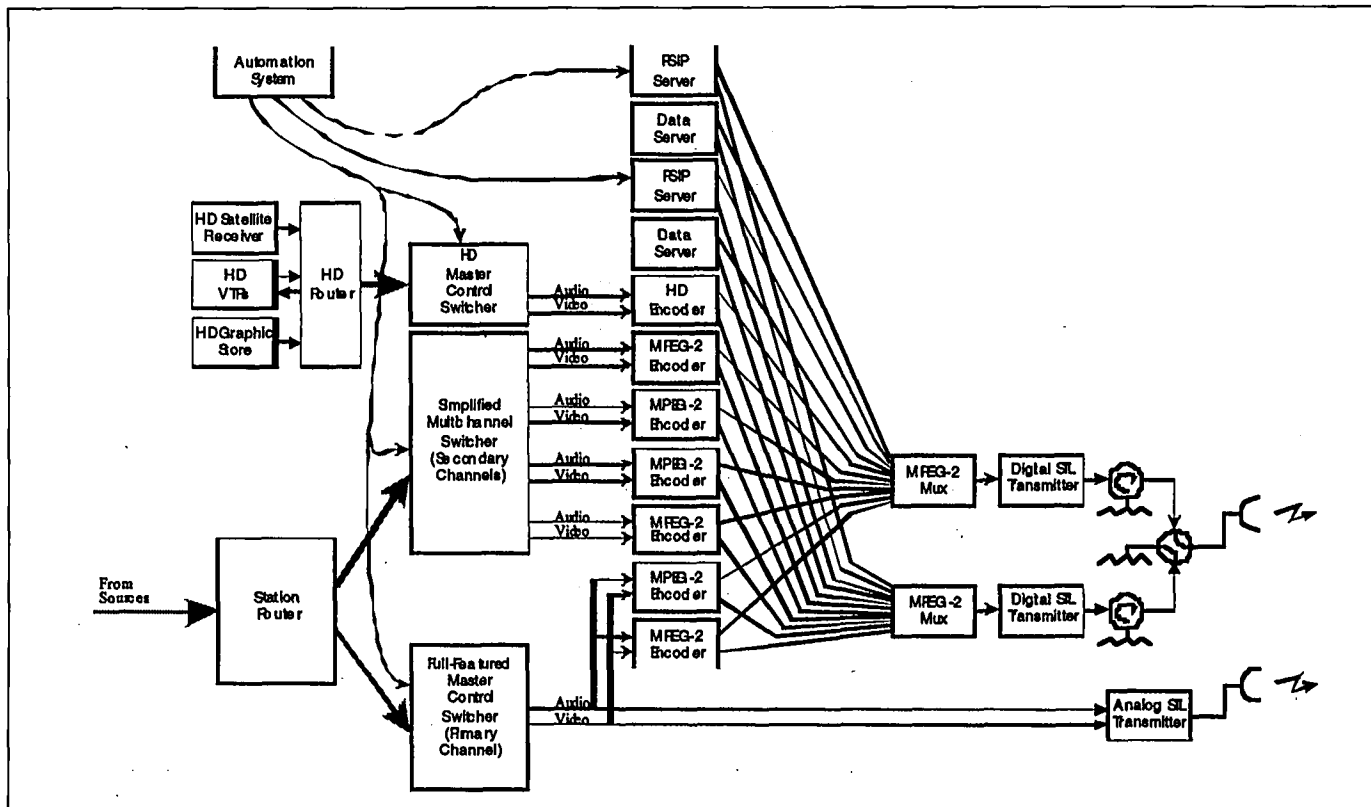


Figure 4. Multiplex plus HD pass-through system, studio system.

At those rare moments, statmux is no more effective than fixed bit-rate allocation. But most of the time, statmux increases quality by allocating bits where they are most needed. Depending on the MPEG equipment selected in phase 1, adding statistical multiplexing may be as simple as adding a software option.

Another consideration is the use of a conditional access system (CAS). As additional services are added, some of the content may be subscription-based, pay-per-view, or otherwise controlled. Although DVB has made great strides, both in definition and deployment of CAS, ATSC is still in the early stages of CAS definition. For the sake of simplicity, and because ATSC CAS definition is in flux, CAS is not depicted in the diagram.

Because phase 1 solved all the digital transmission problems, the digital transmission path from the MPEG multiplexer to the antenna remains the same for phase 2. The diagram for the transmitter site is shown in Fig. 3. As

a variation, decoding the primary digital feed at the transmitter site can eliminate the analog STL. This option is depicted.

Phase 3: High-Definition Pass-Through

As high-definition broadcasting ramps up, source material may come primarily from network feeds. Rather than performing extensive local production, stations may elect to simply pass through network feeds with minimal manipulation. An island of HDTV routing and editing equipment may be adequate to support this capability, meaning that the bulk of the station plant need not change.

Figure 4 shows how HDTV capability may be added to the multiplexed system of phase 2. The approach depicted assumes the network HD feed is decoded for local processing prior to retransmission. The only change to the MPEG system is the addition of a high-definition encoder. The digital broadcast chain from the

multiplexer to the antenna remains the same.

Phase 4: Full-Featured Digital Broadcasting

The last phase represents the plant of the future. Given the rapid changes in market needs and rapid development of new technology, any depiction of the future broadcast facility is somewhat speculative. But it is possible to make some educated guesses.

In a compressed digital video system, there are two primary drivers, content and bit rate, delivering more and better content drives revenue. But the ability to deliver content is constrained by the iron fist of the fixed bit rate channel. The MPEG standard inherently supports a variety of resolutions, frame rates, and quality levels. This flexibility allows the operator to make dynamic adjustments, always keeping the quality and quantity of content in balance.

The first MPEG systems deployed often were configured with nailed up

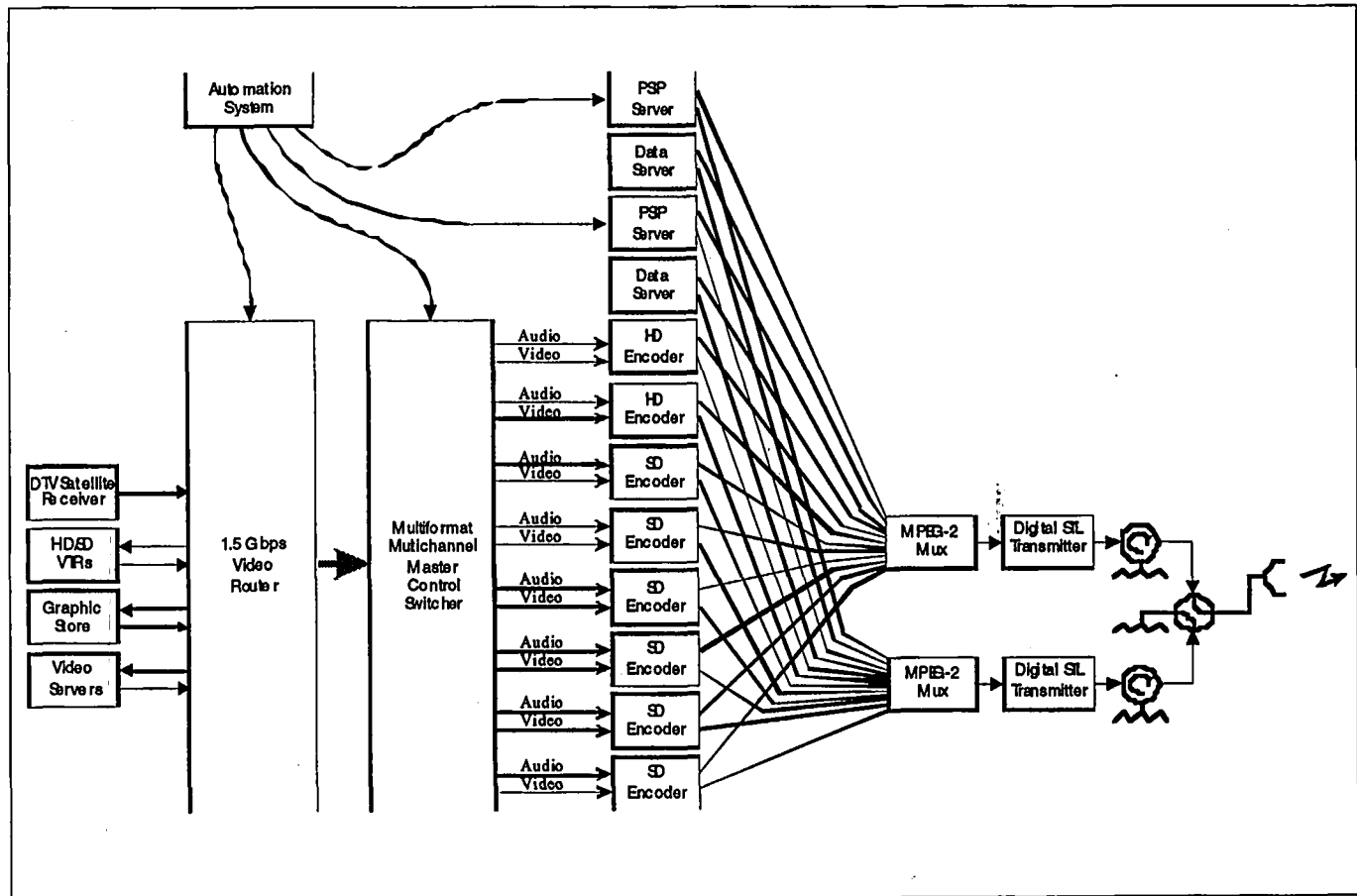


Figure 5. Full-featured DTV system.

parameters—fixed channel count, bit rate, and resolution. Operators inevitably tend toward flexible use of the available bandwidth. Well-designed MPEG equipment already allows a high degree of flexibility in the quality versus quantity tradeoff. The rest of the physical plant will have to catch up.

The routing system and master control switcher are two key pieces. The most flexible approach is to support both variable channel count and variable resolution per channel. Ideally these systems should be agile, operating on both HD and SD. Through the course of a broadcast day, the mix may move from six channels of SD, to two channels of 480P, to one channel of 720P and one channel of 480i, and to one channel of 1080i. The master control switch and router should take it all in stride.

A major issue for phase 4 is the format in which video is routed. With a small HD island in phase 3, one can simply pick a cost-effective and convenient solution. But in phase 4, we are looking to change the routing in the entire facility. Near-term expediency is not the primary consideration in such a major change. Among the candidates are mezzanine compression on SDTI, full bandwidth digital video, and computer networks, such as ATM. Each of these approaches has advantages for different applications. It is likely that all three will coexist in the station plant of the future.

Figure 5 depicts a full-featured DTV system. The MPEG emission system used in phase 3 (HD Pass-Through) remains in place. The changes occur in the rest of the broadcast plant. At this point, cameras, tape decks, video servers, master control switcher, etc., must all be converted to HD. Of all the changes that have occurred in the previous phases, this final conversion to end-to-end HD is perhaps the most expensive step.

The system depicted in Fig. 5 is based on the assumption that a full bandwidth router is available. Ideally any sort of video could be carried over this router. Uncompressed video may be used as input/output to the master control switcher. Compressed formats may be used for tape-to-tape transfers to eliminate generational loss.

Another feature of the ideal router is the ability to carry metadata regarding compression decisions along with decompressed video. At some point, this metadata could be used by the compression front end of tape recorders and by the emission encoders to minimize generational losses.

Not depicted in the diagram, for the sake of simplicity, is the computer network. This infrastructure will be ubiquitous. As video equipment becomes increasingly more digital, the control systems and video routing system will borrow more and more heavily from the computer networking industry. The economies of scale of that industry produce an irresistible force. Perhaps even the venerable 75-ohm video cable will fall victim at some point.

Conclusion

Each broadcaster will have a unique path to DTV. The approach described here may be a sensible approach for some. Whatever approach is taken, it would be wise to take things step by step. Although it is possible to design a new facility from the ground up, this is not economical for most. Even if it were, it does not take into account that technology is moving fast. Building on proven technology at each stage of the upgrade can take some of the uncertainty out of the DTV picture.

Appendix

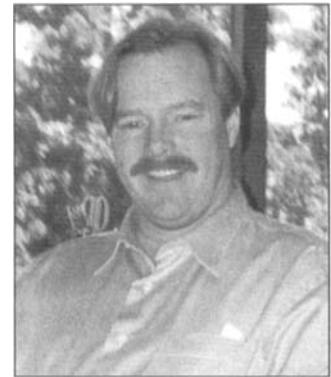
DiviCom History

DiviCom introduced the world's first MPEG-2 video encoder at the World Media Expo in 1994 and has been delivering digital broadcast systems since 1995. MPEG systems have been delivered to program delivery system operators in the fields of direct-to-home satellite broadcast (DTH or DBS), fiber-to-the-curb (FTTC), digital wireless cable (also known as multipoint multichannel digital system, or MMDS), and asynchronous transmission mode (ATM)-based contribution networks. DiviCom has delivered over 2,000 broadcast-grade MPEG-2 encoders, including several installations of 100+ channel systems.

Terrestrial digital broadcasting can be seen as another kind of program

delivery system. Although DTV broadcasting brings new challenges, we can apply many of the ideas developed for other types of systems. Flexible allocation of bit rate across a multiplex of video services, conditional access for pay services, and data delivery are existing capabilities that can be applied to the field of DTV broadcasting.

THE AUTHOR



Mark Magee leads the development of program and data delivery systems for satellite, cable, and broadcast applications. In his previous position as director of engineering for encoder products, he spearheaded the development and successful launch of the MediaView MV40 program encoder with DiviTrack statistical multiplexing. Earlier, he served as principal engineer and project engineer, roles that included defining the requirements and overall architecture of DiviCom's first generation MPEG encoder and multiplexer products.

Magee joined DiviCom in 1993. Prior to that he spent four years as a system engineer with Compression Labs Inc. (CLI), Broadcast Products Division, now a division of General Instrument. While at CLI, he was a key contributor on the technical team that developed the video encoder for the SpectrumSaver system; the first compressed digital video system for broadcast applications.

Magee earned his bachelor's degree in electrical engineering from the University of Texas at Austin.