ST 13.16 Report on Task Force on Packetized Formats

By Eric Pohl, Chairman

This report is a summary of the issues and recommendations discussed at the meetings of the SMPTE Task Force on Packetized Formats (ST13.16), as well as on-line discussion. The issues examined are those concerns of utilization of packetized video formats in television production and broadcast applications.

Summary of Activities

The initial meeting of the task force was held on May 20, 1994. Discussions ensued regarding the many challenges this area presents at this time. General areas of concern were identified, and a desire to increase the group's literacy on computer networking was indicated. (For more details see meeting minutes ST 13.16-892.)

The next meeting was held on August 28, 1994. At this meeting members of the committee identified two areas that needed immediate attention: packetized television interconnections and compression issues. It was agreed that a request would go to the Engineering Vice-President regarding the formation of groups to deal with these issues. (Two weeks later, the S17.45 Ad-Hoc Group on Packetized Television Interconnection and PIX.44 Ad-Hoc Group on Television Compression Systems were formed.) Also at this meeting, a presentation was made by Rod Williams, National Semiconductor, and Dave Powell, Intelligent Resources. This presentation was an overview of computer networking and a discussion of computer network characteristics that need attention in order to be used for video transport.

At the third meeting, on December 17, 1994, a rough draft of the group report was presented and reviewed. Final revisions to the report were done at the last meeting on February 8, 1995.

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General Discussion

The most common interpretations of the words "packetized video formats" are those formats that involve compression and packetization for transport. Some examples expected to see wide use are MP@ML MPEG-2 and ATV. Packetization most commonly is a transport wrapper, often followed by multiplexing. What is expected is the utilization of computer networking and telecommunications-driven standards (e.g., FDDI or ATM) for video transport. Out of this have come several concerns arising from television production requirements, as opposed to requirements driven by distribution of television programming to the end user. This group has attempted to identify these concerns and suggest to the SMPTE Standards Committee the role that the Society can play in addressing these concerns.

There are two main reasons for compression in broadcast and production television: to achieve efficiencies in the storage process and for transmission. Although the compression techniques employed for both of these areas are algorithmically very similar, the efforts in these areas to date have been independent and therefore represent compressed solutions that are closed and work only within one discipline. At the same time, the MPEG effort has proceeded as an open standard that has been utilized for both recording and transmission applications.

Packetized Transport — Areas of Concern

Transport Application Areas

With the advent of compressed systems, the need for transporting video in the compressed domain is greatly desirable in order to minimize the compression/decompression cycles.

When examining video transport, it is useful to break it up into major application areas so that the different requirements that drive these areas can be understood.

Plant Internal Distribution

- Highest quality level
- Shorter runs
- Owned equipment
- No commercial services used

Between Sites (Contribution or STL)

- Utilization of both user-supplied equipment and service provider-supplied equipment.
- Commercial and private services used (standardized rates, not necessarily optimized for video).

Distribution to Affiliate or Head End

- One to many broadcast models

Delivery to End User

- Via affiliate or head end
- Quality less of an issue

Interconnection Issues

Need to Level Concerns Against Each Level of the 7-Layer ISO OSI Model

A mapping of the ISO/OSI 7 layer standard on packetized video transport was proposed for perspective (Table 1).

An area that was discussed at the first meetings was the lack of interface standards for transport of MPEG and other compressed video. Dave Fibush presented a drawing and text that illustrated some specific opportunities for interface work to be done. These are discussed in the next section. It is expected that S17.45 will define packetized interfaces for various application areas (Table 1). Although there may not be a single method proposed, the goal would be to reduce large number of options to a manageable number.

Table1 — ISO/OSI 7-Layer Standard

Layer	Traditional Definition	Television Production	Implementation Example
Application	User determined	Programming, effects, recording, acquisition, contribution, distribution	Play list
Presentation	Data transformation	Signal coding, compression, file systems	Encryption, MPEG-2 compression
Session	Connection management	Control, access management	MPEG systems
Transport	End-to-end management	Mux/demux, quality of service, synchronization	MPEG-2 transport, Rec. 656, TCP/IP
Network	Subnet management	Routing, switching, network protocols	Switching
Data Link	Error management and synchronization	Error detection/correction, acknowledgment, framing	EDH, SDI sync, TRS
Physical	Mechanical, electrical, and procedural	Signal levels, impedances, connectors, bearers, jitter	Coaxial cable, fiber, SDI tx/rx

Compressed Television System

The complete block diagram, shown in Fig. 1, provides an overview of compressed television processing and transmission. Television nominally consists of audio and video; however, the system as shown includes data and control, so may be thought of as a multimedia system. One-direction transmission is shown. Interactive operation would require some or all of the elements to be available in the reverse direction. A multiplicity of methods are depicted, particularly in transmission, making this diagram an overview of many types of applications. MPEG is used as the sample compression system, since it has a variety of data streams already defined and provides for inclusion of other data at the system level. The overview nature of the diagram should be considered to cover other compression methods such as JPEG, DPCM, or H.261, which could be used for the video portion.

A primary purpose of the block diagram is to highlight the possible need for digital interconnection of the compressed data by means not presently defined. Dashed lines in the drawing indicate system locations for the potential application of such interconnections. To aid in understanding of the overall diagram, portions are duplicated here with the associated explanatory text (Figs. 1a-1d).

For completeness, analog television inputs to the system are shown although many facilities are likely to be primarily digital. Video inputs are analog NTSC, PAL, component (e.g., Betacam, M-II, or EBU N-10), or high definition per SMPTE 240M. Video and audio are transformed to standard digital formats by analog-to-digital (A/D) converters. Digital audio would generally be directly accepted by the audio coder, whereas digital video is more likely to require preprocessing. Virtually all compression systems work with component video, so composite inputs will have to be decoded. The "main" profile for MPEG requires chroma subsampling in the vertical direction, producing the so-called 4:2:0 format. Conversion from interlace to progressive scanning may be preferable prior to, rather than as part of, the coding scheme. Pan-and-scan information may be applied at this point in the system, although it might be a better design to transmit the full picture and let the receiver provide the aspect ration conversion. Other filtering or conversions may be required by various coding systems (Fig. 1a).

MPEG-2 is the most recent and complete compression coding scheme. There are separate documents covering video coding, audio coding, and system data formatting. Digital data from each of the coders and other sources is first formed into PES packets and then multiplexed and reformatted into either a transport stream or a program stream. The transport stream uses fixed-length packets, while the program stream uses variable-length packets. A transport stream may carry information from more than one program, while the program stream has data associated with only one program. The other similar channels would be for inclusion in the transport stream from other program sources. A program source is likely to include multiple audio sources and possibly multiple video, data, and control sources. Either defined stream or a series of PES packets could be used for interconnection between equipment in a facility. The transport stream, with its fixed-length packets, is specifically designed for longer-range transmission.

It is these various possible streams of data that are the focus of proposed standardization work. A large number of computer and telecommunication standard interconnect methods are being used to move packetized data within facilities today. Two, or possibly three, different methods may be

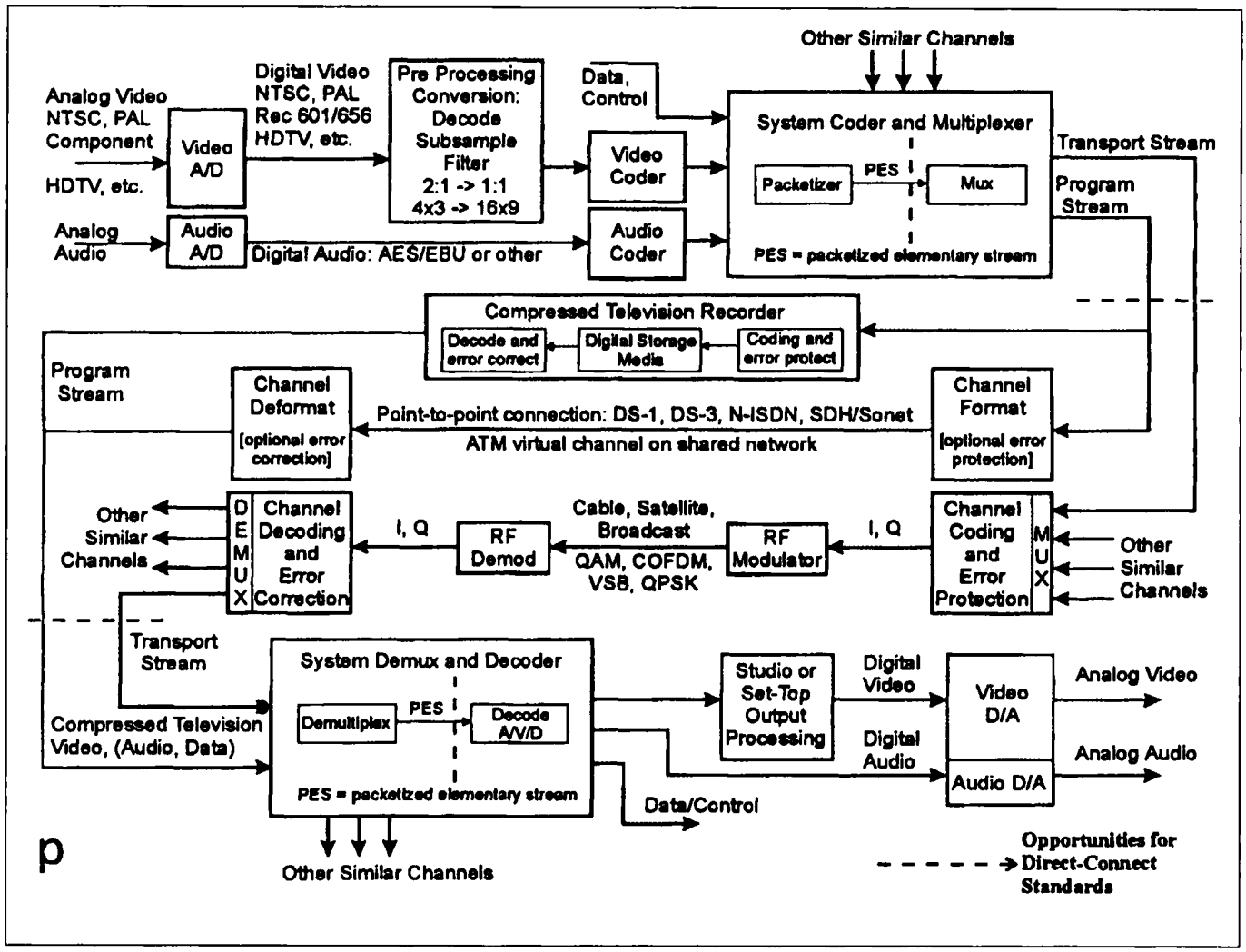


Figure 1. MPEG-2 compressed television system block diagram.

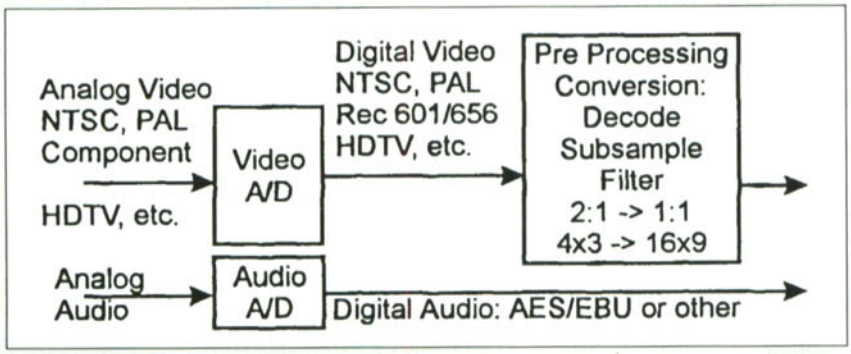
required due to economic and logistic considerations. Agreement by standardization should be used to reduce the many possibilities to the reasonable minimum.

Since the program stream "is designed for use in relatively error-free environments," the diagram (Fig. 1b) shows it as an input to a digital recorder and to various types of telecommunications channels. Because of the characteristics of media-based recording, particularly tape, special formatting, channel coding, and error protection are built into recorders. This makes the record/playback look like an error-free process. Traditional wire or fiber telecommunications channels have relatively low error rates; however, some optional error protection may be required to meet the error-free criteria. The transport stream could be used where the program stream is shown. Also, there can and will be multiplexing of data streams for both recorders and telecommunications channels. Not all of the possibilities are shown in the diagram.

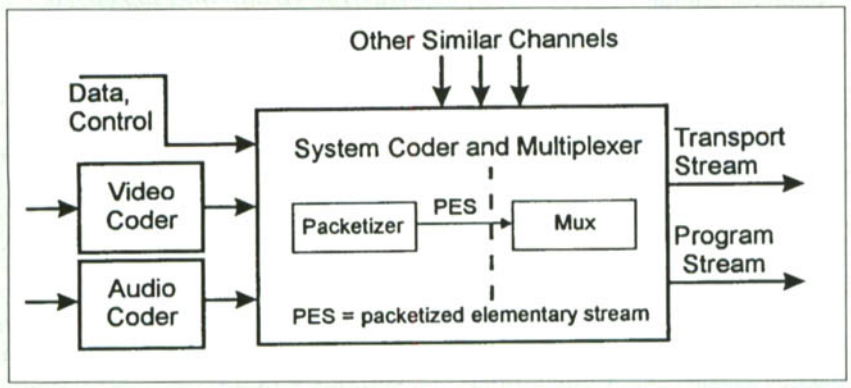
There is a special standardization task for recorders with interchangeable media. Since the recorder coding and error protection may be of a proprietary nature, methods to ensure interchange without publishing coding algorithms must be developed. This is separate from the desired equipment interconnect standard(s).

A number of telecommunications transport methods will be used for compressed television (Fig. 1c) because they are available and needed for other purposes. In fact ATM, which is a packetized protocol riding on various transport layers, may even be considered for interconnection within facilities. ATM in all its forms comprises some of the many facility interconnects that should be reduced to a few by standardization. RF channel communication certainly has its own channel coding methods and may include error protection. Multiplexing of a number of data streams on to one RF channel is one of the most common uses of compressed television today (Fig. 1d).

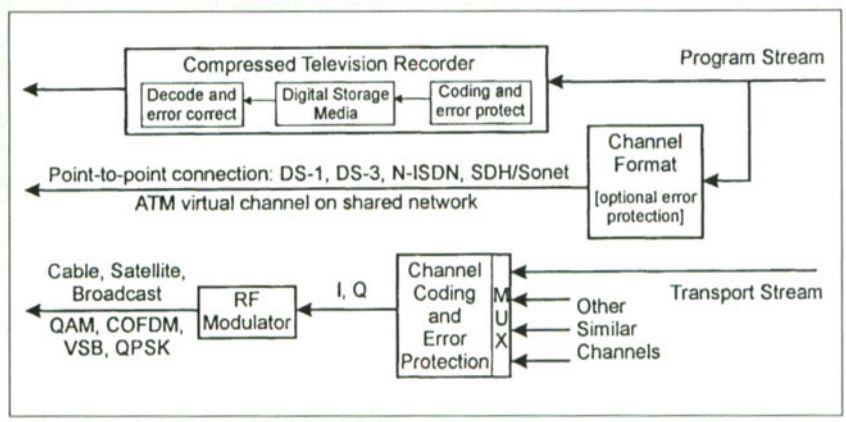
The decode end of the process is basically a reverse of the encoding. An example of set-top output processing might be the conversion of 24-Hz progressive scanned film to a higher frame rate for viewing. As suggested earlier, pan-and-scan data transmitted with the picture could be used to convert 16 x 9 or 2 x 1 images for viewing on the available display aspect ratio.



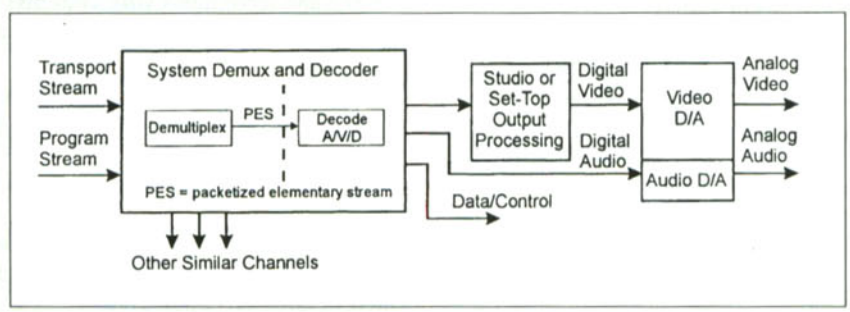
1a



1b



1c



1d

MPEG is an exception in that it covers a transport specification but not any details of the physical layer(s). The transport specification has its roots in the compression effort; there is no media specified. It is likely that there will be several methods of transport. Each method of transport will require specific detail for its area; the common example is ATM. AAL5 (ATM Adaptation Layer 5) is an upper-layer specification that will detail the mapping of MPEG onto ATM; the rest of the ATM spec covers lower layers. Again, in the case of ATM several types of media can be utilized.

- Physical interface standard for MPEG-2ML ML@MP needs to be addressed.
- Physical interface station for ATV needs to be developed.

Use of Data Communications-Type Channels for Packetized Video

Need to Assess Plusses and Minuses

Although there may be opportunity to utilize "high data rate" communications implementations that have come into existence for other applications, there may be both benefits and penalties for utilizing these standards. The traffic characteristics of video are unlike those of data and voice communications.

Since not all "high data rate" solutions will be appropriate — those that may should be identified.

Some considerations are:

- Access to technology developed for large markets can provide economy of scale to the specialized market of broadcast television.
- As "higher bandwidth" communications techniques are deployed in other applications, there is opportunity to interconnect to them and provide efficiencies (telco's utilization of ATM).
- Application of "inappropriate" technology can result in performance and cost problems.
- Suitability for a variety of signal formats (compressed and noncompressed, M-JPEG, reusability has cost benefit).

• Bidirectional traffic provision needs to be examined.
• All layers of the ISO/OSI 7-layer standard must be "appropriate" for video traffic.

Performance Concerns

It is important in addressing these concerns, that the entire solution is optimized (e.g., all layers of implementation, down to the physical media, have to be specified). There may be one combination that may be suitable and another that is not. It becomes apparent that there are many layers involved in determining the source of a performance problem.

For the physical layer, not only the bit error (BER) rate is important, but the statistical nature of the errors should be determined. These errors can cause errors in the data link layer. But depending on how the data link layer is implemented, these errors can result in different types of errors, such as damaged or lost packets. Lastly, the effect of the damaged or lost packets is translated to problems in decoder operation that will result in undesired subjective effects, such as the need for the decoder to resynchronize.

Some basic performance concerns to be investigated are:

• Nonguaranteed rate (not isochronous).
• Excessive latency.
• Unpredictable latency.
• Packet loss, misordering, delay.
• Instability/blocking or availability problems.
• "High" physical layer BER (causes problems at higher layers).
• Need for prioritizing or establishing grades of service depending on the transport application (see outline above).
• Define rules/guidelines for successful/reliable operation — metrics (tests for conformance and performance).
• Protection of signal through successive/concatenated production/distribution processes and coexistence of different types of traffic (real-time mission critical non-real-time background) on shared media.
• Keeping overhead required for error protection from becoming excessive.
• Switching and multiplexing issues.
• Synchronization.

Compression — Areas of Concern

Application Areas

Again, in the case of compression, it is also important to examine the application areas for which compression has come into use in order to understand the different needs behind them.

Recording
• Field acquisition
• Nonlinear editing
• Production quality recording

Transport
• Contribution quality feeds
• ENG quality feeds
• End distribution and multiplex

Issues

As stated in the introduction, there was a strong desire from some members for SMPTE to investigate video signal compression from a television production perspective. Current offerings that are utilized in the television production process involve varying implementations of intraframe-type compression algorithms. Although compression itself is not a "packetized formal issue," the absence of a transport specification associated with a compression scheme is an issue. That, combined with the inability to move compressed video between closed systems and the proliferation of utilization of various computer-type transports (e.g., SCSI), are central concerns.

Besides transport issues, this new group may also find it important to look at the appropriateness of compression utilization for production process, listed earlier.

During the course of the Task Force meetings, a group of manufacturers proposed to MPEG the establishment of an implementation or profile of the MPEG syntax that would be suitable for television production and contribution. Supporting this effort will be an additional focus of the Ad-Hoc Group on Television Compression Systems P18.44.

Concerns Regarding Compression in Production

• Cumulative multigenerational encode/decode effects
• Concatenation with other algorithms
• Transport of compressed data
• Editability of encoded steams
• Methods or standards for preservation of vertical interval data
• Other associated data issues

Actions/Recommendations

Issues to be addressed in S17.45 Ad-Hoc Group on Packetized Television Interconnection

Standards opportunities for:
• MPEG-2 ML@MP interconnections
• MPEG-2 4:2:2 profile interconnections
• ATSC/GA interconnections
(with attention to the performance concerns listed in the prior section).

Issues to be Addressed in Ad-Hoc Group on Television Compression Systems P18.44

• Support MPEG-2 4:2:2 professional profile effort
• Determine if such a profile can meet the needs of broadcast production
• Determine if other system implementations issues need to be addressed (with attention to the performance concerns listed in the prior section).

Other Issues That Need to be Addressed

MPEG System Implemetation Issues (ML@MP, ATV 4:2:2 Profile)
• Switching, multiplexing, and synchronization
• Other methods of transport
• Storage techniques (file systems)
• Interoperability with open systems

More Global Issues to Investigate

Generalized Packet Protocol for Video
• Create syntax for video as a data type
• Address all layers' different implementations to allow coexistence of video in other environments