COMPRESSED DVB STREAM STORAGE IN THE BROADCAST CHAIN

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ABSTRACT

This paper examines the requirements for the storage and manipulation of pre-compressed video streams within the terrestrial and cable DVB transmission chain. In particular it focuses on the needs of regional stations and headends that implement pass through architectures. Solutions are identified that meet the requirements for storage and manipulation of compressed video data and also obviate the need, expense and quality issues of decompression/recompression. The following will be addressed in the paper:

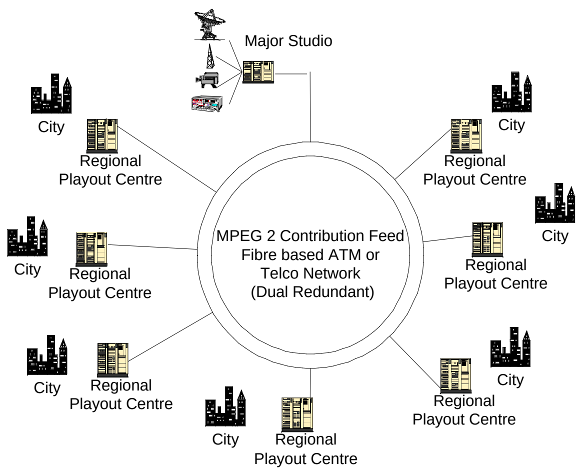
_ Local program overrun network delay
_ Splicing
_ Local advertisement insertion
_ Compressed editing
_ Program storage and transfer
_ Data broadcast
_ VOD/NVOD services
_ Play to air

The paper presents a model of operational requirements and analyses the capability of the equipment designed to solve these needs.

INTRODUCTION

The increasing use of MPEG-2 compression in the transmission chain has been driven by the economics of generating greater program capacity within limited transmission bandwidth.

To date DVB systems have used MPEG-2 primarily as a broadcast distribution format to the tower or down the cable, with limited amounts of manipulation and storage of MPEG encoded material between the encoder and the consumer's decoder.



This transmission methodology has come about from two key factors:

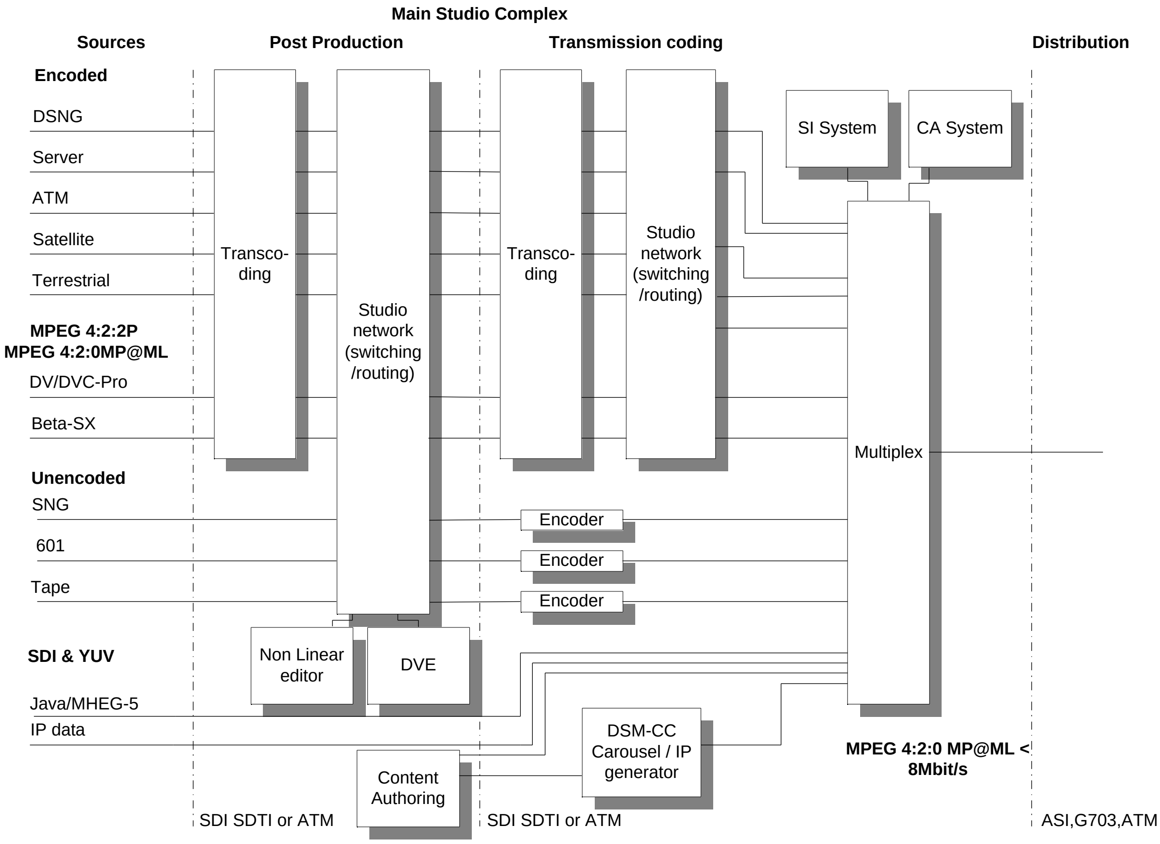
_ The rich infrastructure of CCIR-601 based transmission and manipulation legacy systems possessed by the DVB operators within regional studios leading to decode and re-encode for regional program insertion.

_ The relative difficulty in manipulating lossily compressed MPEG video compared to the manipulation of loss less CCIR-601 encoded material.

This situation is changing with three factors driving the change:

_ Advances in compressed video manipulation technology allowing the storage, splicing and transcoding of MPEG video without use of decompression and recompression.

_ The requirement to cost effectively transfer ever increasing volumes of video quickly over large distances.



- Increasing regionalisation of TV broadcast with the addition of significant amounts of locally generated programming.

To meet this commercial and technical requirement manufacturers are developing new classes of equipment to enable the carriage and manipulation of compressed video.

These new equipment types are nucleating around the storage of compressed video i.e. streaming video servers with native MPEG input/output. These MPEG servers provide the infrastructure around which to add value within the transmission chain.

Physically, they provide the highly robust fault tolerant chassis required to provide 24x7 transmission, and provide a good host platform for the other forms of compressed manipulation required by broadcasters. Importantly they also tend to be located in the right physical location to perform this manipulation.

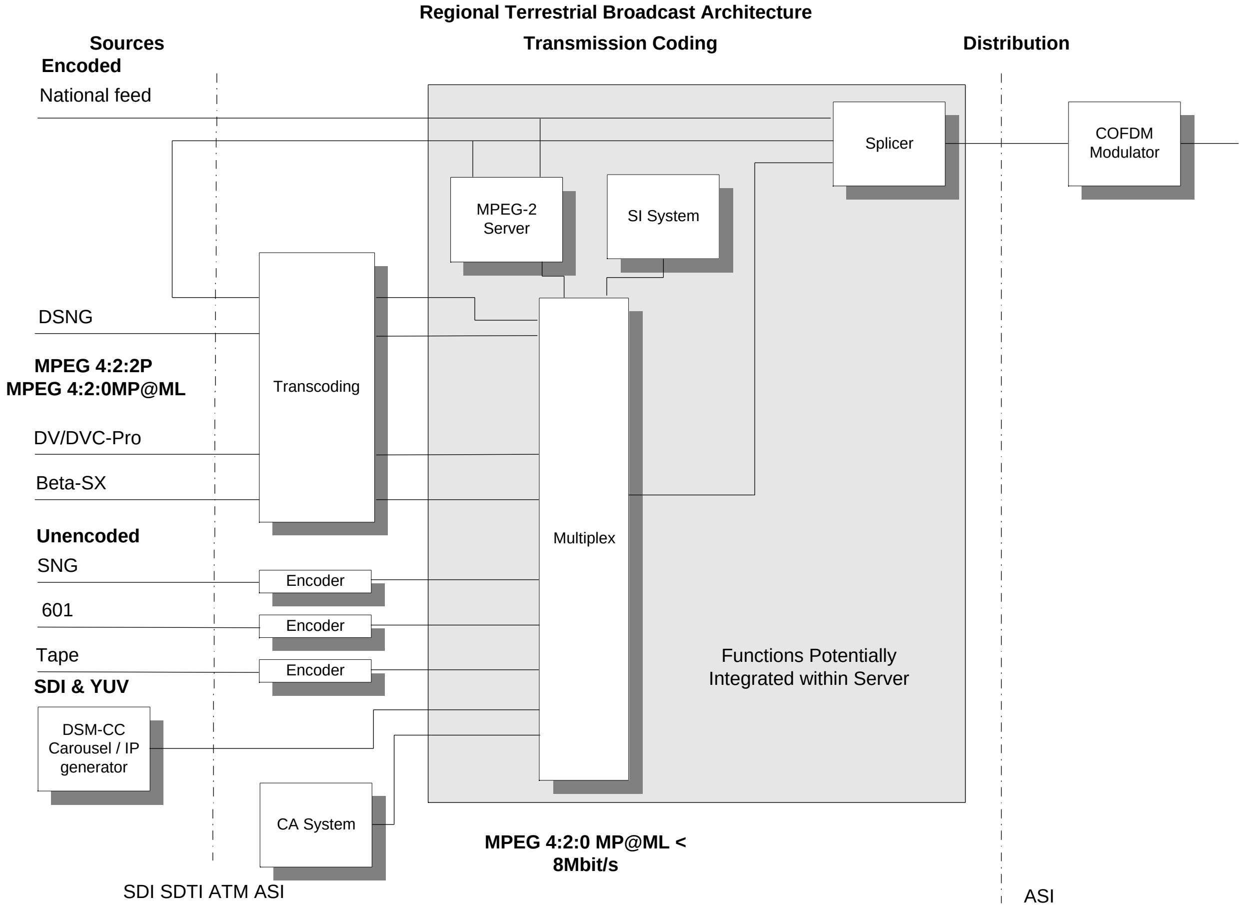
THE USER REQUIREMENT

The major application area for this new class of server is in the reginalisation of networks. Terrestrial and cable networks in particular are increasingly providing local programming from regional studios and headends. The sustaining network feeds to these regions are invariably MPEG compressed, leading to the requirement to cost effectively and without quality loss add local programming, either from a server or live feed.

Commercial channels also have a requirement to add regional advertising material as an important source of revenue.

Other forms of MPEG manipulation will also be required. These include some or all of the following:

- Storage of MPEG compressed Single Program Transport Streams (SPTS) and Multi Program Transport Streams (MPTS) to allow delayed program playout.
- Demultiplexing of MPTS to allow selection of specific programs.
- Storage of MPEG compressed data for clip and add insertion.
- Seamlessly splicing of new regional program material into the sustaining network feed.
- Simple editing of MPEG program material.
- Station logo insertion.
- Bit rate transcoding of material supplied to the station at a rate different to the transmission rate.



_ Data Broadcast insertion.

_ Remultiplexing of MPTS to build up a stream for transmission.

_ Play to air from a MPEG native server.

_ Manipulation of the System Information (SI), particularly the Network Information Table (NIT) and Electronic Program Guide (EPG) to reflect the correct transmission identities and programming.

Additionally, cable networks are implementing value added services by the addition of Video On Demand (VOD) Servers at the regional headend. This positioning limits the backbone network bandwidth loading for pay per view film playout.

New services are also being implemented to provide personalised TV to viewer's with storage implemented at the headend rather than within their set top box.

This again requires the location of native MPEG servers locally.

Compressed storage/manipulation Economics

The economics of storing video in the native MPEG encoded video format are easy to demonstrate. At a terrestrial bitrate of 24 Mbit/s one hours material will take approximately 11 GByte of disk space. Uncompressed CCIR 601 video storage to disk of the same material would occupy 122 GByte of disk.

Storage cost in terms a raw disk size can therefore be significantly cheaper, ignoring the lower spindle speeds and head access time required for native MPEG storage.

Picture Quality Issues

One of the other key advantages of native MPEG manipulation is that it avoids the need to decompress and recompress material with its associated quality loss.

Most terrestrial networks use high bandwidth compressed contribution feeds to minimise the quality loss when material is re-encoded to a lower bit rate. However transmission at a lower bit rate and compressed manipulation is potentially more cost effective.

NEW SERVER APPLICATIONS WITHIN THE BROADCAST CHAIN

The development of augmented services within the DVB domain, along with the classic transmission of video and audio, is leading to the development of several new classes of video servers. These servers provide content primarily for the new interactive services enabled by DVB, with or without use of a return channel.

In particular video on demand and data broadcast services involving data and object carousel transmission require new server systems to be distributed throughout the broadcast chain.

In parallel with this trend, increasing integration of added functionality within the servers is absorbing previously stand alone functionality. This includes functions like multiplexing, splicing and SI insertion.

New MPEG I/O server solutions include the following:

VOD/NVOD

Video on Demand (VOD) and Near Video on Demand (NVOD) MPEG pay per view services are enabled by secure back channels on the network. Telephony for terrestrial systems, DVB RCC or DOCSIS for cable. VOD servers have large numbers of output channels all capable of playing out asynchronously.

Virtual Personal Video Recorder

Cable headends are starting to offer end users the opportunity to store and forward transmitted video material within the headend rather than on the viewers set top box or integrated digital TV. Material of interest to the viewer is held on a local MPEG server for on demand playback with full VTR type capability i.e. pause, fast forward/rewind.

Time zone time shift

Stations spread across geographic time zones require the ability to delay the sustaining network feed. The most cost-efficient and storage-efficient method to achieve this is to record the feed to a stream server at the contribution rate. Time shift servers are in the direct broadcast chain and therefore need redundancy to provide high availability. This typically means redundant power supply units and RAID disk storage. RAID or Redundant Array of Independent Disks, is used for video storage to provide a level of disk redundancy by maintaining checksums on the stored data. A single failed disk will not prevent access to stored data.

Local program over run network delay

Local programming can frequently over run its allocated time slot, again leading to the requirement to delay the sustaining network feed for the duration of the over run. Delays are relatively short and are easily achieved using a disk based stream server similar to the time shift server. The primary difference in requirement comes from the requirement for a far more interactive user interface, sufficiently flexible to account for unscheduled transmission events.

Program repackaging

Some local stations record network program material and transmit it to local as opposed to network schedules. This program repackaging is readily achieved using a stream server with automation facilities. As with all stream servers key features will be;

- Industry standard interfaces ASI [2] or SDTI [3]
- Scalable disk storage
- RAID disk protection
- High speed greater than real time data transfer interfaces like 1Gbit/s Ethernet
- Simple remote Graphical User Interface (GUI)
- Automation interface

Splicing

Concatenation of compressed material e.g. network to local transitions or add insertion, requires the use of a splicing device. This device will allow seamless transitions between two sections of program material without blocking artefacts, syntax errors, and without Video Buffer (VBV) over or under flow. Splicing latency with current generation devices is of the order of several seconds.

Splicers can be either stand alone or incorporated within stream storage servers. Within the context of servers they can be either non real time for use in concatenating stored material for playout, or real-time, particularly for add and clip insertion to a feed from stored material from disk.

Compressed editing

Editing in the compressed domain is entirely feasible, its off line nature allowing for sophisticated frame transcoding and buffer management to provide seamless transitions between element of program material.

Compressed editing suites in conjunction with disk based servers will simplify the task of program packaging within regional stations.

Program storage and transfer

Storage of program material at MPEG-2 compression rates gives the capability to store many hours of material on a reasonable disk size. Use of Gigabit Ethernet for program transfer within a facility can provide at least the 4X real time experienced with VTRs, the prime limit on transfer rate being the disk I/O performance not the network transfer rate, assuming a dedicated network.

Logo insertion

Insertion of station branding logos, age ratings, network I.D.s can be performed in the compressed domain by partially decoding and re-encoding the specific picture area in which the bug is located. This technology has yet to be fully commercially exploited but is clearly feasible, and under development with some manufacturers.

Data Broadcast

Transmission of DVB data broadcast material to augment the video channel. This can include playout from servers streaming the following formats:

_ Multi Protocol Encapsulation

_ Data Piping

_ Data Streaming

_ Data Carousel

_ Object carousel

SI Insertion

Insertion of the System Information protocol (SI) into the program stream is the final stream manipulation required before modulation and power amplification. Real time dynamic SI re-inserters operating separately from an encode process are now readily available.

Play to air

Stream servers capable of playing out to air have been available for some time. These units offer the ability to add RAID configured disk arrays to a streaming engine supporting industry standard electrical interfaces. The units have playout scheduling capabilities with the ability to interface to automation systems.

Interconnect

Within the DVB arena native compressed servers are standardising on two interface formats, Asynchronous Serial Interface (ASI)[2] and Serial Digital Transport Interface (SDTI)[3].

For faster than real time transfer use of industry standard Network Filing Systems (NFS) and 100 Mbit/s and 1 Gbit/s Ethernet is becoming increasingly common.

Storage Area networks

The ability to integrate with a Storage Area Network (SAN) can be significant for MPEG native storage. Larger regional stations are increasingly using SAN technology for online video storage, providing redundancy and the ability to provide multiple accesses to the same stored material.

SUMMARY

The launch of a new generation of compressed stream processing broadcast devices will revolutionise the transmission of MPEG-2 broadcasts over the next three years.

These new devices will integrate much of toady's discreet equipment into a single chassis providing highly cost effective broadcast solutions for regional broadcast stations and headends.

The ability to manipulate store and edit video data in the compressed domain, together with interoperable, open interfaces and network based command and control systems will simplify, enhance, and reduce the cost of storage, editing and transmission, whilst not compromising the quality of the signal.

The new millennium will not be one of decode and re-encode but of streamlined workflow entirely in the MPEG-2 domain.

GLOSSARY OF TERMS

Key areas of technology that will differentiate compressed domain storage, manipulation and splicing equipment will be the following. Of these, the critical areas are frame accuracy, seamlessness, buffer management, open Group of pictures (GOP) and Variable Bit Rate (VBR) capability:

Seamless Splicing
The ability to splice or cut between two streams with the resultant stream remaining MPEG syntax compliant and with no visual artefacts apparent from a decoded stream. A splice which results in a non-compliant MPEG stream or a small visual impairment (blocking, frozen picture, blank picture) or both at the splice point is referred to as near seamless.

GOP accurate
The ability to splice together two MPEG streams at the end of a Group of Pictures (GOP). MPEG data is encoded and transmitted as grouped frames of three types, I Intraframe, B Bidirectional and P Predicted frames. I frames are the only frame type not reliant on information from another frame, and present the easiest option for a point at which to splice. An open GOP is one which references a B frame to a P frame in the previous GOP. The P frame expected by the newly spliced B frame will not be present, leading to picture jump. A closed GOP is self contained and does not reference frames outside its GOP. It is therefore safe to splice at an I frame boundary.

Frame accurate
The ability to splice between two encoded video streams at the video frame rate, 25 Hz at a predetermined and nominated video frame. This implies the ability to splice within a GOP at either an I, B or P frame. Splicing at B or P will probably imply transcoding the B/P to an I to close the GOP.

Variable Bit Rate (VBR) capable
Capable of splicing a variable bit rate (statistical multiplex) stream with another stream also at VBR with a resultant VBR output stream.

Video Buffer Verifier (VBV) Model
True seamless splicers have the capability to monitor the Video Buffer Verifier (VBV) level. This is derived from an idealised decoder model used to predict the buffer state of a typical decoder. A splicer would perform a look ahead calculation of both input streams and modify the buffer fullness at the splice point to prevent overflow or underflow.

SMPTE 312M Splice Point capable
SPMTE [1] have defined a standard way of pre-conditioning a stream to provide pre-marked in and out splice points at which a seamless splice may occur. These splice points are chosen to simplify the job of the splicer, but impose certain restrictions on the choice of in and out point for the splice.

ACKNOWLEDGEMENTS

The author would like to thank and acknowledge the help of his colleagues in Adherent in preparing this paper.

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