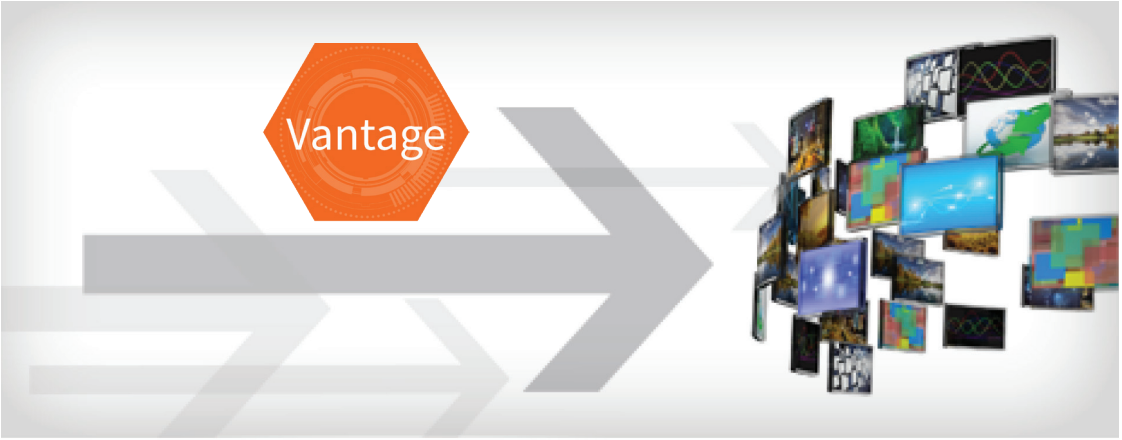

Understanding the Encoding and Monitoring requirements for IPTV and Cable Production and Distribution

"...cable and IPTV providers feel constant pressure to deliver more content at ever lower cost to retain and entice subscribers"

Introduction

Rapidly expanding market share in Cable and IPTV distribution brings both great opportunities and significant challenges. As strong consumer interest in IP-delivered video content drives revenues upward, powerful competitors are entering the IPTV services market, and Cable and IPTV providers feel constant pressure to deliver more content at ever lower cost to retain and entice subscribers. Automating and improving the quality of encoding while reducing required bandwidth have become essential elements in reducing costs to meet the competitive challenge.

IPTV and Cable distribution networks have one thing in common: the heavy use of MPEG-2 Transport Streams as the file wrapper (Transport streams are defined in Section 2.4 of ISO/IEC standard 13818-1). Where the two ecosystems differ is largely in the encoding of the essence itself (although IPTV may also have to accommodate the idea of adaptive bit rate encoding). This paper will look at the different requirements which encoders must satisfy in creating material for delivery via IPTV or Cable infrastructures.

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The Ubiquitous Transport Stream

During content preparation, video is typically encoded into an MPEG-2 Transport Stream file. Such a file is essentially a file-based capture of the stream that will be sent during transmission. These files may be provided to ad insertion servers, VOD servers, IPTV play out devices, or used as the delivery mechanism when providing content to distribution services.

With the ubiquity of IPTV and cable distribution worldwide, Transport Stream files have become one of the most common file formats in the world.

Despite their commonality, Transport Stream files remain one of the least understood and difficult file formats to work with. With multiple standards, legacy infrastructure requirements, and a wide array of configuration possibilities, encoding Transport Streams can be a challenge for even the most sophisticated video professional.

The following topics describe the current state of file-based Transport Stream encoding, outline some of the key considerations for IPTV and cable encoding and discuss some of the new technology around software-based encoding for Transport Streams. For Cable distribution, MPEG-2 is still the major codec for video encoding (and subsequent wrapping into an MPEG-TS), whereas the IPTV world, while still embracing MPEG-2 in many cases, also uses H.264 (AVC) as a codec. The advent of 4K media is having an impact here, though, as H.265 (HEVC) is becoming the de facto encoding scheme for delivering 4K material from head-end to consumer.

The Advantage of Software-based Encoding

When designing an IPTV or Cable production and distribution system, one of the first decisions that must be made is the choice of software-based encoding vs. hardware-based encoding. Until recently, the vast majority of Transport Stream files were created using linear hardware encoders. Such encoders capture a baseband HD or SD signal (either from a live feed or tape), and then convert that signal into compressed video and audio, creating the Transport Stream. When creating a file, this stream is then written directly to disk.

Hardware encoding has advantages, but with the increased power and stability of stock IT hardware, software-based encoding has come of age. Such software solutions typically run on servers and will generally offer file-based input support (unlike many linear hardware encoders). Particularly for content owners and multi-channel video programming distributors (MVPDs), where the source assets may already be file-based, software-based encoding offers several advantages:

Encoding Speed: Without the restriction of a linear input, software-based encoders offer faster-than-real-time encoding and can create finished outputs very quickly. In this regard, the introduction of high-quality GPU-based encoding technologies has caused software encoding technology to leapfrog its hardware-based linear counterpart.

Scalability: Software-based encoders can scale quickly on generic IT hardware, using Ethernet as their primary inputs and outputs, and without requiring significant capital expenditure on SDI routing or specialized hardware purchases.

Redundancy: With the flexibility of Ethernet and file-based inputs, N+1 redundancy can be achieved with software-based encoding in a more cost-effective manner. Where hardware encoding may require fully duplicated SDI backplanes and expensive N+N fully duplicated environments, software can flexibly "float" between generic IT servers and provide full redundancy with limited additional investment.

Automation: File-based processing offers significant opportunities for automation, replacing manual tape management and signal switching with automated software-based processes. "Hot folder" automation allows hundreds of jobs to be submitted in a single click, and integrated decision-making can intelligently switch between encoding profiles and settings based upon media properties - for example encoding SD and HD content differently based upon the input characteristics.

Extensibility: Software-based solutions tend to be modular, with options available to add new formats. For example, as IPTV providers use more adaptive bit rate (ABR) file formats, software solutions can be upgraded with few or no hardware changes.

One-in, Many-out: Software-based solutions often allow you to take in a single input and simultaneously create multiple outputs. Particularly for cable environments, where SD, 720p and 1080i versions of each asset are required, this capability reduces the number of encoders needed and can also reduce the amount of encoding time significantly by allowing parallel encoding.

Software encoders tend to be less expensive and more flexible than hardware encoders, without sacrificing quality. However, due to that very flexibility, software encoders also tend to offer more capabilities and settings, which can intimidate operators familiar with hardware encoders.

"...software encoders have achieved and in many cases surpassed the quality levels of their hardware counterparts, while additionally offering significant performance and cost benefits"

Switching from a "single-purpose" hardware encoder to a "multi-purpose" software encoder may require that operators become familiar with considerations that were previously hidden from them. These considerations include: (1) Video Quality; (2) Video Encoding, and (3) Multiplexing considerations.

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Video Quality Considerations

Virtually every form of video distribution involves some form of video compression. The classic challenge with video compression is to balance two competing interests: video transmission bit rate and video quality.

Reducing Video Bit Rate Is Paramount: Video compression bit rates can have a drastic effect on both operating costs and revenue. For IPTV providers using a Content Delivery Network (CDN), costs can range from $0.02 to $0.30 per hour of delivery, per viewer, depending upon whether a low or a high bit rate is used. For IPTV providers using their own fixed networks, lower bit rates can allow them to extend their reach, reductions in bit rates can allow them to offer services to thousands more customers. Finally, in situations where a fixed network is used to deliver multiple channels and services, each channel or service competes for bits, and lowering a video bit rate can allow additional services to be provided. In short, there are a variety of strong business reasons to lower video bit rate.

Video Quality Matters: The last few years have seen increased studies on the importance of video quality upon viewer experience and subscriber retention. A Conviva/Berkeley/Carnegie Mellon study suggests that quality of experience can drastically affect how long viewers will watch a video, which will in turn affect how many commercials they watch, and how loyal they will be as subscribers.

A similar study by Accenture found that frustrations with video quality and download streaming are of paramount concern to IPTV VOD viewers. As mentioned earlier, poor quality of service to the viewer often results in the viewer obtaining their media elsewhere – sometimes permanently abandoning a service – with a resultant loss in revenue for the initial provider.

Not all compressors are the same! An important note about video quality vs. bit rate is that different encoding technologies offer different levels of quality at different bit rates.

During the annual Moscow State University H.264 shoot-out, researchers compared H.264 encoding technologies from a variety of vendors. This study shows that using a high-quality H.264 encoder can cut the necessary bit rate by as much as half without reducing quality, simply by performing better compression. The winner in the MSU study for several years in a row, the open- source x264 codec, achieves extraordinary quality while using as little as half the bits of some of its competitors. There are a variety of technical reasons for this, but one includes the use of the "lookahead", which pre-analyzes frames to optimize bit utilization. Specifically, when encoding a frame, the lookahead analyzes as many as 60 seconds of material following the current frame to determine which parts of the current frame will be reused in the future.

By allocating bits to the most well-used sections, the lookahead increases the quality of those sections (which in turn increases overall quality) and reduces the number of bits required in total. Such techniques are not well suited for the low-latency encoding applications provided by linear encoders, but they are ideal for file-based offline encoding. In some situations where good video quality and good rate control are critical, the use of multi-pass encoding may be required; this is only possible in a file-based workflow.

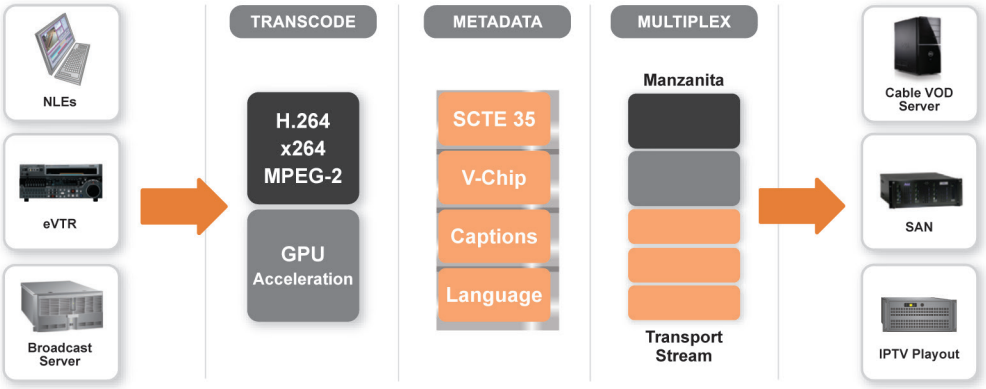

Figure 1: Encoding, Transcoding and Packaging for IPTV/Cable delivery

As indicated previously, the quality of video compression can drastically affect both cost and viewer experience. Over the last few years, software encoders have achieved and, in many cases, surpassed the quality levels of their hardware counterparts, while additionally offering significant performance and cost benefits.

Other Encoding Considerations

As previously noted, most distributors or MVPDs accept Transport Stream files as their standard file-based submission format for VOD, syndicated and commercial content. Upon receipt, these files will generally be run through an analyzer to check for compliance to standards. Some of the most important "non-video" parameters that must meet delivery standards are:

Buffering and Bit Rate: A common error when providing a file to a distributor is that the video or audio will not meet the necessary bit rate requirements. Typically, video bit rate should not vary drastically and must ensure fairly consistent encoding.

Those familiar with the concept of "constant bit rate" understand that even CBR encoding will fluctuate actual bit rates somewhat. When choosing a software-based encoder, it is important to ensure that true CBR encoding is available (to avoid buffer overruns or underflows) and that an HRD (Hypothetical Reference Decoder) is available if doing H.264 encoding.

Audio and Languages: It is also important to ensure that the ability to create properly formed PIDs for multiple languages, and the appropriate codecs for audio encoding are available. In particular, when choosing an encoder, media companies must ensure that the standard used by the distributor is supported. For example, the ATSC and DVB specifications on the presentation of Dolby AC 3 audio are very different.

Multiplexing and Timing: When configuring encoders for distribution, packet timing is a common reason for rejection. For example, analyzers will typically require that timestamps on audio and video packets do not vary too drastically from the program clock, or each other, and may also analyze for "clock jitter " (where the time indicated by a timing byte is too far away from the time that it arrives).

A point of distinction here is that when encoding for delivery of content to a Distributor/MVPD, the capabilities of the viewers' set-top boxes are of little consequence. This is not the case when encoding at an MVPD, where the capabilities of the viewers' set-top boxes must absolutely be considered.

Some of the additional considerations in this case are:

Video Codec Restrictions: Different set-top boxes and splicers may have limitations for what parts of a codec they can play back. For example, an H.264 set-top box may not support hierarchical B-frames or may not allow temporal B-frame prediction. These requirements vary from manufacturer to manufacturer and generally require that the encoder have the necessary settings to achieve the desired compression scheme.

Timing in Multiplexing: Timing accuracy is particularly important with set-top boxes. One common setting requirement is Program Clock Reference (PCR) spacing. Providing frequent PCR fields ensures that a set- top box maintains correct playback timing (for example, a PCR every 35ms may be required by a specific set-top box). However, each PCR occupies at least 6 bytes, which may introduce undesirable bandwidth utilization. An acceptable compromise between frequent PCR and bandwidth may be possible if the target set-top box supports a longer interval (for example, 90 ms).

Ad Insertion: The ability to insert SCTE-35 or DAI markers may be necessary for targeted ad insertion. In addition to creating the necessary packets in the Transport Stream, the video encoding itself should ensure group of pictures (GOP) or instantaneous decoder refresh (IDR) frame alignment with the insertion point. Failure to do so results in the well-known phenomenon where the ad which is to be replaced starts to actually play before being abruptly cut-off by the start of the new material. A second issue then presents as the new ad content is abruptly terminated because it started to play too late in the slot.

Metadata Preservation and Insertion: The ability to preserve and insert V-Chip and copy protection metadata is essential for this last mile of the supply chain. For ad media, the ability to preserve eTV (interactive television) PIDs may also be required.

Assuring Compliance

As mentioned above, most MSOs/MVPDs have a strict set of criteria which the delivered file must adhere to as part of their SLA with the program provider. If a file fails to meet any one of these criteria, the file will be rejected, forcing the originator to re-encode the material. This is a very costly activity, both in terms of the physical cost of the re-encoding, but also in the delay to gaining revenue from the media. Clearly, it is incumbent on any company originating material for delivery to an MSO or MVPD to validate that the program does, in fact, comply to the technical requirements of the client. The question becomes "where and when should technical compliance be confirmed?". The short answer is "as frequently as possible". In truth, any transformative process in the workflow – such as color space conversion, up/down conversion, letterboxing/pillarboxing, application or removal of 3:2 pulldown and encoding – is a potential source of non-compliant material.

For most manual operations, this puts an unsustainable strain on the workflow, as operators must constantly transfer material from each stage of the workflow to the video QC station for compliance testing. Fortunately, in an automated workflow processing engine such as Telestream's Vantage, these QC steps can be built-in to the workflow, and material can automatically be checked for compliance against a checklist of parameters, with little-to-no impact on the workflow throughput. A further step in compliance testing should be performed at the input and output of the Transport Stream encoder, so that the quality of the product as it is to be delivered to the MSO/MVPD can be confirmed. At the output of the encoder stage, the final Transport Stream file can be checked for both video quality and Transport Stream syntax using software such as Telestream's iQ Inspector product line, which is designed for that exact purpose.

Summary

In order to maximize revenue, IPTV/Cable providers must constantly evaluate and update the transcoding/encoding/packaging systems they use to groom MPEG Transport Streams – the ubiquitous packaging technology for this form of media delivery. Therefore, the encoders used must be able to not only produce excellent quality video, but also offer flexibility, allowing for update to newer encoding technology whilst still preserving and/or inserting metadata essential to their business requirements (which in and of themselves are likely to change over time). Encoding and packaging media into the TS is only part of the solution, however – Just as important is the ability to examine the encoded material to ensure it complies with the service provider's technical criteria. This monitoring should take place at multiple locations within the connectivity network, in order to facilitate issue resolution in as timely a manner as possible

Telestream leads the video industry with Vantage, a complete family of world-class video transcoding and workflow products, automated video QC applications and iQ solutions quality assurance products. Vantage offers the most powerful transcoding engine on the market, including an extensive list of encoders and an extremely sophisticated and extensive set of automation features to make transcoding effortless. Among its encoders, Vantage Transcode IPTV VOD includes x264 H.264 coupled with integrated Manzanita mulitplexing to allow detailed control of the encoder and metadata insertion into the transport stream. Telestream's range of automated QC products offer best-in-class capabilities for in-house quality control, and iQ solutions to ensure that your viewers are seeing your content with the quality you intended, and that the companies you are paying to store, prepare, deliver, and play your content are consistently providing the service you expect.

For More Information

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