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New Compression Technologies for Contribution Networks

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Video distribution networks have with the introduction of MPEG-4 AVC been able to halve the required transmission bandwidth enabling the introduction of high definition programming. Contribution networks have been lagging behind in terms of deployable solutions but two compression formats are now ready to battle it out to replace the 15-year old MPEG-2 compression format. This paper will look at what progress broadcasters can expect from these new compression technologies.

Contents

Introduction

For some time, broadcasters have used telco networks to create contribution links to move video and audio content between locations. While more traditional telco networks can carry large amounts of data at competitive rates, they may physically lack the reach of satellite-based systems.

Now, with the growing availability of IP/MPLS (multi-protocol label switching) access points and the ever-increasing demand for quality high-definition content, broadcasters are rethinking their compression strategies. The 2010 FIFA World Cup in South Africa will be the first major sporting event produced in 3D. As 3D grows in importance, large broadcasters will look at creating live contribution links to support the bandwidth of 3D HD for sporting events. These changing requirements are driving the evolution of entirely new contribution workflows.

This paper will cover the latest advances in video compression technologies and how emerging compression formats such as JPEG 2000 and MPEG-4 AVC deliver reduced bandwidth or increased picture quality—and 3D—when compared to MPEG-2.

What Defines Contribution Quality?

Contribution quality is often considered the equivalent of uncompressed or very mildly compressed source material. The video is capable of being edited without taking into account the origination source. Traditionally, MPEG-2 codecs have operated at full frame rate, and a 4:2:2 sampling rate is usually maintained. Compression bit rates have normally been kept a bit over 8 Mb/s for standard-definition video while HD codecs operate close to 50 Mb/s. As we move toward an all-HD contribution network, we've begun to see a number of limitations to the current MPEG-2 approach:

- HD satellite contribution links are costly
- Picture quality is compromised due to limited bit rates
- Acquisition and contribution quality are not identical
- There is little or no support for 1080p 50/60 or 3D formats

HD video represents the biggest compression challenge for contribution applications and is driving many of the technology changes we see today. Figure 1 illustrates the compression squeeze required by MPEG-2 codecs to allow HD broadcast content to be transmitted from camera to the home (or ultimate viewer).

Broadcasters are keen to further improve the compression ratio by offering HD at bit rates as low as 4 Mb/s. This bit rate represents a significant challenge to codec manufacturers who must balance this desire to operate at low bit rates with the need to maintain picture quality. As the bit rate is driven down in the final distribution encoder (to a full 100:1), it is paramount to ensure the picture quality is maintained as high as possible into this encoder. This can be done in two ways:

- Increase the contribution compression performance within the given bandwidth
- Increase the contribution compression bit rate

While the two points above may seem obvious, legacy MPEG-2 codecs and networks have lacked the capability to provide the necessary compression for contribution applications. Video bit rates have, in general, been limited to below 100 Mb/s while the chroma resolution has been limited to 8-bit 4:2:2.

For SD, the situation is slightly different for a number of reasons. Figure 2 shows a comparison between the compression ratios for HD and SD for various applications. The figure illustrates the reduced compression ratio required for SD (merely 10:1) and hence reduced 'pressure' on the encoder. Further, the bandwidth constraint is greatly eased and is rarely squeezed further for cost purposes.

The examples above help demonstrate why HD is driving the adoption of new compression technologies with the introduction of H.264 and JPEG 2000.

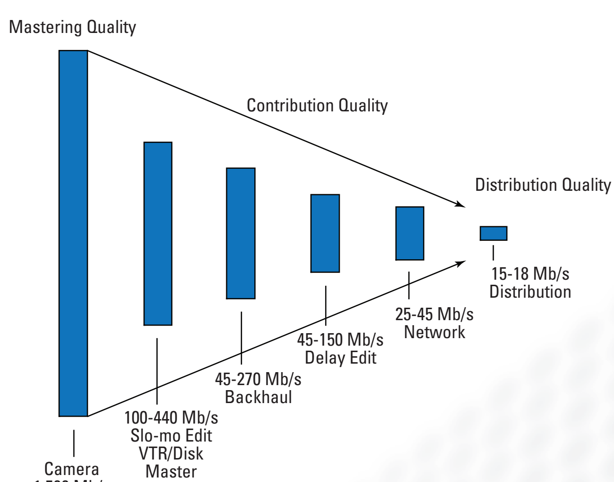


Figure 1. HD content from camera to viewer, 100:1 compression.

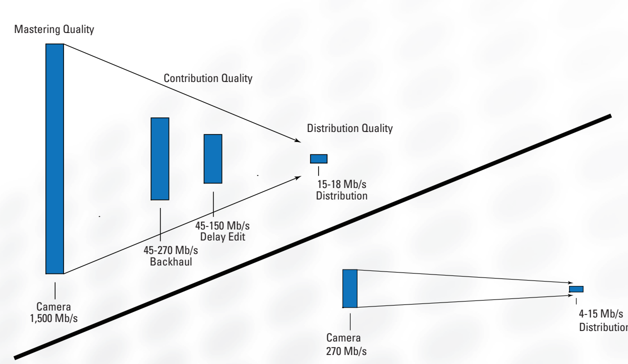


Figure 2. SD content, a milder 10:1 compression versus HD's 100:1.

New Compression Formats for New Video Networks

Video networks are changing. These changes are driven, in large part, by a handful of factors. The first is the need to transport HD content. This requirement could lead to a potential 6-fold increase in bandwidth for 720p/1080i and a 13-fold increase for 1080p50/60 when compared to SD video. The second factor or trend is the increased pressure from consumers to fill their new 40 or 50-inch LCD/plasma screen with crisp, detailed pictures. Third, new technologies such as 3D are becoming increasingly important as a differentiator for premium broadcasters looking to offer services above and beyond HD.

To meet these demands, broadcasters may wish to look at the complete broadcast chain to optimize the picture at every stage of processing. There is help in the move toward fiber-based contribution and distribution links. This trend lays the foundation for high bit-rate video content to be transported in a cost-effective way.

These trends have led equipment vendors to reassess the situation and build a new set of products to meet these new needs. When compared to the current, widely-used MPEG-2 compression format, there are two directions addressed and covered in this paper:

- Reduced bit rate operation using MPEG-4 AVC [1]
- Increased picture quality using JPEG 2000 [1]

High Definition – The Quality Challenge

Delivering high-quality HD content throughout a modern live broadcast workflow is still a challenge and not limited only to the final direct-to-home (DTH) encoder's performance. Much debate and attention has been given to the required bit rate for these encoders, while limited discussions have taken place around the complete chain. It is a well known fact that every time an encode-decode stage (or concatenation) takes place, a drop in quality is also seen. It is not uncommon for six concatenation cycles to occur from the time video is acquired at a sports stadium to its delivery to the home, each causing quality to diminish. In addition, some editing and playout servers are limited in HD resolution to 1440x1080 as compared to full raster 1920x1080.

Another challenge is the quality difference between a simulcast SD program and its HD original, which is expected to be significant by the end user. With the upgrade to HD infrastructure, has the SD channel seen a similarly significant quality increase? This, coupled with the fact that the HD channel is often 'driven' harder (lower bit rate than 6X the SD bit rate), can in many cases limit the perceived quality difference between the two channels.

1080p50/60 – A New Production Format

Before getting into the details of these new compression developments, we want to look at 1080p50/60 which could be the next production format of choice for broadcasters. If this change takes place, it will greatly influence how contribution equipment is designed over the next few years. 1080p50/60 now represents the pinnacle of high-definition performance in the eyes of viewers eager to see Blu-ray-like performance replicated in live HD transmissions.

It is believed that next-generation broadcast systems will start and end with progressive-based equipment. Interlace was introduced into broadcast networks simply as a means to overcome the high scanning frequencies for television. Therefore, there are good reasons to move towards progressive distribution:

- Provide an improvement in picture quality, particularly for sports
- Avoid interlaced to progressive display conversion, which introduces artifacts
- Offer an improvement in mixed live action and graphics scenes (common in sports)
- Take advantage of availability of progressive displays, which are dominant in existing (and likely to be in future playout platforms)
- Will simplify production and distribution systems by using a common format
- Easy path to upgrade to 3 Gb/s interfaces and infrastructure

If further proof is required, we can examine the trend of today's HD sports being broadcast in 720p50/60 format rather than the higher resolution 1080i25/30 format. In the U.S., where HD deployment has made the greatest inroads, 720p60 has become the most common production format among sports broadcasters. ABC, FOX, and ESPN have all chosen the 720p60 format, where some claim it delivers a smoother image for sport's fast action as there are no interlace fields within a frame to produce temporal delay.

The trouble, then, for broadcasters is that the conditions may not be adequate for this shift to take place. Content, technical legacy and profitable service provisioning are significant issues to consider when implementing the next-generation HD 1080p50/60 format. This paper will not discuss the introduction of 1080p in further detail but will purely state that the momentum behind this standard is enough for it to merit serious consideration when planning new video networks. Further, it appears that 1080p50/60 offers a future-proof infrastructure to 3D—an issue that will be covered in the next section.

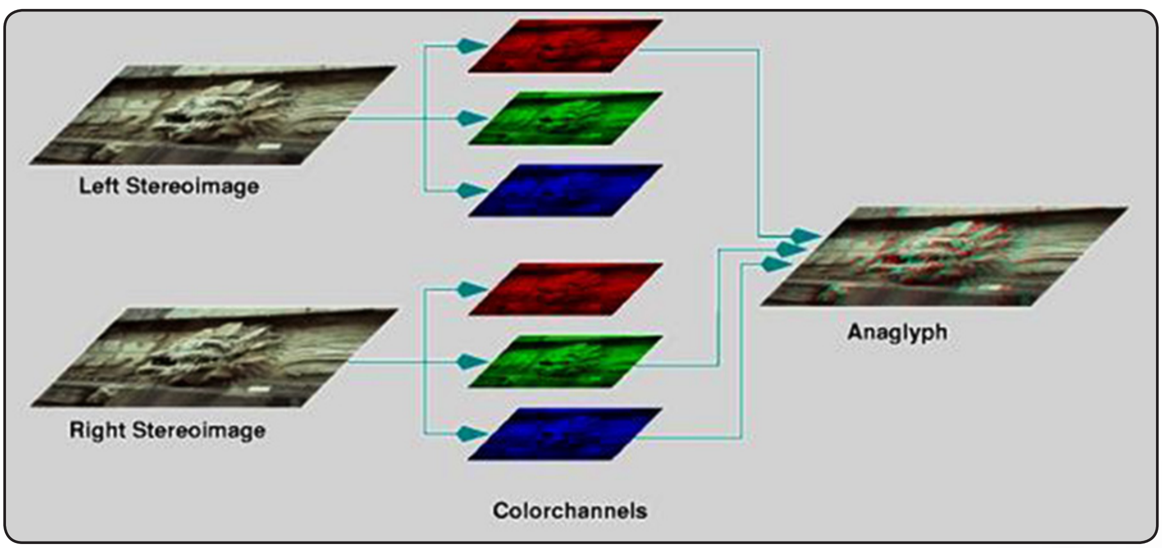
New Compression Formats for New Video Networks (cont.)

3D – A New Viewing Experience

Following the successful introduction of HDTV, the home entertainment industry is contemplating its next move in the home viewing 'experience.' Looking at the recent moves in the film industry that is increasing its 3D output paving the way to a home version of same, will a true 3D viewing experience carry over into consumers' living rooms? Like tablet computers, 3D for the home has appeared and drifted away several times in the past. Nevertheless, flat display technology has made quick yet steady progress in home penetration and is now more or less well-established with large screens, ready for 3D stereography. At this stage success in movie theaters appears to benefit from the 'wow' factor. Among broadcasters, early adopters have begun their own 3D trials, and 2010 looks to be the year for permanent 3D channels.

There are several emerging standards for delivering 3D images to the end consumer. The aim is to maintain as much of the existing infrastructure as possible, leading to a compromise in resolution to make the full image fit into an existing 1080i channel. For contribution applications, this compromise in resolution is, however, not acceptable. Even as a sporting event is shot in 3D, the content must also be made available in 2D HD at full-resolution. The left and right stereo image is handled as two separate HD channels where one of the channels is used as the 2D version.

For a contribution infrastructure, we have a choice of either a single 3G-SDI workflow or a dual HD-SDI workflow. Both are possible, but as the timing between the left and right stereo image is critical to the 3D viewing experience, a single 3G-SDI infrastructure is preferable. Grass Valley™ supports both formats with its new ViBE VA5004 JPEG 2000 contribution codec, while the ViBE EM3000 Premium Distribution encoder is already being used for direct–to-home broadcast of 3D content.



Bit Rate Reduction Using MPEG-4 AVC

For many reasons, MPEG-2 compression was a tough act to follow, and as described previously in this paper, is still very much an evolving standard. For contribution applications, MPEG-2 video has been the format of choice for the last 10 years and products are available with features such as low latency end-to-end delay and 4:2:2 chroma sampling for increased fidelity. As with MPEG-2 video, profiles have been developed within MPEG-4 AVC that cater to the needs of professional users. These Professional Profiles include a number of contribution-specific profiles:

- High 10 Profile, up to 10-bit video/4:2:0 chroma sampling
- High 4:2:2 Profile, up to 10-bit video/4:2:2 chroma sampling
- High 4:4:4 Predictive Profile, up to 14-bit video/4:4:4 chroma sampling

In addition to the above features, advanced 8x8 transform and scaling matrices are covered by the High Profile (up to 8-bit video/4:2:0 chroma sampling) that can potentially offer significant picture quality improvements in the range of 15% over the Main Profile.

What Does MPEG-4 AVC Offer Over MPEG-2 Video?

MPEG-4 AVC builds on the MPEG-2 video standard, but still uses many of the fundamental building blocks behind the original standard. These are:

- Slice and macroblock-based processing of luminance and chrominance pixels
- Discrete Cosine Transform to remove spatial picture redundancy
- Motion Estimation prediction to remove temporal sequence redundancy
- Transform, Quantization and Entropy coding to remove further spatio-temporal redundancy between the original and predicted macroblocks

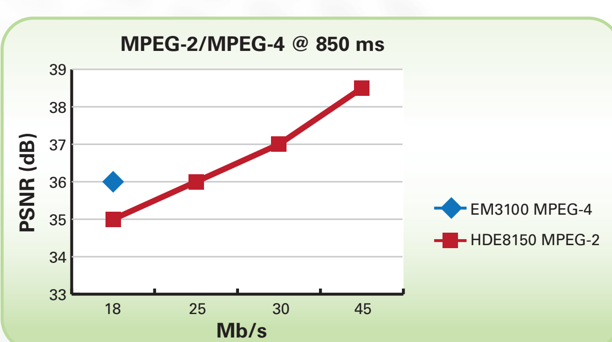
What does MPEG-4 AVC offer over MPEG-2 Video?

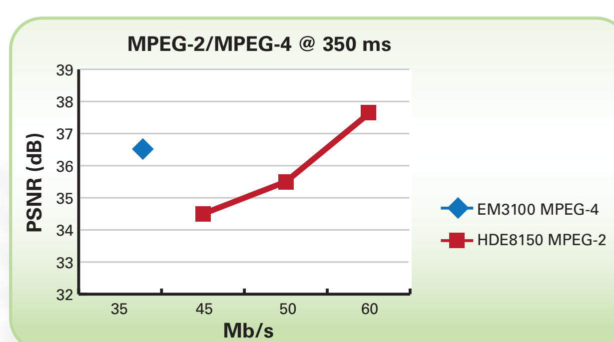
- Picture and Macroblock-Adaptive Field/Frame coding allows coding decisions to be made in either field or frame mode at a picture or macroblock level
- A wide range of intra- and inter-prediction modes for block sizes ranging from 16x16 down to 4x4 pixels. By varying the block size used in motion compensation, broadcasters aim to increase the possibility and accuracy of a match between reference and motion-compensated predicted blocks
- Allowing motion compensation to be performed at one-quarter sample precision and the ability to use motion vectors from outside of the picture area
- More efficient entropy encoding strategies in the form of Context-Based Adaptive Binary Arithmetic Coding (CABAC) and Context-Adaptive Variable Length Coding (CAVLC)

As we can see, the MPEG-4 AVC standard has a set of well-defined tools to cover contribution applications. Manufacturers of encoders and decoders have, however, been fairly slow to bring out equipment that takes advantage of these new standards. Only in the last year have we seen MPEG-4 AVC codecs like the Grass Valley ViBE EM3100 offering picture quality equal to existing MPEG-2 encoders. These codecs offer 4:2:2 profile but are limited to 8-bit resolution, as in the case of MPEG-2 video. These codecs have successfully enabled a significant bit rate reduction over legacy codecs with similar if not equal quality. Bandwidth savings of approximately 40% on a high-definition link can be achieved. The obvious benefit of this is that HD content can be moved around much more easily and at a greatly reduced cost.

In the diagram below, we have compared a best-in-class MPEG-2 video contribution encoder to the new ViBE EM3100 encoder. The results indicate that MPEG-4 AVC provides a significant reduction of up to 40% as the bit rate is reduced. At high bit rates, the gain of moving to MPEG-4 AVC is more marginal. Both progressive and interlaced (720p and 1080i) show similar results. If we take one example of a contribution link currently running at 50 Mb/s using low latency and 4:2:2 sampling, it is possible to reduce this to 30 Mb/s by moving to MPEG-4 AVC with similar latency and 4:2:2 sampling.

Below is another comparison between MPEG-4 AVC and MPEG-2 HD video, with both encoders running in 4:2:2 mode. The transport stream was set at 20 Mb/s and 40 Mb/s, resulting in a video bit rate of 18 Mb/s and 35 Mb/s. The intent of this comparison was to demonstrate the crossover point between the two compression formats. The MPEG-4 AVC bit rate was kept constant to show when the MPEG-2 video would yield equal quality. The results below represent an average value of 14 sequences and included both 1080i and 720p content.





Bit Rate Reduction Using MPEG-4 AVC (cont.)

PSNR is a measure of quality of reconstruction of lossy compression. In this case, the signal is the original data, and the noise is the error introduced by compression. When comparing compression codecs, PSNR is used as an approximation of human perception of reconstruction quality. Therefore, in some cases, one reconstruction may appear to be closer to the original than another, even though it has a lower PSNR. However, a higher PSNR would normally indicate that the reconstruction is of higher quality [3].

As seen in the graphs, MPEG-4 AVC compression performs particularly well at very low latency, yielding close to a 40% reduction in bit rate. At 850 ms, the difference was less yet still offered just over 30% bit rate reduction compared to MPEG-2 compression.

How Latency Influences Picture Quality

Latency, the end-to-end delay introduced by the encoding and decoding process, is of prime importance for contribution links. Live interviews for newsgathering are a good example where latency should be less than 500 ms to maintain a free-flowing conversation. As for MPEG-2 video, it is our experience that latency and required bit rate are also strongly linked for MPEG-4 AVC. As you reduce latency, you also limit the number of compression toolsets that can be used. The first example is to go down to single-pass compression and limit the look-ahead the encoder uses. These limitations have a clear impact on compression performance and the bit rate must be increased to reach the same perceived quality.

The table below shows the average PSNR value across 12 sequences covering both 720p and 1080i content. The content was compressed using the ViBE EM3100 encoder operating in MPEG-4 AVC mode with 4:2:2 chroma sampling. The comparison illustrates the impact of reducing the latency from 850 ms to 350 ms where the bit rate must be doubled to compensate for the reduced latency.

Bit rate	850 ms	350 ms
18 Mb/s	36.6 dB	
35 Mb/s		36.0 dB

Limited Bandwidth Transmission Links

The key advantage of using MPEG-4 AVC compression is the ability to deliver high-quality video at reduced bit rates compared to MPEG-2 video. Broadcasters who were early adopters of MPEG-4 AVC for contribution have used this format for transferring video over contribution links with severe bandwidth restrictions. Just as video applying 4:2:2 sampling sends more color information, it also puts the compression engine under greater constraints as the bit rate is reduced. There is a point at which 4:2:0 will deliver improved picture quality compared to 4:2:2. This is commonly known as the “Knee Point” of 4:2:2. Depending on the latency and the efficiency of the encoder in use, this same inflection point for MPEG-4 AVC can range from 20 Mb/s to 25 Mb/s. For contribution links with bandwidth constraints, 4:2:0 will be the most commonly used format running under 20 Mb/s. The MPEG-4 AVC standard has the capability to deliver broadcast quality at these bit rates.

Increased Picture Quality Using JPEG 2000

Established as an international standard in January 2001, JPEG 2000 is starting to prove its usefulness as a compression format for high bit rate applications. Its lack of early success or acceptance can be attributed to the lack of standardization methods for carrying JPEG 2000-encoded pictures over a transmission link. However, this is now being addressed and the expectation is that carriage will soon become an international standard.

JPEG 2000 is actually a family of standards. Among these standards, JPEG 2000 Part 1 [2] defines lossy and lossless compression methods for color digital still images. It is used in digital cinema as the video compression engine. In this case of digital cinema, the video is considered successive images which are each coded individually. At the core of the JPEG 2000 encoding engine, a Discrete Wavelet Transform (DWT) is applied to each color component of the picture. Successive DWTs are applied on the quarter-sized low frequency picture. Each successive DWT improves the compression efficiency and adds a spatial scalability feature. The transformed picture is then encoded on a block-by-block basis. Each coefficient is uniformly quantified and weighted for the Rate Distortion Optimization function. Each bit-plane is encoded in several consecutive steps by the EBCOT (Embedded Block Coding with Optimal Truncation) entropic coder, where neighboring bits within the block are considered. The elementary packets are then arbitrarily ordered to generate the final code stream. JPEG 2000 is an intra-only compression method. Intra frame encoding allows for low-complexity encoders to be used since it does not require motion estimation. However, the lack of inter prediction (P and B frames) strongly limits compression ratios that can be achieved.

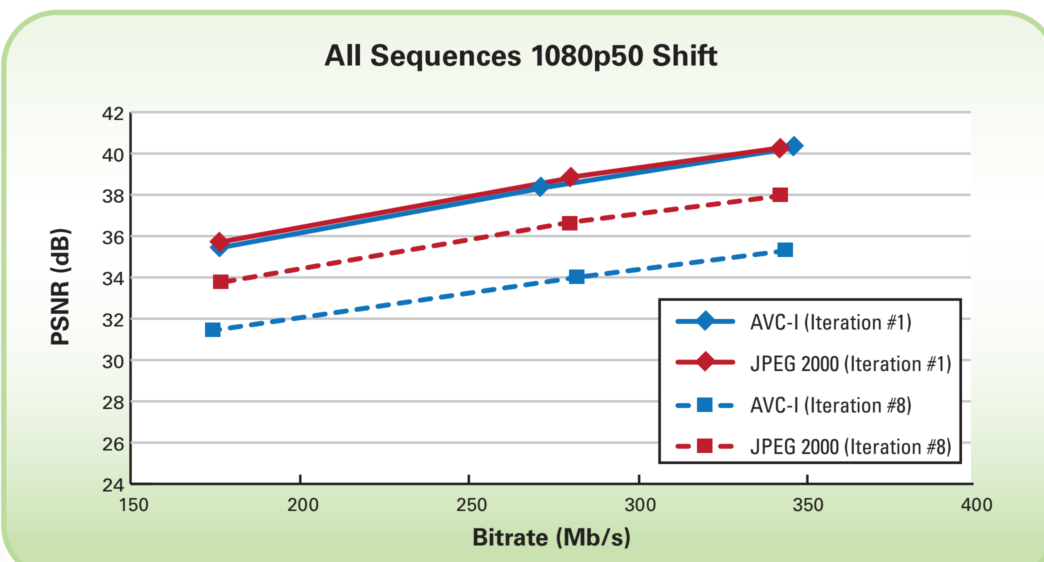
Comparing MPEG-4 AVC and JPEG 2000

Grass Valley carried out an investigation comparing different compression standards for high bit rate applications. The study found that the two best compression formats for these applications are AVC-Intra (AVC-I) and JPEG 2000.

The investigation uncovered that on a purely intra-frame basis, the two compression formats were quite comparable across a range of sequences. The primary difference is in the handling of compression iterations, or concatenations, where JPEG 2000 delivers better results.

Managed Networks

Next-generation video networks are not all about compression. In fact, we have seen some video transmitted uncompressed. This has primarily been the case for SD content where bandwidth is more manageable. As video networks move toward an IP-based transport layer for increased routing capabilities, these same IP networks need to be managed to meet the demand for content flexibility. Content has been changing. It could be live or pre-recorded. Likewise, it could be assets in the form of advertising or video-on-demand. Common for these managed networks is that they demand more from the control and management system. Simple equipment configuration and alarm monitoring are not enough. New features such as link scheduling with bandwidth management are needed. These will allow operators to maximize their revenue through increased network utilization and to address ad-hoc events such as newsgathering.



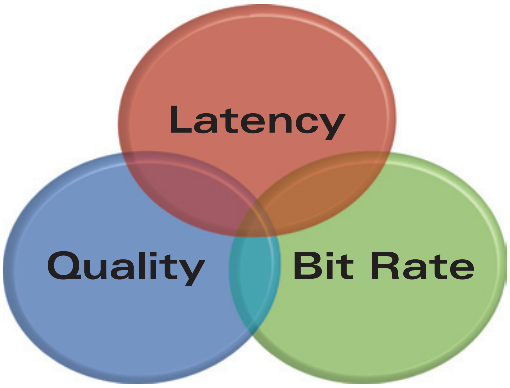
The HD Compression Choice

When looking at their contribution networks, broadcasters are faced with technology choices. Not only do we see a shift from satellite-based contribution networks toward more fiber-based networks, we also have a choice in compression formats. These formats are:

- JPEG 2000
- AVC
- AVC Long GOP

Each format has characteristics and cost points that make them suitable for different applications. It is important to notice that these differences are driven by implementation limitations rather than shortfalls in the standards themselves. An example of the limited performance difference between JPEG 2000 and AVC-I is illustrated in the previous section. JPEG 2000 codecs have, however, been in the market for a couple of years while an AVC-I solution is not expected until 2011.

To make compression choices more representative of real-life applications, this paper splits the requirement into three areas. The choice of compression standard is normally a compromise between the following key components:



Latency

In a digital workflow, latency is never desirable but not necessarily as critical as it can be for some contribution links. For the most part, this applies to live two-way interviews where excessive latency will lead to a breakdown in the flow of the conversation. In general, an end-to-end latency of more than 1 second is not acceptable. This will produce a compression latency of 500 ms and a network latency of the same value.

With latency there is a tradeoff with compression. When latency is reduced, two of the first features to be lost are long look-ahead and dual-pass compression. This “loss” makes the encoder more vulnerable during scene changes or can cause rapid alteration in picture complexity. As latency is reduced, a compromise must be found between quality and bit rate.

In general, JPEG 2000 and AVC-I/short GOP have about 50 ms of end-to-end latency, and this is the primary feature driving bit rates higher for these formats. JPEG 2000 is limited to intra-frame only while AVC can take advantage of GOP structures to achieve a more flexible latency and bit rate compromise (or choice). In current encoder implementations, a GOP structure of “IPIPIP” or “IBPIBP” is normally selected. This leads to a latency of about 500 ms.

Quality

Contribution picture quality can be broken down into visual quality and objective quality. Due to the average high bit rates used for contribution links, the visual quality is normally only compromised for live news interviews where latency is more important and the content has little value after being aired for the first time. For this reason, most news contribution feeds use 4:2:0 sampling mode.

Objective quality is typically more important in contribution. With MPEG-2, only 4:2:2 chroma sampling was offered above what was broadcast to the home. With MPEG-4, the standard is now offering 10-, 12-, and 14-bit pixel resolution and 1080p50/60 picture format alongside 4:2:2 chroma sampling. JPEG 2000 also offers this enhancement over MPEG-2. This enhanced picture information will require a greater bit rate to have any effect on the picture quality.

The HD Compression Choice (cont.)

Bit Rate

The contribution bit rate is often overlooked when discussing high quality video links. In stark contrast to DTH encoders where the challenge is the ability to turn down the bit rate, MPEG-based contribution encoders have the opposite problem. As the bit rate goes up, an encoder will need increased processing power to be able to run many of compression features like CABAC at bit rates above 50 Mb/s. Above a certain bit rate, this offers little quality gain—depending on the specific implementation. JPEG 2000 does not suffer from this problem however this is primarily due to the more balanced processing need between the encoder and decoder. A JPEG 2000 encoder has a more straightforward compression engine compared to MPEG-4 while the decoding side is more complex and requires more processing power.

How to Choose the Right Technology

In terms of compression formats, broadcasters have more choice. These new formats clearly offer significant benefits over the existing MPEG-2 format when moving to HD. The table below is a summary of the feature sets discussed above:

High Quality, Low Latency but High Bit Rate

With the ability to handle up to 500 Mb/s of video with both 4:2:2 and 10-bit resolution, JPEG 2000 is an ideal compression standard for new telco-based contribution links. Add to these attributes good latency performance, and JPEG 2000 makes a very good solution for high-bandwidth links. Note, however, the JPEG 2000 standard is not suitable for use at bit rates below 100 Mb/s. For these types of systems, Grass Valley offers the ViBE VA5004 Video Adaptor.

Good Quality, Low Latency with Limited Bit Rate

Following wide deployment in DTH applications, AVC is beginning to make its way into the contribution arena. Grass Valley launched the first 4:2:2 encoder and today, the format is gaining worldwide momentum. AVC encoders have been utilized mainly for applications with limited bandwidth. With up to 40% greater bit rate utilization than MPEG-2, satellite broadcasters have been the primary users of MPEG-4 AVC encoders. The Grass Valley ViBE EM3100 codec is ideal for these types of contribution links.

Good Quality, Long Latency with Low Bit Rate

When the bit rate becomes the most important feature of the transmission, it is common to move to a dual-pass compression system and reduce the sampling to 4:2:0. An encoder such as the Grass Valley ViBE EM3000 is capable of delivering high quality video at bit rates up to 50 Mb/s and is ideal for contribution links where 4:2:0 chroma sampling is sufficient.

JPEG 2000	AVC	AVC LONG GOP
• +120 Mb/s • 1080p50/60 • 10-bit support • 4:2:2 support • Intra-frame only • Latency: <100 ms	• 20-120 Mb/s • 1080p50/60 • 8/10-bit support • 4:2:2 support • Intra-frame or IP/IBP GOP • Latency: 350-750 ms	• 1080i/720p • 8-bit support • 4:2:0 support • Latency: +500 ms

Grass Valley Contribution Solution

Grass Valley is a leader in delivering solutions enabling the high-quality transmission of broadcast content over telecom networks. With a wide range of products covering the most common networks, Grass Valley is a leader in this market.

Comprehensive Codec Range

The Grass Valley ViBE video compression product family offers state-of-the-art encoding and decoding capability. The ViBE encoder products deliver a wide video compression range from ultra-low bit rates to industry-leading low latency. Premium video quality is ensured by a high-performance, Grass Valley-designed compression engine. With the introduction of bandwidth-intensive HD, video compression is moving to MPEG-4 and JPEG 2000 to enable high-quality distribution within available bandwidths. Our ViBE range provides compression in MPEG-2, JPEG 2000 and MPEG-4, in HD and SD formats. With integrated ASI and IP transport interfaces and the option for PDH network integration, ViBE encoders can either feed the telco network directly or through a network adapter. The ViBE decoder range complements the encoder range with a flexible architecture. The ViBE decoders can be integrated in the ViBE telco chassis alongside encoders for a flexible configuration, or configured as standalone IRDs. The ViBE compression family is designed for reliable transmission and supports forward error correction (FEC) over both IP and PDH networks.

Flexible Network Adapters

For content processing, the Grass Valley NetProcessor is a compact solution offering high ASI density with up to 700 Mb/s throughput data rate, allowing smooth migration from legacy networks to IP. The NetProcessor offers high reliability—including redundancy for interfaces and power supplies and enhanced monitoring of both service and component bit rates. The units can deliver superior capabilities for Single Frequency Network-adapted streams for digital terrestrial networks. With advanced IP streaming, full professional MPEG FEC support, and data transfer capabilities, the NetProcessor offers unrivalled capabilities.

Telco Management System

The Grass Valley XMS™ eXtensible Management System offers full QOS control with a dedicated telecom transmission add-on for phonebook-style link creation. Controlling both Grass Valley and third-party equipment, the XMS system offers full topology visibility and redundancy control of the entire network. The Grass Valley Granite QOS probes can be used to monitor and collect the streams running on the network—offering both equipment and stream redundancy switching.

Conclusion

The development of compression standards is moving in several directions, all suitable for next-generation video networks. As far as replacing MPEG-2 video as a contribution format, broadcasters have the choice of either reducing the bit rate by adopting MPEG-4 AVC or improving (increasing) video quality by implementing JPEG 2000. Note that this is due to current codec implementation limitations rather than limitations in the compression standards themselves.

While both formats are still in their infancy, they are maturing to the point of being commonly available. Tests have demonstrated that MPEG-4 AVC can provide the same picture quality and latency as MPEG-2 video using greatly reduced bandwidth. In some cases, the use of MPEG-4 AVC can save up to 40% in transmission costs. The JPEG 2000 standard, on the other hand, has established itself in the higher bit rate 'category' as it typically requires in excess of 100 Mb/s bit rates to yield quality images.

Using JPEG 2000 can result in reduced hardware costs and it offers two important benefits. JPEG 2000 has the capability to carry 10-bit, 4:2:2 video with less than 100 ms latency and it is also particularly good at handling encoding concatenations with minimal loss of picture quality after the first compression stage.

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[1] *Advanced Video Coding for Generic Audiovisual Services*, ITU-T Rec. H.264 and ISO/IEC 14496-10 (MPEG-4 AVC), ITU-T and ISO/IEC JTC 1, Version 1: May 2003, Version 2: May 2004, Version 3: Mar. 2005, Version 4: Sept. 2005, Version 5 and Version 6: June 2006, Version 7: Apr. 2007, Version 8 (including SVC extension): Consented in July 2007, Version 9: March 2009 (including MVC extension).

[2] *JPEG 2000 Core coding system*, ITU-T Rec. T.800 (2002)/Cor.2 (08/2007) | ISO/IEC 15444-1:2004/Cor.2:2008, ITU-T and ISO/IEC JTC 1, Technical Corrigendum 2: April 2008

[3] *Wikipedia*, http://en.wikipedia.org/wiki/PSNR

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