ADVANCED VIDEO CODING FURTHERS HD SERVICES

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Abstract

The use of Advanced Video Coding to enable bandwidth efficient HDTV Video on Demand and broadcast television is gaining in popularity as technological advancements in MPEG-2 compression continue to slow. While MPEG-2 has been the undisputed leader in video compression for the past decade, algorithms such as Windows Media 9 Video and MPEG-4 Part 10 are emerging at a time when consumers are requiring more broadcast channels and VOD services in HD.

As the subscriber volume grows, using MPEG-2 compression for HD will result in bandwidth bottlenecks in the networks. To solve this problem, increasingly efficient compression algorithms will be required to satisfy this consumer demand. Algorithms such as WM9V and MPEG-4 Part 10 have the potential to outperform MPEG-2 by up to 50%, meaning that a 50% data reduction to deliver the same quality picture is possible — taking full advantage of network bandwidth and increasing revenue generation possibilities. This paper will discuss advanced video coding techniques and how they apply to HD to enable bandwidth efficient deployment of HDTV for both broadcast television and VOD.

EVOLUTION OF MPEG-2 BIT RATES

The MPEG-2 standard [1] reached commercial deployability in 1994 and has since been widely adopted for standard definition television (SDTV) broadcast and on-demand services, becoming the defacto professional broadcast digital video compression standard. Since 1994 advances in technology, systems design, implementation efficiency and video pre-processing techniques have reduced the bit rate required to digitize an acceptable broadcast quality picture into the home. Figure 1 shows this bit rate reduction over time for MPEG-2.

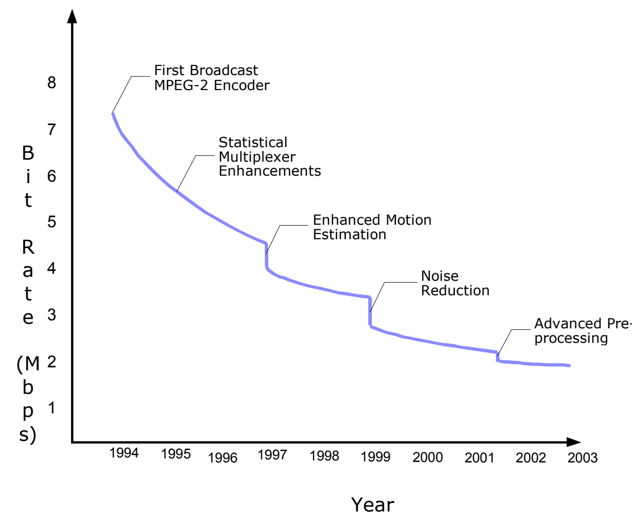

Figure 1 – MPEG-2 bit rate for standard definition broadcast quality picture over time.

A high definition television (HDTV) video picture has 4-6 times more information to be processed than a standard definition picture (horizontal resolution x vertical resolution x frames per second), as the bit rate for a standard definition picture reached the 3-4Mbps (Megabits per second) range in 1998 then it became feasible to deploy HDTV digital video services within the bit rates available on terrestrial, cable and satellite transmission platforms.

We can see from the curve of Figure 1 that each new technique and technology leap has returned less of a bit rate efficiency improvement as we approach the fundamental limits of performance of the MPEG-2 compression algorithm. With continuing development we are likely to only achieve a further 10% MPEG-2 efficiency improvement at a commercially viable cost. This places a limit on the potential bit rate of MPEG-2 based standard and high definition services in the future to achieve an acceptable broadcast picture - in the order of ~1.75-2.0Mbps for SDTV and ~8-10Mbps for HDTV.

Competition from satellite platforms, who are launching 30-40 channel HDTV services, in addition to increasing demands from the customer, for example HDTV Video-On-Demand (VOD) content, place continuing pressures on cable broadcasters. The bandwidth available to the home is limited on any system, including cable, and while "all digital" system upgrades and reducing the homes per node try to overcome the system capacity limits they carry with them an investment and infrastructure cost penalties. A major improvement in coding efficiency would enable many more services to be deployed across existing infrastructures, and this is the promise of advanced video coding techniques such as MPEG-4 part 10 [2] and Windows Media Player 9 Video [3].

BITRATES OF ADVANCED VIDEO CODING

The nature of the video compression algorithms being used in any of these coding techniques being discussed means that the perceived picture quality of a constant bit rate video service will vary depending on the complexity of the picture. A "talking heads" sequence, typical in news programming for example, is relatively simple to encode – there is little motion or detail changes between frames – whereas sport material involves both high motion and high detail changes between frames, testing the limits of the coding algorithm implementation. The reverse of this is also true – a constant quality picture requires a variable bit rate. Other system techniques, such as statistical multiplexing, try to make advantage of this by flexibly sharing a pool of bit rate between a number of channels to optimize picture quality verses bit rate. As the bit rate for a "broadcast quality" video is such a subjective matter a range of bit rates are indicated in figure 2.

It should also be noted that different performances can be achieved between real-time encoding products, required for live TV broadcasting, and products using non-real time encoding processes, that can be employed for the creation of stored assets, such as VOD movies.

	MPEG-2, today	Advanced Video Coding techniques, 1st deployments	Advanced Video Coding techniques, promise over time
HDTV, real-time	10-16 Mbps	6-10 Mbps	4-6 Mbps
HDTV, non real-time	6-8 Mbps	3-5 Mbps(1)	2-4 Mbps
SDTV, real-time	2-4 Mbps	1-2 Mbps	0.5-1 Mbps
SDTV, non real-time	1-3 Mbps(2)	0.5-1.5 Mbps	0.5-1 Mbps

(1) As evidenced by content samples on Microsoft website, www.microsoft.com

(2) Note, 3.2Mbps transport (~2.8Mbps video) typically used for MPEG-2 VOD assets today

Figure 2 – Advanced Video Coding Techniques vs MPEG-2 bit rates, by service resolution.

While there are differences in the techniques used in the MPEG-4 part 10 and Windows Media Player 9 Video coding algorithms, resulting in some differences in video coding artefacts, it has been shown through subjective and objective testing [4] that both these techniques produce averagely equivalent quality over a range of bit rates and programming material types, therefore no distinction between coding algorithms is made in figure 2. It should be noted that broadcast video applications are most likely to use the "Main Profile" of MPEG-2 part 10 or the "Advanced Profile" of Windows Media Player 9 Video.

TECHNIQUES THAT ENABLE THE SAVINGS

The new advanced coding techniques achieve their efficiency improvements over MPEG-2 in a number of areas:

- More efficient syntax – saving of bits from fewer and shorter headers, greater range of allowable picture sizes, and carriage mechanisms within native IP and with MPEG based transport streams.
- Removal of more information from the picture – improvements in coding techniques and motion prediction tools, including the addition of a more flexible selection of block sizes.
- Hiding artefacts – as bit rates are pushed lower there is an increased likelihood of blocking artefacts on difficult scenes. Tools such as loop filtering hide the blocking artefact edges making them less perceptible to the viewer, therefore allowing the bit rate to be pushed lower.

In comparison to MPEG-2 some of the changes that yield the greatest savings are:

- Multiple intra-prediction modes for Field/Frame adaptive coding at picture level, and Field/Frame adaptive coding at macroblock level (MBAFF) – provides for more flexibility when a picture sequence exhibits a mixture of progressive and interlaces characteristics within a field/frame.
- Additional block sizes for intra prediction within I Picture.
- In-loop deblocking filter, provides no benefit at higher bit rates but has clear advantages at bit rates lower than traditional MPEG-2 operating ranges.
- Improvements in motion estimation including Tree-structured motion segmentation with a selection of block sizes and 1/4-sample motion compensation.
- Additional coding efficiencies from range of alternative integer transform block sizes, the definition of multiple variable-length coding (VLC) tables enabling Context-based Adaptive VLC-based entropy coding (CAVLC), and for MPEG-4 part 10 the option for Context-based Adaptive Binary Arithmetic Coding (CABAC).

CARRIAGE OF ADVANCED CODED VIDEO IN A CABLE SYSTEM

The advanced coding techniques have several options of carriage mechanism for transmission.

MPEG Transport Stream

The packetization of advanced coded video within the traditional MPEG transport stream carriage mechanism enables Advanced Coded services to be broadcast on any existing network carrying MPEG-2 services today. Using MPEG transport stream also provides a number of other advantages:

- Timing Reference - MPEG transport timing references ensure the synchronization of video, audio and time critical metadata services when the digitized services are presented to the customer to view.
- Ancillary data carriage - Other MPEG transport related standards also provide a

definition for the carriage of ancillary services such as vertical blanking interval data, such as Closed Captioning and V-chip information.

- Audio codec choices – there are multiple audio codecs defined within various standards and specification which utilize MPEG transport carriage today. Combined with the commonality of the MPEG timing reference this enables an operator to mix and match video and audio codecs to meet their needs.

IP Carriage

The packetization of Advanced Coded video services within a native IP transport removes unwanted overhead (header tax from Advanced Coded Video packets over MPEG transport encapsulated into IP frames) when Advanced Coded Video services are intended to be transported over Internet Protocol based networks.

CONCLUSION

The major improvement in coding efficiency that are being achieved with first generation MPEG-4 part 10 and Windows Media Player 9 video codecs will enable many more services to be deployed across existing infrastructures. The efficiency improvement will further improve as more research and development resources and time improve each generation of product implementation. While the support for MPEG transport stream carriage provides an answer for existing networks, the native IP carriage for next generation networks will become more prevalent over time. The IP carriage mechanism allows a migration to an IP based core network, or even a Switched Digital Video over QAM network to achieve infrastructure cost savings or provision a greater number of services over a bandwidth limited edge. The combination of compression efficiencies over MPEG-2 combined with next generation transmission networks will enable cable operators to further provision advanced HDTV services to their customers.

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