Compression for Acquisition, Contribution and Mezzanine

The biggest problem with an analyses like this is the moving target. My first involvement in compression was in the 80's designing teleconferencing systems. The power companies were our biggest customers as they had the dedicated circuits to handle the required bit-rates (H 120 at 1.5 mbs). Soon after came Mpeg 2 for DVD requiring highly skilled operators (compressionists) to achieve the required quality. Now we have HD streaming over a DSL connection and the next generation codec (HEVC) promises an additional 50% data rate reduction.

Aquisition

Not shooting in the RAW? Then you are most likely using compression for your acquisition. Compression saves storage space and reduces transmission bandwidth. The compression process includes the transformation into a viewable format. During acquisition each frame has to be compressed as it is recorded. This limits the amount of processing which can be applied, therefore data rate reductions for a given quality level are less than the theoretical limits of the codec used. [definition of Raw: The information that the sensors in the camera detect is saved directly without compression. This is similar to motion picture negatives in that it requires post-processing in order to give an accurate representation.]

Contribution

Compression for getting the data from the field to the station is essential in today's live broadcast environment, however computational constraints do not yet allow for implementation of the newest algorithms. Contribution compression only needs to run in real time during live broadcast. The more time spent processing, the higher the quality at a given data rate. This can be a real advantage when contributing over a DSL link.

Mezzanine

The mezzanine is where files are stored before further processing, whether for production or transmission purposes. Compression used here has to be compatible with the tools that will be applied to these assets. The other concern is longevity, as mezzanine formats are deeply embedded in the production processes, changing this format can have wide reaching technological and financial implications.

What are the tradeoffs between staying in the acquisition format until conversion for delivery or using specific codecs at each stage in the process?

Efficiency

There are symmetric codecs and asymmetric codecs. In many cases the processing power available to decode is much less than that available to encode. H264 is an example of an asymmetric codec as it was designed primarily for consumer consumption. A more efficient codec requires less compute cycles. Another measure of efficiency is the compression ratio at a given quality level. SSIM is adjusted for the human vision system whereas PSNR is an objective number arrived at by subtracting the encoded image from the source.

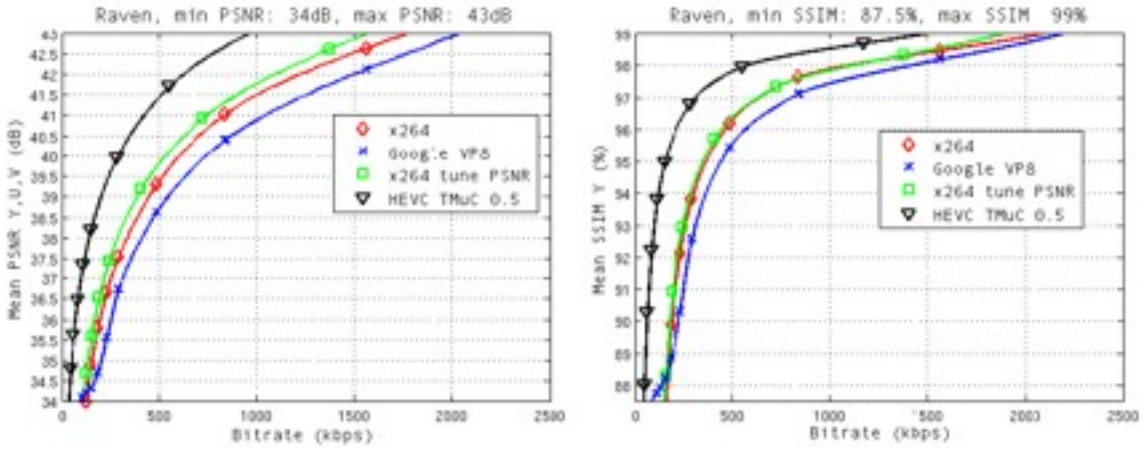

Figure 1. Rate-distortion results of sequence "Raven". Left: PSNR results, right: SSIM results. The points represent measurements while the curves have been fitted to the experimental data by cubic interpolation within the specified range of PSNR or SSIM.

Quality

Absolute quality ranges from mathematically lossless to visually useless. Mathematically lossless codecs achieve at most a 3:1 compression ratio and have few applications outside of long term archives. The term "visually lossless" falls somewhere between these two extremes and equates to an SSIM of better than 95%. By absolute quality we mean the maximum achievable quality regardless of compute time or bit rate.

Economy

Conversion costs money but a reduced data load provides savings. How can DSLR cameras deliver such high quality at such a low cost? They have reduced the on-board electronics to an absolute minimum. This results in a large uncompressed file requiring external processing or a compressed file with visible compromises.

Usability

An interframe based compression algorithm can be 10 x as efficient as an intraframe codec, but an intraframe codec is always preferred when editing or other real time processing is to be applied. A mezzanine format which can easily be converted for delivery is much more useful than a raw file requiring hours of processing.

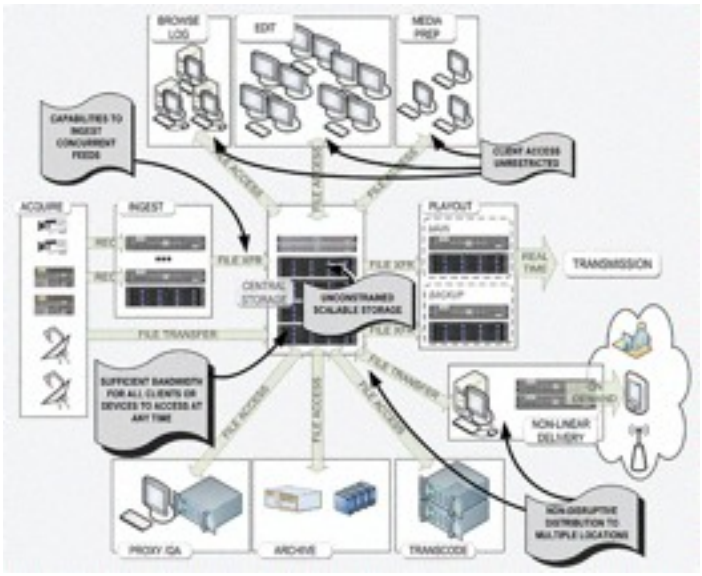

Fig 3 Encode Decode cycles in the Production chain

As the above diagram shows there are many places in the production cycle where compression may be used. Technically it would be possible to have an entirely uncompressed workflow. Practically we have to at least compress prior to transmission.

Application	Bandwith	Effeciency	Type
Wireless Camera	Bandwidth avialability constrained	Real time codec	Intraframe
VTR	High bandwidth available	Real time codec	Intraframe
SAT uplink	Bandwidth avialability constrained	Non Real time OK	Interframe OK
Ingest server	High bandwidth available	Non Real time OK	Interframe OK
Production Server	High bandwidth available	Real time codec	Intraframe
Mezzanine server	Bandwidth avialability constrained	Non Real time OK	Interframe OK
Conversion Server	High bandwidth available	Non Real time OK	Interframe OK
Editing System	High bandwidth available	Real time codec	Intraframe

The bandwidth is constrained on the mezzanine server because of the amount of data stored. A 50% reduction can save millions of dollars.

Fig 4 Typical codec application points and constraints

When using multiple codecs as above one has to watch out for concatenation, the multiplication of encoding artefacts caused by repeated transcodes. This is least visible when moving from lower bit rates to higher bit rates (or PSNR). Interframe codecs require less data for the same PSNR but are more compute intensive. Interframe codecs provide an *average* low bit rate at a fixed quality level, this means high bandwidth must be available even though storage required is lower.

For some of the above applications you will not have a choice of codecs to use as they are specified by the manufacturer. The production server and editing system have the same constraints so it makes sense to use the same codec for these applications. The ingest server should use the same codec as the mezzanine server or have a higher PSNR. Assets on the mezzanine server may have low data rates due to interframe compression but must have high enough quality to feed the production server. This transcode does not have to be in real time if your planning system knows in advance what is needed. Actually given available CPU cycles this can be faster than real time.

If you look at FourCC.org you will find over 300 named codecs. The list is not complete and there are new ones added frequently. The major broadcast manufacturers also have there own preferred flavours. This is where the conversion server comes into play. This is more likely a server farm running multiple applications to cover all the required codecs. Make sure that this is expandable in reasonable units as Moores law is unforgiving.