KEY DIGITAL® KNOWLEDGE CENTER — WHITE PAPER

H.264 and MJPEG Compression for HDMI over IP in ProAV applications

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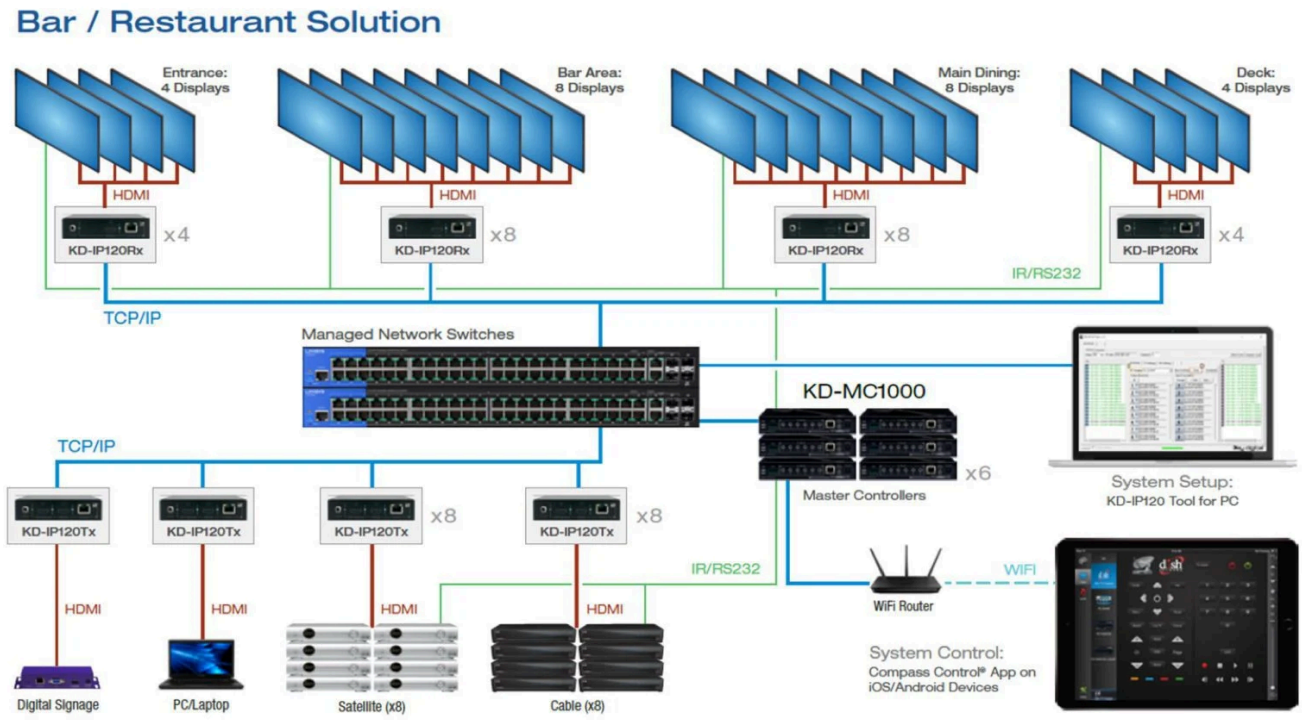
1. Running on IT infrastructure

Emmy Award winning HDBaseT technology achieved a very significant goal for ProAV – twisted pair type cabling CAT5e/6/6a was now capable of providing clear, artifact-free digital HDMI video for distances up to 330 feet (100m). However, HDBaseT was specifically designed to be not compatible with IT infrastructure such as 1KBaseT or 10KVBaseT connectivity and switching products using TCP/IP protocols at its core. There is a clear reason why: uncompressed 1080P/60/422/10bit requires 2.5 Gb/s data rate.

Currently, most common IP switches deployed are 1KBaseT and allow up to 1 Gb/s data rate on each port. In addition, large matrix switching systems using 1Gb/s switchers will demand 100Gb/s SFP transfer port capability in order to create matrix transparent systems that use more than one IP switch with 1Gp/s ports. So even if each port data rate can be reduced to be below 1Gb/s the upper limit of the switchers used will quickly top at 40x48 type systems with SFP speeds in the area of 10 Gb/s. If SFP ports are in the area of 1Gb/s, as it most commonly used today, these switchers are only practical 24x24 matrix switch sizes. In order to have free hand on matrix switch size and cost of IT investiture the data rate has to be significantly reduced.

Below is an example how very high compression H.264 system used with KD-IP1080pTx/Rx encoders and decoders creates a Bar/Restaurant application using IP switchers as you see from the *Figure 1* below.



2. H.264 to the Rescue

After decades of very successful research into video compression technologies, a H.264 system was developed that offered additional compression reduction comparing to currently used MPEG2 for ATSC and initially for DVD.

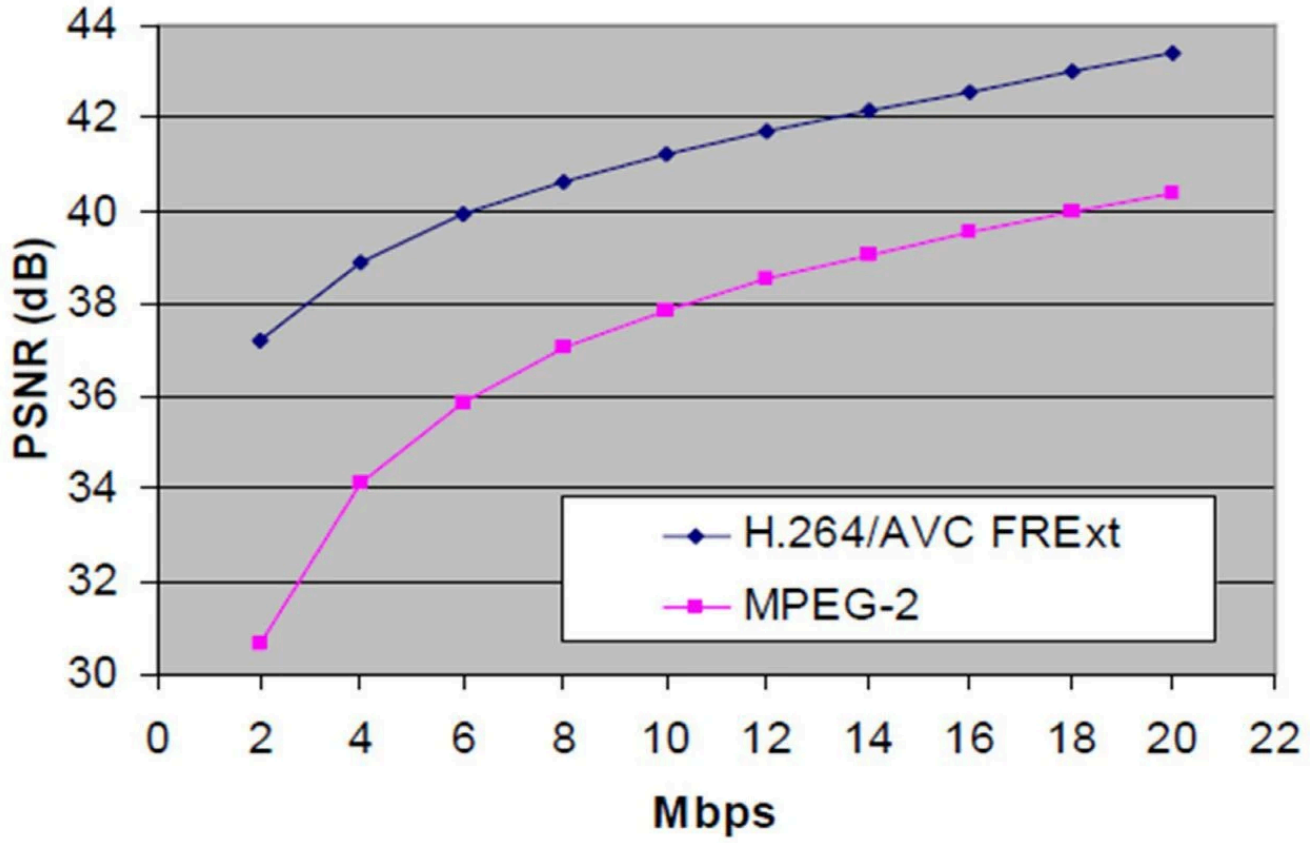


Table 1

As you see from *Table 1* above, the H.264 compression at the data rates of ~6 Mb/s performs the same as MPG2 at ~20 Mb/s. 20 Mb/s is MPEG2 data rate used for todays ATSC and some Cable and Satellite digital TV broadcasting for HDTV. That type of data rate reduction is a very significant advantage for H.264. Therefore, H.264 is a compression that is predominantly used today for all Internet streaming applications as well as for more contemporary applications in Cable and Satellite distribution.

The ProAV products employing HDMI over IP divide basically into two categories today: MJPEG2000 based and H.264 based. The MJPEG2000 is essentially an intra-frame compression that does not utilize code the differences and motion vectors between the frames. H.264, on the other end, utilizes all possible methods to reduce the data rate, including coding differences of 15 to 30 frames sequences with all possible methods of residual data coding, and motion vector prediction and coding.

Below in *Table 2*, H.264 to MJPEG comparative graphs are shown. It's second by second comparisons how different compression data schemes change data demands with real time video playback. According to that data MJPEG is about 10 times less efficient then H.264. So for 1080p/60 format H.264 will perform at ~18Mb/s while MJPEG at ~180Mb/s. There is also a cost to such data reduction – time delay. H.264 display is probably 300ms to 500ms behind the source while MJPEG is approximately 30ms.

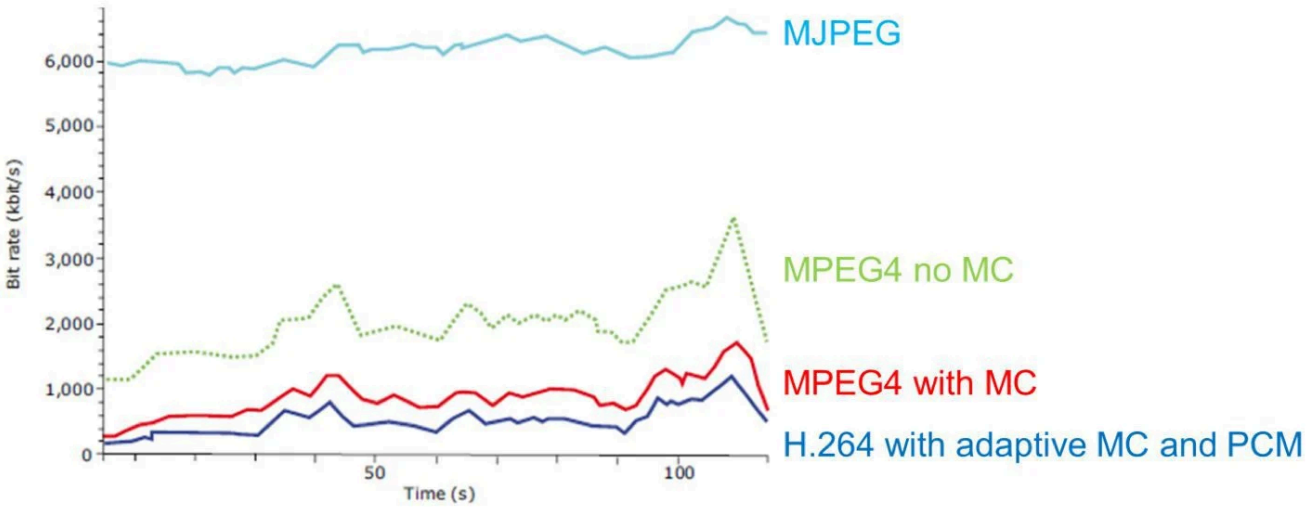


Table 2

Simply, H.264 is MJPEG plus Motion Compensation and prediction. MJPEG (similar to MJPEG2000) is basically an Intra-Frame compression system as it shown in *Figure 2* below:

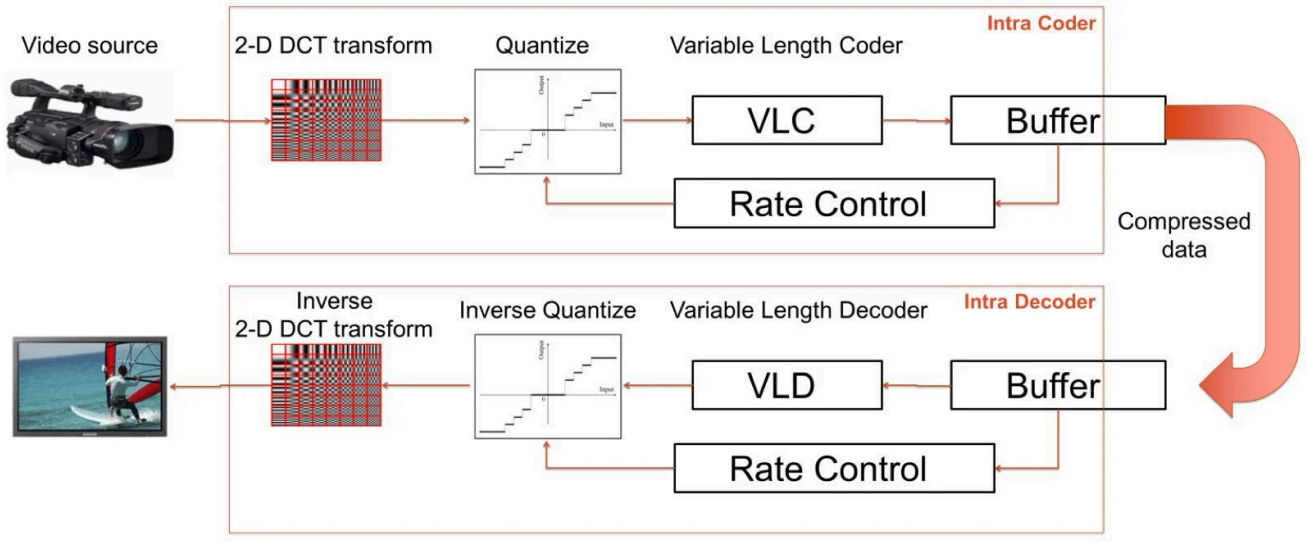


Figure 2

The Intra Frame Codec is local inside each frame. Two dimensional frequency transform (DCT) signal quantized and then coded by Variable Length Coder. Output Buffer has a feedback to control the Quantize operation level, keeping data rate constant. That is one reason why when image texture becomes too demanding from the data allocated in any compression system viewer see “blockings” effects produced by level of quantization being too course.

To further reduce the data rate Motion, differences between the frames have to be encoded as it shown in *Figure 3* below.

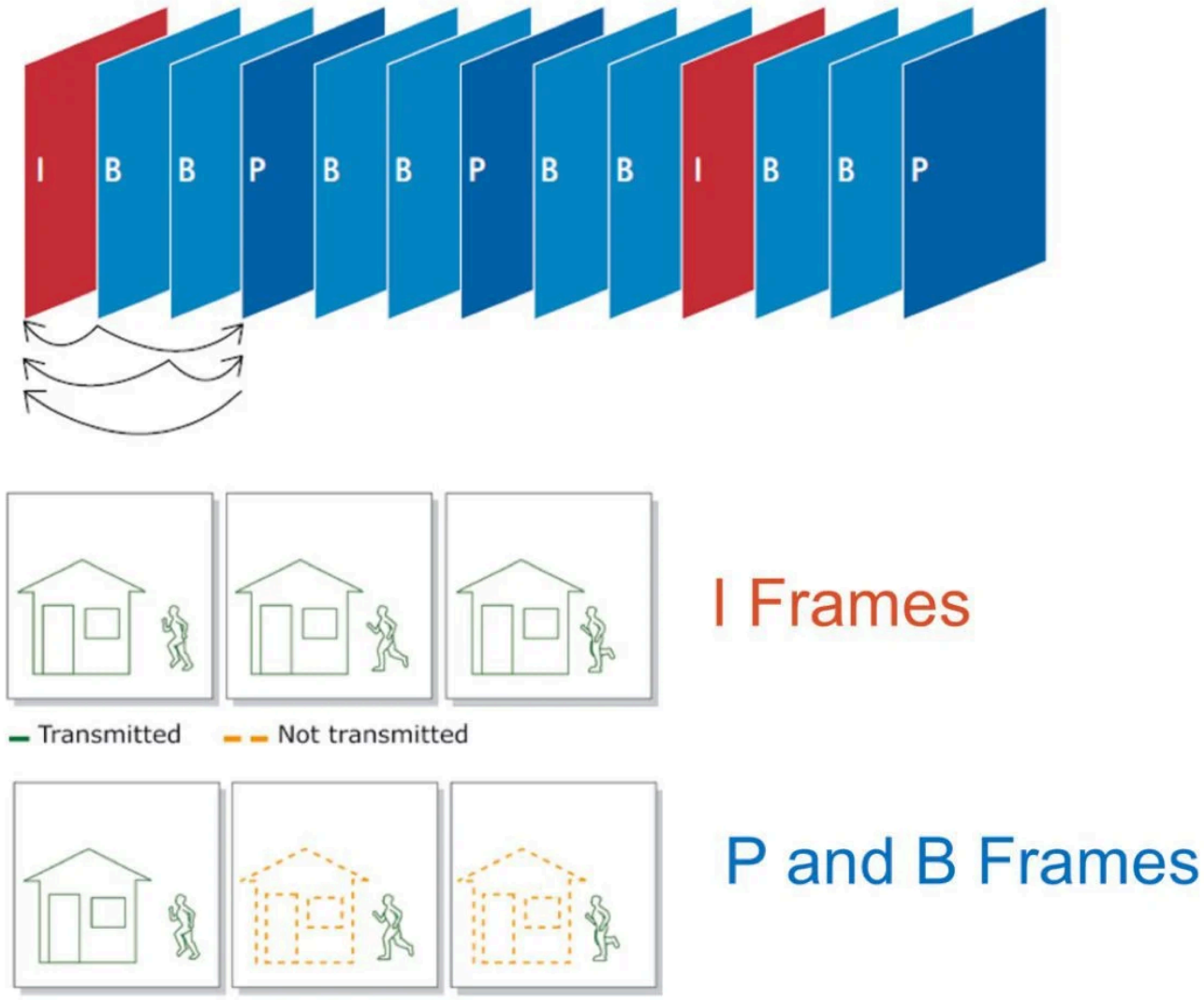


Figure 3

To unitize motion three types of frames are created:

- I Frame is Intra coded Frame or Anchor Frame. Every pixel is coded and transmitted. MJPEG systems consists only of I Frames
- P Frame is a combination of previous I frame and Motion Compensation vectors information from the I Frame. Only changes from I to P frames are transmitted. P frames are transmitted between I frames
- B Frame is a combination of I Frame and Motion compensation from P Frame. Only differences between B and P are transmitted. B frames are transmitted between P frames or between P frames.

Adding Motion Compensation and two additional type of frames allows H.264 to reduce data rate as much as 10 times compare to MJPEG.

Below Figure 4 shows a basic block diagram of H.264 Codec. Intra-Frame block is basically a complete system used for MJPEG with additional Motion Compensation and Motion Estimation systems added to generate and decode P and B frames.

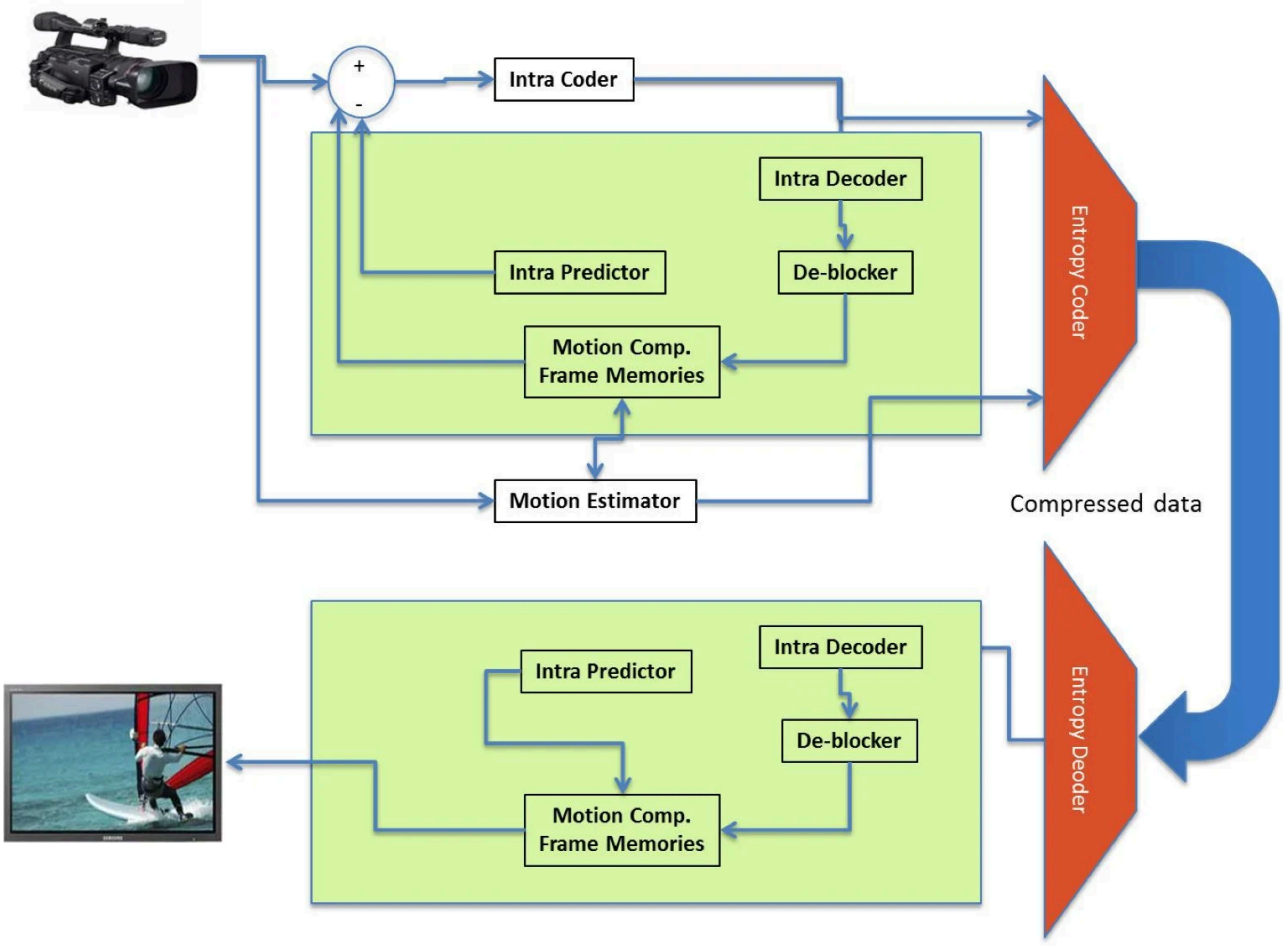


Figure 4

Essentially every H.264 Encoder has a H.264 Decoder (green section) built-in to accurately predict and transmit P and B frames.

Conclusions

- All Internet streaming and Satellite broadcasters today use H.264. Cable and companies use mix of older MPEG2 and H.264. Terrestrial broadcast ATSC uses only MPEG2.
- 15 Mb/s for 1080p/60 video low bit rate allows large IP switch stacking creating large 256x512 matrix system, coaxial extension up to 1,800 feet and WiFi extension up to 100 feet using standard 1000BaseT IP products.
- H.264 allows direct point to point 400 feet connection with CAT5e to and from IP switch.
- 800 feet connection possible with IP switch repeat: 400 feet for Tx to IP switch plus 400 feet IP switch to Rx.
- Flexible configuration allow for Any Input and Any Output count. For example using single 48 port IP switch user can create 1x47 or 74x1 Matrix configurations with all possible combinations in between.
- Stacking Network Switchers add input or output channels.
- Maximum Video Sources for Managed Smart IGMP switch = 1024.
- Maximum Video Displays = 1024+.
- Control Options: PC GUI, iOS/Android App, Control System.