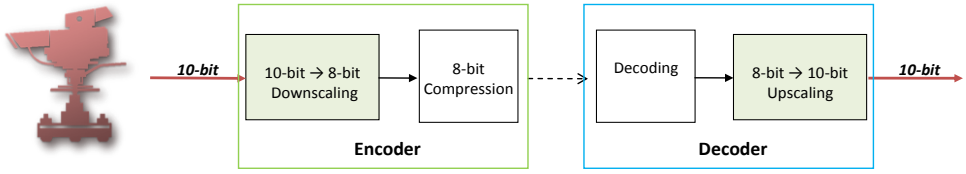
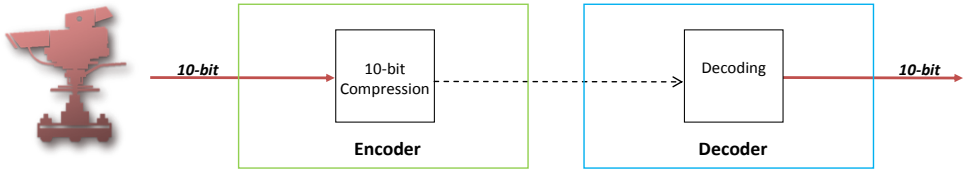
Why does 10-bit save bandwidth (even when content is 8-bit)?

10-bit compression of a 10-bit source provides a better quality than using 8-bit compression algorithms. The reason is simply because the scaling stages needed before encoding and after decoding much are less efficient than the MPEG compression algorithm. In other words, it is better to ***compress*** than just scale video components to reduce the amount of transmitted information. Thus 10-bit compression of 10-bit sources actually saves bandwidth. The other advantage is that it is possible to transmit details that would have been destroyed by the scaling stages, fine gradients for instance.

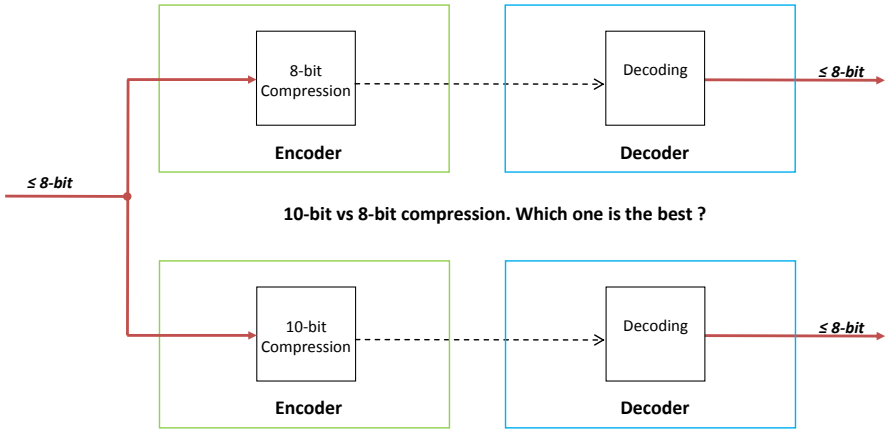


8-bit compression of a 10-bit source



10-bit compression of a 10-bit source

However, this is only a part of the story: encoding pictures using 10-bit processing always saves bandwidth compared to 8-bit processing, ***whatever the source pixel bit depth***.



This could seem counter intuitive but some knowledge on how encoders work explains this. We're going to explore this in 5 steps.

What does "saving bandwidth" mean?

Bandwidth is saved if less bit-rate is needed, keeping the same video quality. When comparing encoders or encoding technologies, both bit-rate and video quality has to be considered: less bit-rate keeping the same quality is equivalent to more quality keeping the same bit-rate.

What is a better video quality?

The video quality is better when the decoded video is closer to the source. The most common way of expressing "closeness" in video processing is stating that there are less errors ***relative*** to the pixel bit-depth. For example, a 1 error bit on a 8-bit signal provide the same relative error than 3 bits of error in a 10-bit signal: 7 bits only are actually meaningful in both cases.

Where are errors introduced in a MPEG encoder?

Video is compressed with a lossy process that introduce errors ***relative*** to the source: the quantization process. Since those errors are relative, they do not depend of the source pixel bit-depth; but only on encoding tools efficiency when a given bit-rate has to be achieved.

What happens with 10-bit video source when using a "perfect" MPEG encoder?

A 10-bit source carries about 20% more information than an 8-bit one. Assuming the same encoding tools efficiency, the same bit-rate can be achieved just by quantizing 4 times more (2 bits). Since the ***relative*** error is the same in both cases, the video quality ***should not*** change.

So why does a AVC/H.264 10-bit encoder perform better than 8-bit?

When encoding with the 10-bit tool, the compression process is performed with at least 10-bit accuracy compared to only 8-bit otherwise. So there is less truncation errors, especially in the motion compensation stage, increasing the efficiency of compression tools. As a consequence, there is less need to quantize to achieve a given bit-rate.

The net result is a ***better quality*** for the same bit-rate or conversely ***less bit-rate*** for the same quality: between 5% and 20% on typical sources.