Choosing a Codec

Picking the right video codec isn't as easy as it used to be. But with the right information, you can determine which one will work best for your project.

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Choosing a codec used to be simple. Real charged for the server but was still cost-effective for many content distributors; Windows Media was free but offered limited server and playback support. QuickTime's quality trailed the big two considerably at any data rate south of the gargantuan files used to transmit *Star Wars, Episode One: The Phantom Menace* via progressive download. These well-defined differences made it fairly easy to choose a compression technology based on financial, qualitative, or religious reasons (for QuickTime devotées, of course—and yes, we're aware that QuickTime is really a "wrapper," not a codec in itself, but most of us use "QuickTime" as a convenient shorthand).

The codec world has gotten more complicated. Playback compatibility requirements have expanded, and you might be willing to trade UNIX playback for compatibility with a 3GPP cell phone. The availability of digital rights management (DRM) protection is critical to those selling their content, and royalty costs are becoming a consideration. Flash has emerged from a vector-based format for creative Web advertising to a mainstream video technology with a surprisingly powerful compression scheme. After years of playing quality catch-up, MPEG-4 video is starting to shine, especially some of the new implementations of the Advanced Video Coding (AVC). But will the new ones all play on your Windows or Mac machine?

Video quality at a given bit rate, while historically the most important comparative metric between codecs, may now take a back seat to device compatibility, player ubiquity, royalty cost, or DRM scheme. But that doesn't lessen the importance of understanding how your chosen codec stacks up against the relevant competition; after all, the most visceral observations your viewers will make depend precisely on quality. And whether your codec is at the top of the heap or the bottom of the barrel, the ability to eke out the last bit of potential quality via shooting techniques, encoder choice, pre-processing, or choosing between techniques like variable and constant bit rate encoding has never been more important.

In the interest of full disclosure, I'll acknowledge now that I'm the author of three research reports published by StreamingMedia.com that benchmark codec and encoder quality. As such, I've spent the better part of the last four months playing files produced by a number of codec vendors and encoding, playing, and re-encoding test files that I produced myself. You know the drill: this article is designed to describe the studies, providing sufficient relevant information to make it worth your time to read the article while not giving away the vital information contained in the study. If I provide sufficient incentive to convince you to buy one or more reports, so much the better. But at the very least, this article should provide some food for thought for your next encoding session.

Formalities out of the way, let's get started.

How We Tested

Let me start with a bit of history. Back in 1993, I produced my first codec survey in a product called the Video Compression Sampler. This product analyzed five codecs (Cinepak, Indeo, Video 1 [in 8- and 16-bit], and Xing's proprietary MPEG and RLE), using four simple test clips ranging from a

talking head to high motion, encoded at seven different data rate/resolution/frame rate combinations. Experiments also included on the disc swelled the number of files to about 300.

I encoded all the test files on an 80486 computer that took roughly 45 minutes to encode each 20-second clip. There were no frame shots and no analysis; I sold the CD with a dual-window player program that let you load and play the files side by side and draw your own conclusions.

This time, I started with a test file with 42 different scenes divided into five categories: business, action, entertainment, animation, and pan and zoom. I sent the file to a number of vendors (Apple, Microsoft, Nero, Real, and Sorenson Media) with instructions to produce files in five basic configurations, targeting 56Kbps modems, 3GPP cell phones, LANs (100Kbps and 300Kbps), and broadband (500Kbps).

From these codec benchmarking efforts, I produced files with the Macromedia Flash 8 Video Encoder, Autodesk Cleaner XL 1.5, Canopus ProCoder, Sorenson Squeeze, and On2 Flix Pro Encoder. In the end, the study compared files in three groups:
• *Flash, which included the new VP6 codec encoded with both Sorenson Squeeze and On2's Flix Pro Encoders, files produced by the Macromedia Flash 8 Video Encoder, and files encoded using the Sorenson Spark and Wildform codecs.*
• *MPEG-4, which included Apple's H.264 technology, Sorenson's MPEG-4, files produced by Nero using the Ateme codec, and the MainConcept Encoder.*
• *Proprietary, which included RealVideo, Microsoft's Windows Media, and the best of the Flash and MPEG-4-based codecs.*

Each study had three major goals:
• *First, to identify the highest-quality codec in the group and rank the other participants.*
• *Second, to describe how to optimize files produced by the major contenders in each category through preprocessing and encoding alternatives such as noise-reduction techniques, and scaling and deinterlacing in third-party programs, as well as using various encoding programs like Cleaner XL, Canopus ProCoder, or Sorenson Squeeze.*
• *Third, to identify the problems commonly experienced by the major contenders and discuss shooting and scene setup techniques to minimize these problems.*

To compare the codecs and rate the encoding alternatives, I evaluated each of the 42 test scenes in each encoded file for still-frame quality, playback smoothness, color, and temporal quality (the lack of motion artifacts). Each main study included 25 different scoring categories (five classes of videos times five encoding configurations), plus assorted other analyses to assess encoders and encoding configurations. • Overall, I produced and/or evaluated more than 585 video files and grabbed and analyzed more than 8,000 frames from the video files in groups of four, all dutifully rated in an Excel worksheet that's more than 1MB in size. That's probably just the average size of a Dennis Kozlowski expense report, but pretty large for just data entry and formulae. I compiled the results into three downloadable PDF reports with the aforementioned screenshots and encoded tests files also available for download with the purchased report.

And the Winner Is?
If it were only that simple . . . In a way, it is. The overall best codec was Real Networks' Real Video. Though it didn't win every category in every comparison, it held up remarkably well across the board.

That wasn't the real surprise, however. The shock of the study for me, having penned an article entitled "MPEG-4 is Dead" a few scant months earlier, was how much the MPEG-4 codecs have improved in their latest iterations. The same goes for Flash. While quality didn't quite meet the hype from the vendors who support them, MPEG-4 and Flash codecs are close enough in quality not to rule them out if other factors (device playback, etc.) dictate their use.

It's Gonna Cost You (You Can't Get There from Here)
We said that Real performed very well in our trials; the relevant question is how well, and how much higher must you boost the data rate of video files you create using other codecs to match Real's quality. We analyzed this for several key technologies; here we see an analysis of the (CBR-based) Flash 8 Video Encoder.

In **Figure 1**, the original Real file, at 300Kbps, is in the center of the top row, while the two-pass, variable bit rate (VBR) VP6 file is beneath it. Both are surrounded by Flash 8 files produced at 450, 500, 550, and 600Kbps. Though it's probably tough to tell in this picture, the mosquito-like artifacts around the lettering in the 450Kbps clip (and not present at all in the Real clip), are only slightly less prominent in the 600Kbps clip. The bottom line is that at twice the data rate, you still don't get the

quality.

Figure 1

While the data rate cost for Real-equivalent quality is less in some low-motion sequences, data rate won't help with some scenes; your only option is to redecorate. More on that later under the subheading "You Look Marvy Against Black."

Your Mileage May Vary
We saw great variability in results over the different categories in the study. For example, in the Flash study (which included Real Video for context), Real won the 500Kbps business video category by 39% over the VP6 codec produced by On2's Flix Pro Encoder. However, in the next category, Action, the VP6 video bettered Real by more than 32%.

For some content providers, that may be enough to convince them to switch codecs for different projects; for others, it's just a warning that they may have to boost data rate or change their shoot to produce sufficient quality. Everyone should understand that there is no one-size-fits-all codec that encompasses the complete range of video, animation, and pan-and-zoom clips.

Choose Your Encoder with Care
To produce optimal quality, you don't just choose a codec; you choose a codec/encoder combination. This may come as a bit of a surprise, because most encoding tool vendors incorporate pre-built, self-sufficient chunks of code from the codec vendor to handle the encoding chore. The encoding tool inputs the source file and performs the scaling, deinterlacing, and other processing selected by the user, and then hands off the resulting file to the encoding module for compression.

At first glance, this dynamic would seem to leave little room for difference in encoding output quality, but this wasn't the case in our tests for two reasons. First, scaling and deinterlacing quality are absolutely critical to the quality of the final encoded file, and this varies among the encoders (see section under the subheading "It's All About Deinterlacing"). However, even when we input the same file, already scaled and deinterlaced, into multiple encoders, we saw very different results.

Though Figure 2 is a bit extreme, it kind of proves the point. One of the batch encoding utilities produced the day-glo image on the right, while the Microsoft encoder was much more accurate on the left.

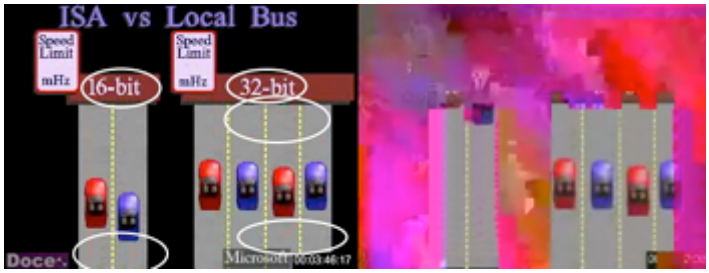

Figure 2

In other tests, the encoder that performed best when encoding Windows Media files turned out to be the worst encoder for Flash VP6 files. Equally interesting was that the Real Encoder bested all three batch encoders in quality tests, though one was very close, while Microsoft's Windows Media Encoder placed third out of four Windows Media encoding tools.

In other trials, the encoder that produced the best VBR VP6 files produced the worst constant bit rate (CBR) files for low-motion footage. Overall, choosing the right encoding tool is as important as choosing the right codec.

Get to Know Your Encoder
As streaming production becomes more prevalent, software vendors make their encoding tools more user-friendly. Of course, this doesn't mean that they're foolproof, and often missing one or two key buttons or checkboxes can make the difference between great and awful quality.

Take the image in **Figure 3**. On the left is relative beauty at 500Kbps, on the right, a rebuke from the boss. The difference? An obscure deinterlace setting hidden in a Filter screen that you don't see when accessing the Flix Pro main encoding controls (**Figure 4**). This isn't a problem with Sorenson Squeeze, which automatically enables deinterlacing, but there is another "gotcha" we talk about in the report that can wreak almost equal havoc on your video quality when producing Flash FLV files.

Figure 3

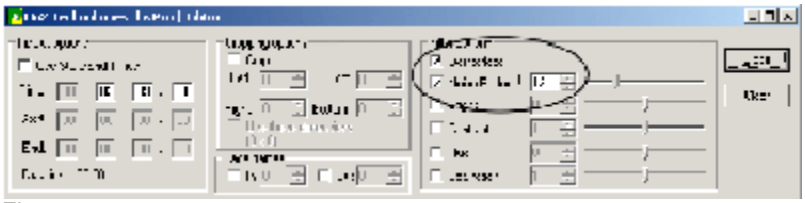
Figure 4

To be completely descriptive, the reports don't attempt to detail how to produce the files in each encoder. Rather, they point out hard-to-identify issues that can unnecessarily degrade video quality in some of the key encoding tools you'll likely use to produce your video files.

Man Bites Dog
Choosing the right encoding parameters can be as important as deinterlacing and noise reduction for producing top-quality output. We compared the quality of Windows Media, Apple's H.264, and RealVideo files produced using CBR and VBR techniques. Though VBR showed advantages in some of the categories, CBR was better in others.

With Apple's H.264, we noticed that VBR visibly degraded low-motion talking head shots—as shown in **Figure 5**—which is probably not the tradeoff you want to make for slightly improved quality in dynamic scenes where the artifacts are harder to spot. Note that Apple created both of these files, not me, so save me the emails.

Figure 5

In our Flash trials, which pitted video encoded using the CBR Flash 8 Video Encoder against two VBR VP6 Encoders, Flash 8 bested both in several low-motion sequences. Clearly, strict adherence to the “VBR is better” mantra will cost you serious quality in some configurations.

Where Can You Play That Thang? Work with me on this one. All Flash codecs play in . . . that’s right, Macromedia Flash 8. All Windows Media codecs play in . . . that’s right, the Windows Media Player. RealVideo plays in the . . . the Real Player. So obviously, all H.264 codecs play in the H.264-compatible QuickTime Player, right?

Well, no. Apple has implemented the Main Profile of H.264 into its encoders and players, as has Sorenson. However, encoded files produced with more advanced techniques, like the Advanced Simple Profile used in the Ateme Encoder featured in Nero’s line of products, won’t play in the QuickTime Player.

So, while the files look great, your viewers will have to download or otherwise acquire a separate player to play the video. This is definitely a workable solution if your audience is relatively small, but it’s still an important factor to include you your analysis.

You Look Marvy Against Black
Both of the images shown in **Figure 6** were encoded with Microsoft Windows Media to our 100Kbps parameters. Quick, how much younger am I in the picture on the right? Er, scratch that. Instead, tell me why the image on the left looks so much better. Obviously, the primary difference is the background, which is stable, unmoving black velvet on the left, and a moving mass of people at a trade show on the right. Well, that and six years, but definitely going the wrong way.


Figure 6

Anyway, simply stated, the easiest way to make your streaming video look good, for most codecs, is to shoot against a flat black non-reflecting screen that sucks in the light, shows no detail, and allows the codec to focus solely on the money shot. Unfortunately, this rule isn’t universal; a couple of codecs faded very badly against black, and one started creating reddish artifacts.

Interestingly, in our 42 shots, we found several other background colors and schemes that produced more artifacts than King Tut’s tomb, as shown in the shot of lovely Larissa in **Figure 7**, adjusted with a tone map tool to highlight the banding most obvious on the left.


Figure 7

This is an artsy, two-camera shot with overlay, the back camera shooting the wide-angle view, with the side camera shooting a close-up of the mallets. Some codecs proved impervious to these issues; others produced artifacts on cue. For those, avoid these types of shots and backgrounds, and you can eliminate or minimize these problems before they get to the encoder. Overall, beyond your choice of codec and encoder, the easiest way to improve the quality of your video is to manage the background and motion content.

It's All About Deinterlacing
Most encoding tools offer "noise reduction" or similar filters that are designed to improve the compressed quality of your video files. We tested these with most major encoding tools and found that they range from generally neutral to slightly positive, but occasionally negative.

Other than color correction and black and white contrast adjustments, which helped with most (but not all) codecs, we discovered that the most reliable way to improve video quality was to scale and deinterlace your video footage with a high-quality tool. Even this tended to produce subtle adjustments most noticeable on images with lots of motion and detailed hard edges.

For example, **Figure 8** shows a clip from our test file that shows the champion golfer finishing his swing on a short par 3. On the left, the image was deinterlaced in AlgoSuite, an Adobe After Effects plug-in from Algolith (www.algolith.com), on the right using Adobe After Effects' native tool, which is easily better than 99% of deinterlacing tools in streaming media encoders. Which starting point do you think would produce a higher-quality compressed file?

Figure 8

Of course, as Heinlein taught us, there ain't no such thing as a free lunch, and AlgoSuite has some sharp edges, like glacial processing time and a somewhat confusing interface. Still, if you have the time and money (about $1,200), and a client to impress, it's a great widget in your toolkit.

Always Leave 'em Wanting More . . .

So that's it; I could talk forever, but I've probably already given away too much. But what have we learned so far?

It's not just a Real/Windows Media world anymore; Flash and MPEG-4 have achieved something very close to parity on many types of videos. When choosing an encoder to produce your video, remember that not all encoders produce equal quality, and that all encoding tools have their peccadilloes.

Beyond your choice of codec and encoding tool, creating the optimal background for your codec is the easiest way to improve video quality, but what works for one codec doesn't work for them all. Finally, most of the noise removal filters out there are fool's gold; a rare exception is a high-quality scaling or deinterlacing tool.