A General Introduction to Digital Video

Digital video is a hugely complicated subject and it would be impossible to explain all the variations and standards available and in use, instead this document aims to explain some of the concepts and terms that you may encounter from time to time

Neil Castell
Digital Dataworks Ltd
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Introduction

We start with a look back at how film and television has been consumed in the past.

Before television, the local cinema was the main source of moving entertainment and news, the latest film would always be accompanied by newsreel footage of events the world over. Amateur film makers would always be able to project a film or two for their family and friends, but usually only the latest holiday spectacular.

Then television entered our lives and changed them forever, now we could be entertained and informed in the comfort of our own homes, but only according to the schedules of the broadcasters. This situation was changed with the advent of the consumer video recorder, VHS and Betamax allowed us to record our favourite broadcasts and watch them over and over, as often, and whenever, we chose. We could pop out to the nearest video library and rent a movie to watch at home without the 'inconvenience' of going to the cinema – and so 'video on demand' was born.

Videotape satisfied our needs for a while, but then a new device appeared on the consumer market – Philips CDi – this was one of the forerunners of the games console and, if you bought the add-on module, you could play films from a CD, not just music, Mpeg-1 had arrived. The quality wasn't great and you needed an expensive box to play the disks on, but it pointed the way forward.

The DVD disk soon appeared and solved these shortcomings. It could hold over two hours of high quality video, it was much cheaper to produce, it was resistant to damage, never needed rewinding – and needed yet another new format of digital video (Mpeg-2). This was so good that it is still in common use today for both DVD and some satellite broadcasts. But nothing stands still – high definition was coming...

Up to now, digital television pictures contained 442,368 pixels to make up the image, High Definition video uses 2,073,600 pixels – more than 4 times the number of pixels. The problem is that with the increase in the number of channels, there wasn't enough bandwidth available to transmit high definition video using Mpeg-2, a new, more efficient codec was needed, and so Mpeg-4 was developed. This format not only allowed full HD video to be broadcast from satellites, but it is also used for high definition Blue-Ray disks, and can be scaled down to cover every conceivable device from television to mobile phone.

Mpeg-4 is a very successful codec, so successful that there are literally dozens of different implementations of it, each tailored to a specific purpose, so if you are dealing with an Mpeg-4 file, find out what variant is involved before making assumptions...

Common Digital Video File Formats

QuickTime movie – mov / qt (current - mainly computer use)

QuickTime was one of the first types of digital video and was supplied by Apple on all its Macintosh computers. It used the Cinepak codec to produce small, blocky and jerky pictures, but it was a pioneer at the time.

Windows video format (Audio Visual Interleave) – avi (current – mainly computer use)

Microsoft's version of digital video came along a little later and used the Indeo codec which gave a little better quality picture. At this time neither format played on the other's hardware – a sign of the format 'wars' to come.

MPEG-1 - mpg / mpeg (obsolete)

A true breakthrough in quality, Mpeg-1 files were at least as good as VHS videotape but could fit onto a CD. They could be produced and copied on a powerful personal computer and faultlessly reproduced onto the new recordable CD disks.

MPEG-2 - mpg / mpv / m2v (current – used by DVDs and some satellite broadcasts)

If Mpeg-1 was a breakthrough, Mpeg-2 was a huge leap forward from there. It used a much higher data rate and gave much more detailed images, but it needed more bandwidth to be broadcast. It became the format used for satellite television broadcast and, back on the ground, a new form of disk was developed to hold the extra information - DVD

MPEG-3 - (cancelled)

As Mpeg-2 was being developed, its successor was also being planned, but by the time Mpeg-2 was finally completed it contained nearly all of the improvements intended for Mpeg-3, so the project was cancelled. However there is a misunderstanding that the mp3 music format is Mpeg-3 but in actual fact this popular music file format stands for Mpeg-1 layer 3 audio.

MPEG-4 - mpg4 / mp4 / m4v (current – everything!)

As the dream of high definition television edged ever closer, yet another format was needed to contain the ever-increasing detail in a manageable bandwidth. This time a format was proposed that could be configured to service the increasing range of devices – not just for the higher detail, but to accommodate the much smaller

bandwidth available to the new breed of mobile devices. Mpeg-4 was designed to be used for everything from Blue-Ray disks to video on your mobile phone; from high definition television broadcasts to web-based streaming video. It is currently the most sophisticated format in use, but no doubt something even better is planned...

2K/4K – jp2 (current – film production and projection)

2K is the format mainly used for digital movie production and in digital cinemas for projection. It uses jpeg2000 encoded frames of 2048 x 1080 pixels (2,211,840 pixels in total). There is an even higher resolution version (4K) which uses 4096 x 2160 pixels (8,847,360 pixels) and is mainly used in movie production for special effects and compositing. It will eventually replace 2K as a digital projection format.

Digitising at the Scottish Screen Archive

The digitising facility at the Scottish Screen Archive has been set up to try and cover all possible uses of digital video with as little effort as possible.

The suite simultaneously captures 6 different versions of the video tape being played, each one has its own purpose and use.

1 – Uncompressed QuickTime

This format is meant for long-term archiving as an access master storage format. It contains all the information held on the source video tape with absolutely no loss at all. The format generates huge files which are difficult to work with on anything less than the edit suite and require large amounts of storage space. This format is 'broadcast' quality, in fact the footage would need to be compressed before transmission. 1 hour of uncompressed QuickTime video requires about 75.6 GB of hard disk storage.

2 – DV

This format uses a small amount of compression to reduce the file size but this is almost invisible to the human eye. This format can be viewed and worked with on any modern computer and can be used as a source for DVD production. It is not generally regarded as 'broadcast' quality, but most TV stations will accept this if a better quality is not available. 1 hour of DV video requires about 13.3 GB of hard disk storage.

3 – QuickTime with timecode

This is an Mpeg-4 encoded version of the source tape which has captured and displays the timecode of the original source tape. This version can be used as a timecoded viewing copy and is intended to be linked into the catalogue to allow viewing, cataloguing and selection over an intranet. 1 hour of QuickTime with timecode requires about 756 MB of hard disk storage.

4 – Intranet viewing copy

This is an Mpeg-4 encoded version of the source tape with a spoiler logo in the corner. Its purpose is to act as a viewing copy for visitors to the archive and is intended to be linked into the catalogue. 1 hour of Intranet video requires about 600 MB of hard disk storage.

5 – Flash 8

This format is specifically for the SSA website. This version has a spoiler logo and is encoded with the On2 VP6 codec in a format suitable for Flash Player 8 and above (current version of Flash Player is 10). It is intended for general public viewing over the internet. 1 hour of Flash 8 video requires about 540 MB of hard disk storage.

File Sizes Versus Formats – 5 minute clip

This table summarises the storage capacity for a 5-minute clip in a variety of formats. This is fairly unscientific and is only intended to give a basic idea of file size.

Format		*File size (5 minutes)*
3GPP 64 Kbps (MPEG-4)	(mobile phone)	2.867 MB
ISMA Profile 0 (MPEG-4)		6.9 MB
ISMA Profile 1 (MPEG-4)		13.9 MB
website Flash 8		45.0 MB
QuickTime with Timecode		63.0 MB
QuickTime Sorenson Video 2		73.9 MB
QuickTime Video		96.4 MB
QuickTime Sorenson Video 3.1		90.9 MB
QuickTime MPEG-4 Part 10		99.9 MB
MPEG-2 multiplexed stream		150.0 MB
QuickTime Motion JPEG B		154.1 MB
QuickTime Motion JPEG A		154.9 MB
QuickTime JPEG 2000		160.5 MB
QuickTime uncompressed 8-bit 4:2:2		165.7 MB
MPEG-2 broadcast compatible	(Audio and video split into 2 files, total size given)	198.9 MB
QuickTime H.263 codec at best quality		209.7 MB
QuickTime uncompressed 10-bit 4:2:2		271.4 MB
QuickTime Pixlet codec		310.5 MB
DV25 (estimated)		937.5 MB
PAL DV shot on a handycam		1.01 GB
DV storage format		1.11 GB
QuickTime Component video		1.5 GB
DV50 (estimated)		1.875 GB
525i30 NTSC raw		2.575 GB
625i25 PAL raw		3.106 GB
YUV420 converted from muxed MPEG-2 with Compression Master		4.43 GB
SDI format A—Composite NTSC (143 Mbps)		5.362 GB
D-cinema, 24 fps 1920 × 1080 delivered on HDCAM		5.96 GB
Uncompressed QuickTime		6.3 GB
SDI format B—Composite PAL (177 Mbps)		6.637 GB
30 FPS HDTV 1920 × 1080 HDCAM compressed (7:1)		7.449 GB
SDI format C—4:2:2 component (270 Mbps)		10.125 GB
SDI format D—4:2:2 component (16:9) (360 Mbps)		13.5 GB
25 FPS 1080 × 720 commercial definition—raw		16.294 GB
30 FPS HDTV 1920 × 1080 4:2:2		34.761 GB
D-cinema, 24 fps 1920 × 1080 raw		41.713 GB
30-fps HDTV 1920 × 1080 raw		52.142 GB

Glossary

Bandwidth	A term borrowed from radio and TV broadcasting to describe the capacity required to transport information from one place to another.
CD	Compact Disk is a format developed by Phillips for delivering digital audio.
Cinepak	This is a very old legacy codec from the early days of QuickTime.
Codec	A software or hardware device to encode and decode video, audio or other media. The encoder and decoder for a particular compression format. The word is contracted from Coder- Decoder. The codec refers to both ends of the process of squeezing video down and expanding it on playback
DivX	A popular standard for compressing video to a reasonably good quality at low bit rates. A 2-hour movie compresses to a size that comfortably fits on a CD-ROM. This is derived from the MPEG- 4 standard with some additional enhancements that make it noncompliant in some minor respects.
DRM	Digital Rights Management seeks to control access to content so that commercial models can be built.
DV	DV is a standard digital video format used in DVCAM and DVCPro equipment. This is a transfer codec with various derivative and related siblings and is often used with FireWire. DV is used at the low end in TV production but at the high end of semi-pro and amateur cameras. There are variants for higher performance professional use. All DV-based codecs yield good quality video. The DV codec is very portable across professional and amateur systems and virtually all desktop-editing systems support it. You should avoid recompressing it until you are ready to convert it to a delivery format.
DV25	Digital video compressed to transfer at 25 Mbps is called DV25. The compression is slightly lossy but undetectable to the human eye. This format is used in distribution systems.
DV50	Digital Video transferred at a bit rate of 50 Mbps with such slight compression as to be almost undetectable with measuring equipment. This format is used in production systems.
DVCAM	A popular professional format of video recording and storage that is a slight compromise on quality in order to reduce the cost but is good enough for news-gathering footage for broadcast TV. It is likely to become popular as a high-end consumer format.
DVCPro50	The NTSC and PAL variants of this correspond to the lower spec DVCPro formats. Because of the higher bit rate, the compression is reduced to 3.3:1 instead of 5:1. DVCPro50 also supports the 4:2:2 colour sampling but results in larger files. Recompression should be avoided unless going to a target delivery format. This is a production format.
DVCPro—HD	This is the HDTV format and operates at several raster sizes from 1080i60 to 720p60. It supports higher data rates and colour sampling is improved over other DV formats; uses a 4:2:2 sampling format. Designed for broadcast or D-cinema use. This format delivers excellent quality for all uses but is also quite bulky and not intended for amateur use. DVCPro supports variable compression ratios. The files created in this format are huge and while there is some light compression, it

	still requires large systems to cope. You only need this codec to work in high definition for broadcasting purposes.
DVD	Digital Versatile Disk is a format that was developed for the delivery of movies and other data sets that are too bulky for transfer on a CD format.
Ethernet	A networking system for connecting computers together.
FireWire	An interface designed to support hard disks and fast video transfers. Originally developed by Apple Computer, it has become ubiquitous as an interface for downloading material from portable DV cameras.
Frame	A single picture within a video sequence.
H.264	The newest and most advanced codec. This is the one codec to rule them all. It is a modern codec developed for consumer applications at much better bit rate/performance trade-offs than MPEG-2. Although not technically a video-conferencing standard, some telecommunications companies are looking at deploying this for delivery of video content to mobile phones.
IEEE 1394	Otherwise known as FireWire. The standard was developed originally by Apple Computer and then ratified by the IEEE.
iLink	The FireWire interface on Sony equipment is referred to by this brand name.
Indeo Video	This is a video format developed by Intel. It was well supported on Mac OS 9 but a codec has not been made available for Mac OS X. Availability on Windows is more common.
Intranet	Your own private network system, which may or may not be accessible via the Internet.
JPEG	Joint Photographic Experts Group.
LAN	Local Area Network. Usually Ethernet running at 10 Megabits or 100 Megabits. Sometimes 1000 Mbits are deployed and referred to as Gigabit Ethernet.
Mbps	Megabits per second. Digital video transmitted via satellite using MPEG-2 compression typically uses 3.5 to 4.5 Mb/s to carry the content stream.
Motion JPEG	A means of creating moving-image files by storing a series of still images that are individually coded with the JPEG standard protocol. This is a key frame-only format but now that the JPEG standard has been revised to the wavelet-based JPEG 2000 version, this is a somewhat dated codec. Motion JPEG is still widely used since it is embedded in a lot of studio-quality video servers but it is a legacy format when choosing codecs for new projects.
MPEG	Motion Picture Experts Group. A working group within the ISO/IEC standards body. This group is concerned with the standardization of moving-picture representations in the digital environment.
MPEG-1	The original MPEG video standard designed for CD-ROM applications and other similar levels of compression. This is a legacy format. Still useful for some solutions but new projects should use a later codec.
MPEG-2	Widely used for digital TV and DVD products. A much improved codec that supersedes MPEG-1 in many respects. It has been popularized by DVD content encoding and DVB transmission.

MPEG-3	This was cancelled because the proposed work was included in MPEG-2 with a small enhancement.
MPEG-4	A huge leap forward in the description of multimedia content.
MPEG-4 Part 2	The original video standard for MPEG-4 was referred to as MPEG-4 visual. While the compression is not as efficient as Part 10 of the MPEG-4 standard, there are some interesting features that Part 2 offers for multimedia applications. These additional features may be added to a later version of the MPEG-4 Part 10 standard. This codec is not recommended for use in new projects.
MPEG-4 part 10	A codec that has been developed jointly by the ISO/MPEG and ITU-T/VCEG working groups. Currently equivalent to H.264.
SDI	Serial Digital Interface. Used commonly in studio environments.