Introduction

This whitepaper is for digital video professionals or enthusiasts looking for a better understanding of digital video and digital video production, prepared by METUS Technology professionals with years of experience in analog/digital audiovisual and broadcast. It focuses on digital video and compression know-how, continues with phases of working with digital video and an overall look to digital workflow solutions.

Digital Video

An *analog* signal is a continuously varying voltage, whereas a *digital* signal is the numerical representation of an analog signal, simply ones and zeros**.** In that regard, ***Digital Video*** (**DV**) describes recording, editing and playback video technology that is based on digital signals rather than analog signals.

It was late 1970s when first prototypes of *digital videotape recorders* (**VTR**) were developed. First commercial instruction by Sony followed in 1987. Starting from the early 1990s digital video met our PCs, and now it is safe to say that video has made the transition from analog to digital, and it happened in every level of the industry -from big broadcasters to hobbyists. As we see it, there are some major reasons for this transition;

No generation loss. Means; digital video can be viewed, edited or copied almost endlessly with no loss of quality.

Easy to produce. Means; digital video, audio, titles, effects, and a great variety of metadata is easy to produce, edit and integrate.

Tidy. Means; there are considerable savings from a space, storage and efforts point of view when comparing digital video to analog video.

Smooth distribution. Means; digital video can be distributed easily through various media such as Internet, CD/DVDs and 3G mobile networks, thus creating the opportunity to address to each and every need.

In short, digital video - a widely accepted technology by now- delivers better sound and picture quality with no generation loss, uses the broadcast spectrum more efficiently and adds versatility for a wide range of applications and new revenue streams with decreasing costs.

Side note

broad perspective

A critical factor for using digital video in a system is to be able to use the technology without having to create it. For example, think about a medical instrument OEM or a national library, practices that do not necessarily have expertise in video. With digital video and the computing that surrounds it, these clients are able to treat video as just another system component, integrating it into the system with relative ease similar to the other off-the-shelf/ready to use components. The result of using digital video is that they are able to focus on using the video technology to enhance the value of their own expertise rather than creating it. At the end of the day, we are all used to handle digital files, move them around, copy them etc. Relieved from the technical headache, it only leaves them to focus on their core business: monetizing their content and expertise.

Side note

Video Compression

When digitized, an ordinary analog video sequence can consume as much as 165 Mbps (million bits per second), equivalent to over 20 MBs (megabytes) of data per second. As may be expected, a series of techniques –called *video compression* techniques – have been derived to reduce this high *bit-rate*. The ability to perform this task is quantified by the *compression ratio*. As the compression ratio gets higher, the bandwidth consumption lessens. Of course, the goal of compression is to reduce the data rate while keeping the image quality as high as possible.

What is a 'codec' ?

Codec is a short name for coder-decoder, the algorithm that takes a raw data file and turns it into a compressed file (or the inverse-algorithm when it is the case for decompressing). Codecs may be found in hardware (such as in DV camcorders and capture cards) or in software. When compressed files contain only some of the data found in the original file, and actually codec is the necessary "translator" that decides what data makes it to the compressed version and what data gets discarded. In brief, a codec is used to compress and then decompress the content to get the compression needed to work with digital audio and video.

Video content that is compressed using one standard cannot be decompressed with a different standard. This is simply because one algorithm cannot correctly decode the output from another algorithm but it is possible to implement many different codecs in the same software or hardware, which would then enable multiple formats to be compressed.

**side note*

Recent History

In the late 1980s the Motion Picture Experts Group (MPEG) was formed with the purpose of deriving a standard for the coding of moving pictures and audio. It has since produced the standards for MPEG 1, MPEG-2, and MPEG-4 as well as standards not concerned with the actual coding of multimedia, such as MPEG-7 and MPEG-21.
(also see: MPEG, p.5)

**side note*

The Basics of Video Compression

To begin with, we have to note that majority of video codecs uses ***lossy compression*** meaning that through the compression data is reduced to an extent where the original information cannot be obtained when the video is decompressed.

Lossless codecs perform an average *compression factor* of over 3, but a typical MPEG-4 lossy compression video has a compression factor between 20 and 200. As in all lossy compression, there is a tradeoff between video quality, cost of processing of compression and decompression, and system requirements. Highly/overly compressed video may present visible or distracting *artifacts* such as *contour* or *blockiness*. But keep in mind that in most cases, human eye cannot detect this reduced detail (loss of video data) when viewing the decompressed video.

A number of codecs compress video using ***intraframe*** compression. With intraframe, or *spatial* compression, each frame of video is compressed separately. Many video compression schemes start by discarding color detail in the picture. As long as this type of compression is not too severe, it is generally acceptable. Also common is ***interframe***, or *temporal* compression. This type of compression takes advantage of the fact that any given frame of video is often very similar to the frames before and after it. Instead of storing all complete frames, interframe compression saves just the image data that is different.

In brief, basic compression scheme for most standards can be summarized as follows: divide the picture into blocks, determine relevant picture information, discard redundant or insignificant information, and encode relevant picture information with the least number of bits possible.

All of these techniques are based on an accurate understanding of how the human brain and eyes work together to form a complex visual system. As a result of these subtle reductions, a significant reduction in the resultant file size for the video is achievable with little or no adverse effect in visual quality.

Side note

CBR and VBR

Some codecs have a fixed compression ratio that compresses video at a fixed data rate *(Constant Bit Rate* **-** ***CBR).*** Others can compress each frame differently depending on the content, resulting in a data rate that varies over time *(Variable Bit Rate* **-** ***VBR).***

The optimal selection depends on the application and available network infrastructure. With limited bandwidth available, the preferred mode is normally CBR as this mode generates a constant and predefined bit rate. The disadvantage with CBR is that image quality will vary. While the quality will remain relatively high when there is no or little motion in a scene, it will significantly decrease with increased motion.

With VBR, a predefined level of image quality can be maintained regardless of motion or the lack of it in a scene. This is often desirable for applications where there is a need for high quality. Since the bit rate in VBR may vary -even when an average target bit rate is defined- the network infrastructure (available bandwidth) for such a system needs to have a higher capacity.

Side note

An Overview of Compression Formats

MPEG

Early parts of ***MPEG-1*** were released in 1993, becoming the first public standard of the MPEG committee. It is commonly limited to about 1.5 Mbps, although the specification is capable of much higher bit rates. It was basically designed to allow video and audio to be encoded into the bitrate of a CD. It is still used on Video CDs (VCD) and can be used for low-quality video on DVD. It was also used in digital satellite/cable TV services before MPEG-2 became widespread.

The ***MPEG-2*** project mainly focused on extending the compression technique of MPEG-1 to cover larger pictures and higher quality at the expense of a higher bandwidth usage. MPEG-2 also provides more advanced techniques to enhance the video quality at the same bit rate. Of course, the expense is the need for far more complex equipment. MPEG-2 is considered important because it has been chosen as the compression scheme for over-the-air digital television *ATSC, DVB* and *ISDB*, digital satellite TV services, digital cable television signals, SVCD and DVD Video. It is also used for Blu-ray discs.

The next generation of MPEG, ***MPEG-4***, is based upon the same techniques with MPEG-1 and MPEG-2. Once again, the new standard focused on growing needs. Support for lower bandwidth consuming applications, e.g. mobile devices like cell phones, and also support for applications with extremely high quality and almost unlimited bandwidth is the most important new feature of MPEG-4. It is also applicable with any frame rate, while MPEG-2 was locked to 25 fps for PAL and 30 fps for NTSC.

Side note

Getting Complex

The broadcast world is going digital, and the digital domain is expanding enormously for video professionals. In the past, 'going digital' meant taking video from analog tape, encoding it to MPEG-2 and then transmitting it. However, the entire broadcast landscape is getting more complex with distribution via terrestrial, satellite, cable, DVD, internet and mobile; not just standard definition (SD) but also high definition (HD) and many other resolutions to suit the new distribution media. Content is being re-purposed at these different resolutions and frame rates, using various new codecs and at different bit rates, with different system requirements for each.

Side note

Side note

DV

DV was launched in 1995 with joint efforts by leading producers of video camcorders. DV25 (compression format) uses lossy compression of video while audio is stored uncompressed. An intraframe video compression scheme is used to compress video on a frame-by-frame basis. DV25 is compressed at a fixed rate of 5:1 and delivers video at 25 Mbps (audio and control information is also included in the data stream). 1 hour of DV25 footage takes 13 GBs (gigabytes), also meaning that a mini-DV cassette stands for 13 GB offline storage at the same time.

Side note

H.264

H.264/MPEG-4 Part 10 or AVC (*Advanced Video Coding*) is currently one of the most commonly used formats for recording, compression and distribution of high definition (HD) video. The first version of the standard was released in 2003.

The main goal for the initiative was to provide good video quality at substantially lower bit rates (to be precise; an average bit rate reduction of 50% given a fixed video quality compared with any other video standard) with better error robustness than previous standards or better video quality at an unchanged bit rate. The standard is further designed to give lower ***latency*** as well as better quality for higher latency.

An additional goal was to provide enough flexibility to allow the standard to be applied to a wide variety of applications: for both low and high bit rates, for low and high resolution video, and with high and low latency demands. Entertainment video including broadcast, satellite, cable and DVD (1-10 Mbps, high latency); telecom services (<1Mbps, low latency); streaming services (low bit-rate, high latency) are included in this variety.

Side note

Everywhere

H.264 is widely used by streaming internet sources, such as videos from Vimeo, YouTube, and iTunes Store, web software such as the Adobe Flash Player and Microsoft Silverlight, and also various HDTV broadcasts over terrestrial (ATSC, ISDB-T, DVB-T or DVB-T2), cable (DVB-C) and satellite (DVB-S and DVB-S2) and is also one of the codec standards for Blue-ray Discs.

Side note

MXF

*First of all, **Material Exchange Format (MXF)** is not a compression scheme. It is a powerful file format that simplifies the integration of systems using other compression formats (MPEG, DV etc. as well as future, as yet unspecified formats)*

Changing technology of television production and digital services means the ways for moving content --programme video and audio- in studios is changing too. Not only is there far greater use of computers and IT-related products, but also reliance on automation and the re-use of material have expanded. Besides the need to carry metadata, file transfers are needed to fit with computer operations and streamed for real-time operations.

The development of the Material Exchange Format (MXF) is a quest of collaboration between manufacturers and between major organizations such as **Pro-MPEG**, **EBU** (European Broadcasting Union) and **AAF** (Advanced Authoring Format) Association (first developed in 2000). Main goal was to achieve interoperability of content between various applications used in the television production chain, leading to operational efficiency and creative freedom through a unified networked environment.

MXF bundles video, audio, and programme data together (together termed as ***essence***) along with metadata and places them into a wrapper. Its body is stream based and carries the essence and some of the metadata. It holds a sequence of video frames, each complete with associated audio and data essence, plus frame-based metadata. The latter typically comprises timecode and file format information for each of the video frames.

**Side note*

Which MXF ?

Make no mistake, MXF is not monolithic. You must be aware that we are talking about a toolset, and products using this toolset expose different control knobs named 'operational platforms'. Most products in the market today use either **OP1A** or **OPAtom** control knobs, and it is not surprising that these "OPs" are so widely used. These are the simplest MXF configurations, and it was perfectly expectable that these would be the first ones to reach the market.

**Side note*

Working with Digital Video

There are a wide variety of factors to consider when bringing *digital* into your workflow. A video workflow may be as simple as converting a file to the right format and delivering it. Or it may be much more complex, involving automated processes from ingest to asset management, asset management to editing, editing for various distribution points, and so on.

Acquiring and Delivering Your Content

Encoding Video

Everything naturally starts with source footage, either native-digital or digitized. In order to digitize and/or transform your content to the format and specifications you need, a capture/encoding tool is essential. But it needs to do more than simple video and audio compression. Most important of all, it must be able to accept multiple sources such as analog video (composite, component, S-Video), digital video (SDI, HD-SDI), IP stream and DVB. And of course various different video profiles such as SD PAL or HD NTSC, and various formats such as AVI, MPEG, MXF, H.264, Quicktime or XDCAM. That said, it is important to assess your workflow plans to find a solution that best fits to your current capture needs, while offering the flexibility to address future needs.

Side note

Analog Capture

Yes, we are the ones who told you video has made the transition from analog to digital but make no mistake, there are analog camcorders and VTRs available and are widely used still today. Chances are you will come across some of them yourself. So, you may have to encode analog video to digital; which requires an encoding solution that is analog-available. Your camcorder or VTR connects directly (composite, S-video, component) to your capture software through a digitizing hardware (hardware video capture board) and encoded as a digital file in a video profile or multiple profiles you designate.

Side note

Transcoding Video

What do you need your materials to be transformed into? This is one of the most important questions when working with digital video but generally easy to answer, because the target-viewing platform e.g. mobile phones or web browsers will mostly dictate the profile and specifications of your output. So it is again the time to assess your workflow plans to find a solution that offers a broad range of settings and variables to transcode your video to address different destination devices, including TV, HDTV, DVD, IPTV or mobile phones etc. Since formats and viewing platforms are evolving and changing every day, it is important to choose an encoder/transcoder that is frequently updated to support these needs.

Besides, other transformations except video format will be mostly included in your transcode process such as ***scaling***, ***de-interlacing***, ***frame rate conversion*** etc. These variables (pre-processing) also have a direct impact on the final quality of your video so it is utmost importance to be sure that your encoding/transcoding solution handles these transformations with ease, producing high quality results. Some encoding tools include preset templates to simplify this process; others allow you to customize the settings. The certain quality of the final product depends on the ability to fine-tune settings, using both templates and customized settings in your transcoding software.

If accuracy and quality is rule number 1 for business success, of course speed and quickness is 1A. High quality is worthless if cannot be delivered to your clients on time. As an important part of the sector going HD in our day (with substantially bigger file sizes and computer intensity on the process), the question of speed becomes much more crucial. How much time encoding takes for a certain profile is mainly dependent on both the workstation hardware and the software that runs it. For hardware point of view; encoding is mainly a CPU intensive process (GPU may be also heavily involved in the process , see side note- *hardware accelerated encoding*) and also encoding speed is directly related to the data transfer rate of the hard drives used. On the other hand, it is important to use a software solution that is optimized for speed and has the ability to accelerate the process.

Side note

Hardware Accelerated Encoding

Over the past few years, we have witnessed the development of hardware-accelerated video transcoding. That means a surge in the availability of graphics cards and processors that can decode and subsequently re-encode compressed video, whether using graphics processor - GPU shaders or dedicated transcoding logic.

Intel® SandyBridge enabled CPU and motherboards, coupled with Intel on-board graphics, provide the option to off-load **H.264** encoding from the CPU to the GPU. Some branded workstations are certified with SandyBridge technology, such as the *HP Z-220*. That means in a single workstation – using a supporting software-, it is now possible to capture 4x full HD inputs or 8x SD inputs into files, streams or both.

Side note

Streaming Video

Video streaming is the act of transmitting compressed audiovisual content across a private or public network (like the Internet, a LAN, satellite, or cable television) to be processed and played back on a client player (such as a TV, smart phone or computer) while enabling real time or on-demand audio, video and multimedia content.

IPTV is a system through which television services are delivered using the IP suite over a network such as the Internet, instead of being delivered through traditional terrestrial, satellite signal, and cable television formats. As of 2013, it is safe to note that this is not a fresh innovation only big broadcasters try to explore, but one common and requested delivery method for not only the individuals but also professional video. IPTV services include the famous ***VOD*** and ***local IPTV*** as well as **live** television or ***time-shifted*** television broadcast.

Video on Demand (**VOD**) systems allow users to select and view audio and video content using IPTV technology. VOD is seen as the next chapter after traditional TV and is a fast growing business around the world. Most attractive aspect probably being that the end-user can control the experience by manipulating controls on the player interface to move forward or backward, to pause or to jump to any point in the program, like an actual DVD experience.

It appears that you will need to deliver your live or on-demand content as an IP stream sometime soon if not already. Better to have an encoding solution which can also be described as a '**streamer'**. In the case of a small production, live concert for Internet; the workflow clearly needs quality and stable capturing/transcoding/streaming from the same encoding tool.

Side note
UDP, RTP, STP ?
User Datagram Protocol (UDP) is a member of the IP suite which allows computer applications to send datagrams to other hosts without prior efforts to set up paths. Well, UDP is the sole base IPTV relies on. **Real Time Transport Protocol (RTP)** defines standardized packages for video and audio over IP (works with UDP) and **Session Description Protocol (SDP)** works in conjunction with RTP in some IPTV applications focusing on negotiations between end points about session profile.
Side note

Side note
Local IPTV
Local IPTV is designed to distribute television and video across building and campus networks over a local area network (LAN). The content is sent directly to campus LAN allowing very high quality (result of a comparatively limitless bandwidth) and advanced access controls with relatively lower costs.
Side note

Side note
Online Marketing
Online video is playing an increasingly important role in both business-to-consumer (B2C) and business-to-business (B2B) marketing. According to comScore, Americans are watching more online video than ever with over a hundred million viewers per day in the United States in 2011, a 43 percent increase over 2010. The number of videos viewed per month rose from 30. 1 million to 43.5 million and the number of videos per viewer rose from 175 to 239 per months over the same period. In addition, the average viewing time per video rose from 5 minutes to 5.8 minutes.
Side note

Polishing Your Content: **Post-Production**

Shooting (or for other cases, acquiring) the raw footage is *production*. Lighting, setting, working with talent, working out camera angles or such are your primary concerns while getting the images and sound on tape or film. At the end, you will have a collection of clips (at different places and times) from your production.

Post-production on the other hand, is the creative process of video production and can be described as an art or a skill. To be able to actually develop and deliver your story and final work; you need editing and assembling your clips, adding visual effects, graphics and a soundtrack etc. and to go with all of that, lots of artistic creativity and editing technique.

This is where we meet ***Non-Linear Editing*** (NLE), the widespread system for post-production process superseding ***film editing*** and ***linear editing***. NLE is commonly used to describe digital editing systems which are able to perform *non-destructive* editing –source files are not lost or modified- on the source material. This is achieved by means of ***EDL*** (edit decision list) which contains an ordered list for sequences of images stored on disk and/or timecode data representing where each video clip can be obtained in order to conform the final cut thus eliminating the need to change the initial raw material.

Post production is done by means of one of the wide range NLE software running a dedicated workstation. In addition to simple trim and editing, they often include easy to use features such as real-time editing and rendering, making transitions, adding effects, titles and graphics, color correction, mixing and synchronizing audio etc.

Many editors build complex and sophisticated digital videos from tens or hundreds (or even thousands) of highly modular digital building blocks. NLE and its modular approach lets editors and others quickly exchange various parts and create myriad new forms consistent in look and feel with the originals. It dramatically reduces cost and time to market for your content.

As we see it, it is an important key for successful video production to be comfortable with your NLE solution as well as the NLE integration in your workflow. You must play and explore different brands products, study with your needs and listen to your editing team's idea before deciding on your NLE software. Another important aspect is the integration with your workflow because your editors must be able to access and use the content (whether proxy or full resolution) they need from your central archive (library) according to their security settings and access permissions. True MAM solutions provide built-in ***GUI*** (*graphical user interface*) extensions designed and developed to be used in popular NLE softwares and also they have the ability to generate EDLs and export to NLE software to save significant time and budget for post-production phase.

Side note
NLE History
AVID introduced the first successful NLE system, AVID/1 in 1989. In early 1990s, it was already accepted as the industry standard for digital video editing. During 1990s a wider professional choice range became available and spread, including Adobe **Premiere**, Apple **Final Cut** and Grassvalley **Edius** (developed and released by Canopus until 2005).
Side note

Managing and Archiving Your Content : **Media Asset Management**

As might be expected, one of the most pressing challenges facing the media and entertainment industry is the rapid growth of content stored and delivered digitally and how to manage it through all phases of the workflow process. The need for **Media Asset Management** (MAM) systems grew out of a desire to organize, manipulate, store and share media quickly and easily. With correct workflow design and a skillful product, MAM systems can help building a better business, simply being able to leverage existing revenue sources (repurposing, new content iteration etc.) as well as the ability to tap into new revenue sources (automated delivery for IPTV and mobile platforms or monetizing assets by making them available to other content providers for a fee, etc.)

A ***digital asset*** is any item of text or media that has been formatted digitally and categorized in three major groups which may be defined as textual content (digital assets), images and multimedia (media assets).

Side note
'Media Asset'
Media assets are generally created in the MAM software by combining any media object (video file, audio file, picture file, documents, tape cassettes, etc.) and some attributes such as metadata, category, proxy and storyboard related to this object.
Side note

In the sense of broadcast and IT, ***Media Asset Management*** (**MAM**) is a general term that refers to any function a client performs in the process of managing and storing media. Media asset management is a type of *digital asset management* (DAM). In common use, media asset management can mean the same as DAM, but it technically refers specifically to management tasks involving media file types, which usually include audio, video, and images.

When speaking of managing content, ***metadata*** is essential. Simply put, metadata is 'data about data' -information about a video file, audio clip, or a web page like file locations, assigned IDs, durations, titles, descriptions, annotations, key words, usage rights-. With a rich metadata catalogue of assets and advanced search capabilities, users spend less time searching and more time finding/creating content. Simply, a true MAM solution provides many defining categories and unlimited metadata fields for search optimization within your organization and for the delivery platform to your clients.

Side note
Numbers

News production is one of the most exciting and pressing part of broadcast, where it is always uber-dynamic and competitive. In a news environment, creating newly generated material can cost 1.000-3.000 US dollars per minute, while extracting it from the archive can reduce that expense to somewhere as 1-3 US dollars per minute. Studies show that the introduction of a MAM system typically allows customers to increase the efficiency and the percentage of reused news material from 10% to 40%. With the help of MAM automation process, what (or whatever) once took days now takes hours. That is why ROI analyses with existing customers reveals that many MAM-supported processes achieve a complete ROI in less than a year.

**Side note*

As previously mentioned, video conversion takes an important place in a digital video workflow. In that regard, a key advantage of MAM solutions is their ability to do video conversions/transcoding on the fly so there is no need for you to provide/use more than one version of video. Also, when working with videos in your workflow, ***proxy*** concept is important. Proxy is a lower resolution copy of the original file, resulting with less storage and bandwidth consumption. Also, as it is faster, it is often used in workflows when tape library archiving is used.

When ideally built, your MAM system will monitor designated folders (watch folder) and automatically creates assets/proxies –storyboards and metadata also, if needed- from the files existing in the watch folder, concurrently archiving the same files on your central storage according to predefined rules. This, as expected, maximizes workflow efficiency.

Another big advantage of MAM systems is the help they offer with distribution of tasks and security. Within organizations, user and administrator access levels and permissions are of a big importance. Different work groups like editors, marketing, management or admins have to be defined with different access levels (e.g. raw footage, edited videos or proxies) and permissions for manipulating the content (e.g. read, edit, or delete). It is also possible to track back all changes on your assets with advanced logging options.

At the end of the day, it is clear that –in business sense- your media and data are your most valuable assets. Defining a strategy to manage, store, and access these assets is critical to your success. Storage requirements are exploding as more content is captured in HD, facilities migrate from tape-based analog and digital assets to file-based workflows, and content is produced in multiple formats to address audience consumption requirements. It is more important than ever to prepare for the growth of MAM systems and related storage environments. Today's workflows require fast access to content for editing and repurposing, which imposes a need for a storage infrastructure and asset management system that addresses performance, capacity, and the preservation of these digital assets.

**Side note*

Broadcast point of view

While broadcasters have used asset management systems in the form of program tape libraries and news clip archives since the beginning of television, the advent of digital files as the primary media for audiovisual content and increasing requirements for the repurposing of video assets have created a demand for more sophisticated asset management tools. It is not an overstatement that todays MAM is simply life-blood for your whole workflow, managing your whole storage and integrating with third party products where needed while presenting instrumental features for your technical team as well as the flexibility for possible future developments and needs.

**Side note*

Finally, providing a backbone for a flexible production and distribution infrastructure with different interfaces, enabling integration with a wide variety of products and tools is what should be expected from an ideal MAM system. Broadcasters and integrators as well as all businesses including digital media, can use this to adapt the solution without changes to the core platform. MAM system can be utilized in workflows with third parties connected to the system to extend the overall capabilities for post-production, archiving, playout and traffic systems, workflow automations, distribution and web delivery.

In conclusion, Media Asset Management solutions provide a wide array of competitive advantages to any business enterprise. These include creation of more efficient processes, better utilization of resources, more effective monetization of existing content, generation of new revenue streams and development of a platform for sustained growth, now and in the future.

For the role and benefits of MAM in your post-production processes, please see Post-Production in this whitepaper.