

WebCCTV & Codecs: Why... What... Which... How...



Management summary

This white paper deals with the standard video formats that Quadrox uses in its software. It explains the basics of digital video, as well as the specific compression and container formats that you might encounter when using Quadrox software. After reading this white paper, you should know which codecs to use in which situations, and how to ensure that you can play back a video file created by Quadrox.

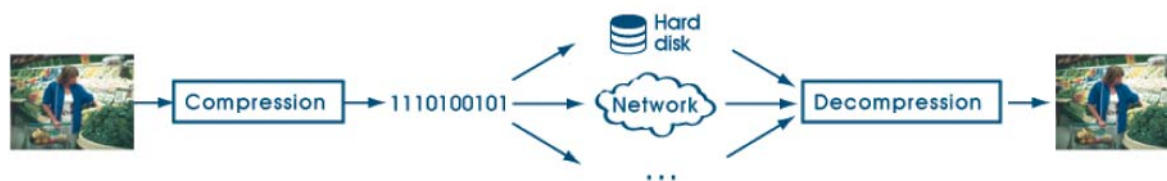
Video basics

Uncompressed digital video consists of a series of digital images that, if displayed in quick succession on a computer screen, give the impression of a moving image. Each digital image is an array of image points, called pixels, which are just numbers representing the brightness and colour of that particular point.



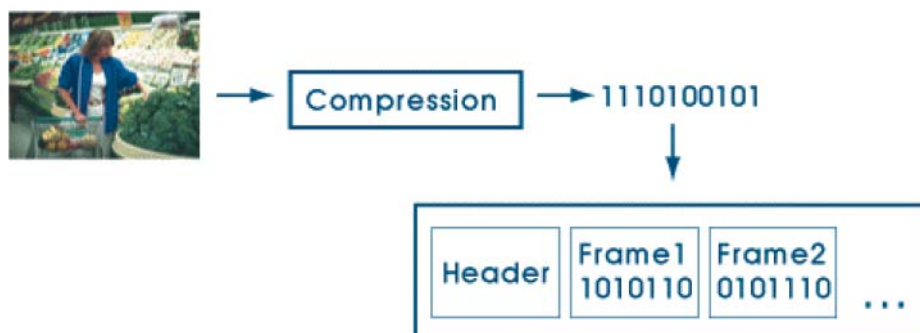
You will understand that with more than 300 000 pixels per image (depending on the resolution), a couple of bytes per pixel and 25 images per second, digital video constitutes a huge amount of data that needs to be stored or transmitted over the network. In fact, video is one of the most data-intensive applications in modern computing. That is why it is important to have a good compression algorithm and a good infrastructure to support such data flows.

Luckily, digital video can be represented with much fewer bits by using a mathematical compression algorithm. This algorithm is often referred to as a codec – short for COmpressor/DECompressor. It works by representing the video data in a different way and retaining only information that is relevant to the human eye. The result is a complex data structure, which can only be visualised after decompressing it to its original form.



Not every codec is the same. Some algorithms manage to select the most relevant information better than others, resulting in a better visual quality for the same data size. Also different implementations of the same algorithm differ greatly in quality, speed and performance. For instance, many implementations exist of the popular MPEG-4 algorithm, but only few of them will give you the quality that matches the hype.

After applying a codec to digital video, you end up with raw compressed data. This data is stored in a special file format, called a video container, taking into account its special properties. It is crucial that you understand that the container – or file format – is not the same as the video data itself. Consider it as the map in which you store your paperwork.



The choice of container does not affect the visual quality of the video. However it provides facilities for handling the video data more easily. You will be able to find your papers more easily in a nice map with separation pages than in a shoebox.

As another analogy, we can consider text files. Although the content of the text in a .txt file and in a .doc file can be exactly the same, in the .doc file (generated in Microsoft Word) you will be able to store layouts, tables, etc, which will make your text easier to read and navigate, and just nicer to look at.

Similarly, the different video containers offer different facilities to the application that works with them. Video file formats differ in popularity – which influences the amount of players that support it – quick random access to the data and robustness against failure and file corruption. It is important that you choose the file format that best suites your needs, especially in the security industry.

Video container in Quadrox software: ASF

The file format – or video container – used by Quadrox is Microsoft’s Advanced Systems Format, or ASF. This format is part of Windows Media. Microsoft defines it as “an extensible file format designed to store synchronized multimedia data”. It supports data delivery over a wide variety of networks and protocols while still proving suitable for local playback. For all practical applications, it can be considered as the successor of the AVI, the well-known previous video container from Microsoft.

In fact, Microsoft provides three file formats for multimedia data, which are all very similar to each other: ASF, WMV and WMA. The latter two are limited to contain only data that is compressed using the Windows Media codecs; additionally WMA can contain only audio data.

ASF however can contain all types of multimedia data, no matter its form or origin. For example, popular compression formats like (motion) JPEG and MPEG-4 can be stored in ASF files without a problem. This makes it a very versatile and flexible container format.

ASF is an open format. Not only did Microsoft publish an SDK to work with it, but also the specification of the format is freely available on the Microsoft website¹. Any software developer can use the SDK and specification to make an application that uses this format, on any platform or operating system. As a result, most popular video players in the market today support ASF files.

¹ <http://www.microsoft.com/windows/windowsmedia/format/asfspec.aspx>

Another advantage of using the open format is that you can not only play the WebCCTV recorded files anywhere, but also process them without knowledge of the internal working or protocols of WebCCTV. You do not need an SDK from Quadrox to work with our files. This is useful if you want to extract information (e.g. a still picture of a part of the image), enhance the images, do calculations on them or any other form of processing, whether you are a software integrator, a developer of video algorithms or a forensic expert at the police.

ASF is designed for video streaming over networks, as well as local playback on a computer. This is a major improvement over its predecessor, AVI. An AVI file needs to be fully available (e.g. downloaded) before you can play it. This means that if the transmission – over a network, but also to a hard disk – is interrupted for any reason, the file will be corrupted and you will not be able to play it back.

Because an ASF file or stream does not need to be complete before you start to play it, any corruption that may occur will not affect the entire file. This is a great advancement in robustness against slow and unreliable networks like the Internet, but also against e.g. sudden power cuts at the video recorder side. It also reduces the delay before you can see video.

Additionally, ASF has provisions for advanced streaming features that provide you with the best quality of service (QoS), like multi-bit-rate video for instance. It also has the ability to store metadata, index and script commands, and other types of information. The file container supports files as large as 17 million terabytes.

All of this gives Quadrox the opportunity to provide you with robust recording, easily usable video and advanced features in the WebCCTV recording software.

Codecs in Quadrox software

At Quadrox, we try to avoid (re-)compression of digital video coming from network cameras, since this can only lead to a degradation of quality and because it affects the overall performance of the system due to the CPU-intensive nature of video processing. Thus we support multiple codecs: any codec that is playable by Windows Media (DirectShow). The main codecs used by Quadrox and security camera manufacturers are WMV (Windows Media), Motion JPEG and MPEG-4.

The WMV codec is delivered by default with every Windows Media Player. And as you know, a Windows Media Player is available on every machine with the Windows operating system, which comprise over 90% of all desktop computers in the market. As a result, movies that are exported in WMV are playable on virtually any machine in the field. Also many standalone video players like DVD players nowadays allow WMV video to be played on televisions and other devices in your home or office. WMV is used in WebCCTV for compression of analogue cameras for recording and recompression for network cameras in low bandwidth mode.

JPEG stands for Joint Picture Expert Group. Apart from a committee, it is also a standard for the compression of still pictures. JPEG is one of the most common and wide spread image formats.

When every frame of a video sequence is compressed using the JPEG standard, we speak of Motion JPEG or MJPEG. Although JPEG is standard, MJPEG is not. Apart from its definition as a sequence of JPEG images, there are no agreements on the details of an MJPEG stream and different manufacturers make their own interpretation of it. Still, it is a very popular format in security video (network) cameras and recorders alike, due to its simplicity.

Quadrox uses MJPEG for live streaming of analogue video. All incoming MJPEG streams from network cameras are used for recording and streaming without recompression. The so-called fourCC code (a 4-letter name for the codec in the file and stream headers) for WebCCTV's MJPEG streams is JR24.

Quadrox has also developed a variant to MJPEG in which only those areas of the image that visually changed are coded and transmitted. We call it Differential JPEG, and it is used for streaming analogue cameras in low bandwidth mode. It is similar to Mobotix' MxPEG compression, but neither are standard compression mechanisms. That is why they are being phased out in Quadrox software.

A compression standard that has gained a lot of popularity in security video lately is MPEG-4. MPEG stands for the Motion Picture Expert Group, a committee that has produced several video standards including MPEG-2 (DVD), MPEG-4 and H.264 (also known as MPEG-4 part 10).

Technically, MPEG-4 is similar (but not the same) as WMV. Both provide compression efficiency by encoding only differences between frames, and not each frame separately. This makes them more efficient (less bits for the same quality) but also heavier in processing than MJPEG.

MPEG-4 is used in WebCCTV when network cameras use this format. The Quadrox software uses it for streaming and recording without recompression.

An overview of which codec is used for each type of camera in the Quadrox software, can be found in the table below.

| | Recording + Export | Live (High Bandwidth) | Live (Low Bandwidth) |
|------------------|--------------------|-----------------------|----------------------------|
| Analogue Cameras | WMV | MJPEG | Diff JPEG |
| Network Cameras | MJPEG/MPEG-4 | MJPEG/MPEG-4 | WMV (Recompression)/MPEG-4 |

Where do you need codecs?

Every time you compress or decompress a video stream in one of the formats above, you need a codec. This is true for all video-related software and hardware devices from every manufacturer. A codec can be implemented in hardware as part of a chip, it can be embedded in the software or provided as a separately installed component that is used by a general platform. WebCCTV mostly makes use of the latter: the platform that our software is based on is DirectShow, and codecs are provided as so-called DirectShow filters.

Let's start with compression. In analogue DVRs, the video is transformed from an analogue into a digital signal by a hardware capture card inside the recorder. WebCCTV then compresses this digital data on the recorder's processor. Hence the appropriate compression codecs are needed on the recorder.

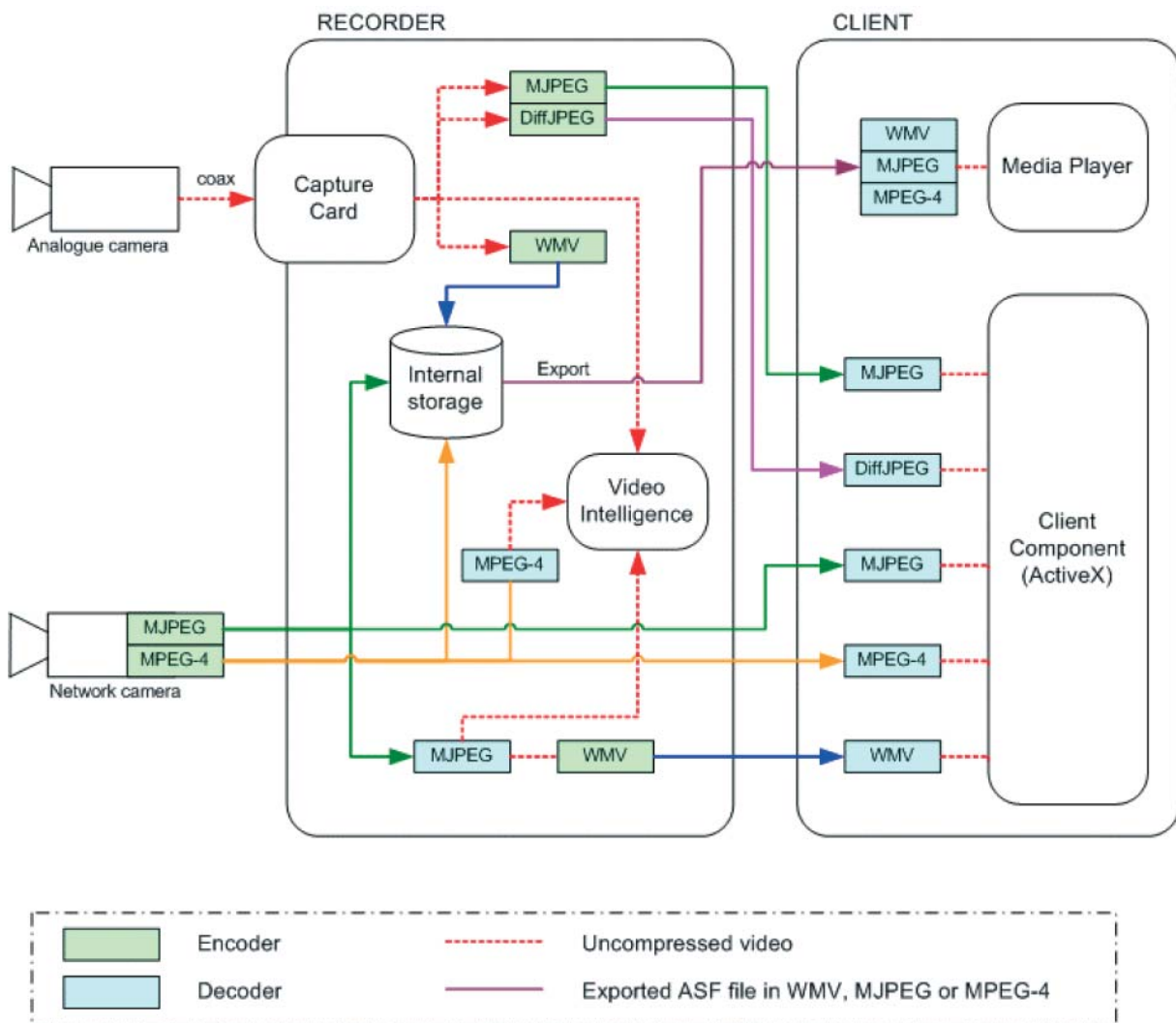
When using network cameras however, compression is done in the hardware of the camera itself. The data is transmitted over the network and arrives at the recorder in compressed digital form. In theory, no codecs are needed in the recorder for the data to be recorded or streamed.

There are two notable exceptions to this. The first occurs when the recorder somehow needs to process the video, e.g. to calculate the amount of activity or to run a video intelligence algorithm on it. Calculations on video have to be done on uncompressed video, so we need a decoder on the recorder.

Secondly, in some cases the video needs to be recompressed, e.g. in low bandwidth mode. Recompression is simply decompressing and then compressing again the resulting raw images. Both decoders and encoders are needed in this case. Of course, this action takes quite a lot of resources and there is always quality loss involved, so recompression is avoided as much as possible.

In order to visualise a video stream in the WebCCTV application, the images first have to be decompressed. This means that a decoder should be present on every video client.

When exporting a movie, WebCCTV doesn't recompress the movie. It simply copies the images from the internal storage into a new ASF container (file). This process is called transmultiplexing, and it doesn't require any codecs. When an exported file is played however, again a decoder is needed before visualisation, just like with the visualisation inside the application.



Bringing it all together: Codecs in practice

To make your life easy, Quadrox provides a codec pack that contains all the mentioned codecs. Installing this codec pack on a client machine or a PC at which you want to play an exported file should ensure that all the necessary decoders are installed.

An overview of the default available codecs for most systems in the market can be found in the table below.

| | Default installed ² | ActiveX ³ | Manual installation (Quadrox Codecs Pack) ⁴ |
|------------------------------------|--------------------------------|----------------------|--|
| Recorder ⁵ | WMV/MJPEG/Diff JPEG/MPEG-4 | | |
| Client(Windows) ⁶ | WMV | MJPEG/Diff JPEG | MPEG-4 |
| PC for playing Export (Windows) | WMV | | MJPEG/MPEG-4 |
| PC for playing Export(Non Windows) | | | MJPEG/MPEG-4/WMV |

On the recorder itself, all needed codecs are installed by default. There are three encoders (WMV, MJPEG and Differential JPEG) and two decoders used for video intelligence and low bandwidth streaming (MJPEG and MPEG-4). WMV is delivered together with Windows Media. As MPEG-4 codec, we use the popular open source Xvid codec. This can be replaced by any other MPEG-4 codec. The MJPEG and differential JPEG implementations are proprietary.

For windows based client machines WMV is again pre-installed with Windows Media. MJPEG and Diff JPEG codecs are integrated in the ActiveX which will be installed automatically when connecting for the first time to the WebCCTV web application. MPEG-4 has to be installed manually if needed. This can easily be done by installing the Quadrox Codec Pack. MPEG-4 is not available through the ActiveX because of license restrictions.

The codec pack contains two MPEG-4 codecs - Xvid and DivX 5 - because of technical difficulties with playing MPEG-4 in Windows Media Player⁷. If you use another media player, you can use any MPEG-4 codec of your choice.

If you want to play exported files on a windows based PC which has never connected to the WebCCTV web application, only WMV is installed by default. The remaining codecs can (if necessary) easily be installed by using the Quadrox Codec Pack.

For non windows based PC's where you want to play exported files and has never connected to the web application, you have to install all codecs manually. Quadrox produces (and uses) only Windows software, so those codecs will come from the operating system manufacturers or other 3rd parties. This is possible because of the use of standard compression.

The MJPEG codec contained in both the ActiveX component and the Quadrox Codec Pack is a proprietary implementation, since MJPEG is not an official standard. However, the JPEG compression itself is standard, so you can use other MJPEG codecs (e.g. the Morgan M-JPEG filter) on your client PC or for playback of exported files. JPEG decoders for pictures (e.g. the ones used in image viewers or browsers) can not be used to decode MJPEG video streams.

² These codecs are installed by default on your Operating System.

³ These codecs are automatically installed if you connect for the first time to the WebCCTV web application.

⁴ The Quadrox Codecs Pack contains all necessary codecs and can be found at <http://www.webcctv.com/start.asp?main=tools>

⁵ The recorder is the unit on which the Quadrox WebCCTV software is installed.

⁶ The client PC is a PC which is used to connect to the WebCCTV recorder by opening the WebCCTV web application.

⁷ This is a problem of the Windows Media Player from Microsoft, not an issue with MPEG-4 or the way that Quadrox software records or streams video.

Conclusion

Quadrox uses ASF, an open format, as a container and standard compression algorithms (WMV, MJPEG, MPEG-4), separately available as DirectShow filters. This makes the software flexible (i.e. future compression technologies can easily be added), and it ensures that you can play WebCCTV video on your own choice of media player and with your own choice of codec manufacturer.

Sometimes this means that you will have to install such codecs yourselves, when we can't do it automatically due to license restrictions or because we don't have access to the PC on which an exported file is played. Yet, unlike many of our competitors, we don't believe in forcing you to use a proprietary video player with a proprietary codec embedded. This freedom of choice, and guaranteed access to the video without the need for Quadrox software, is at the very heart of the Quadrox philosophy.