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Canopus Video Editing System Base Technology

White Paper

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Canopus released its first video editing system in January 1998. Since then, Canopus hardware and software video products have flourished in markets around the world and made the company a leader in the industry. As Canopus products gained international acclaim, the fast, powerful and reliable performance of Canopus's high-quality video technology became apparent to video editors around the world.

Canopus's proprietary technologies are the key to our success and the reason why a company that manufactured video cards for gamers has become the leading provider of video editing systems.

This document aims to describe our technology for handling video images that is the foundation of all Canopus products and why our video editing systems outshine the rest.

Canopus Editing Solutions are :

Fast - Speed to guarantee world-class, realtime performance

Canopus video editing systems feature high-performance, realtime video processing and editing of HD resolution video.

Accurate - Accuracy to avoid degradation of the original images

There are three phases of the video editing process where the beauty of the original, high-quality HD images may get damaged—digitizing, editing and outputting. Canopus has developed its own algorithms and processes that work to minimize degradation of image quality while maintaining realtime performance.

Flexible - Flexibility to support various formats

Even though Canopus develops its own video processing technologies, our products have always been compatible with industry-standard components. Canopus editing systems can be seamlessly integrated into your existing workflow, and support for open standards makes it easy to edit mixed video formats.

Canopus Video Editing System Base Technology

Technology for Speed and Flexibility

The high performance and flexibility of Canopus Nonlinear Editing Systems allows it to edit a wide range of audio and video formats. This is possible because of our deep understanding of the PC platform's architecture, extensive research and experience optimizing hardware and software for the PC platform, and our long-standing commitment to providing realtime editing solutions to our customers.

1. Scalable Technology

What is scalable technology?

Scalable technology allows product performance to increase in proportion with the speed of the PC. This method, which has been perfected by only a few select companies, is a combination of the following technologies:

> PC technology
> High-speed software codec
> Algorithm optimization for maximum performance and ease of processing
> Support for multi-processor systems
> Optimized software that leverages the CPU's built-in instruction sets
> Buffering technology for faster hard disk drive access

Scalable technology guarantees that Canopus products have no limits on realtime processing and will can take full advantage of increases in PC performance as well.

Putting Scalable Technology to Use

The key to putting scalable technology into practice is the appropriate allocation of hardware and software processes.
Improvements in the processing speed of PCs are made every day, but the speed of fixed hardware stays the same. That is why Canopus focused on the design of both software and hardware, where the improvements made in CPU speed are directly reflected on the NLE performance, by removing the possibilities of the hardware speed impeding performance.

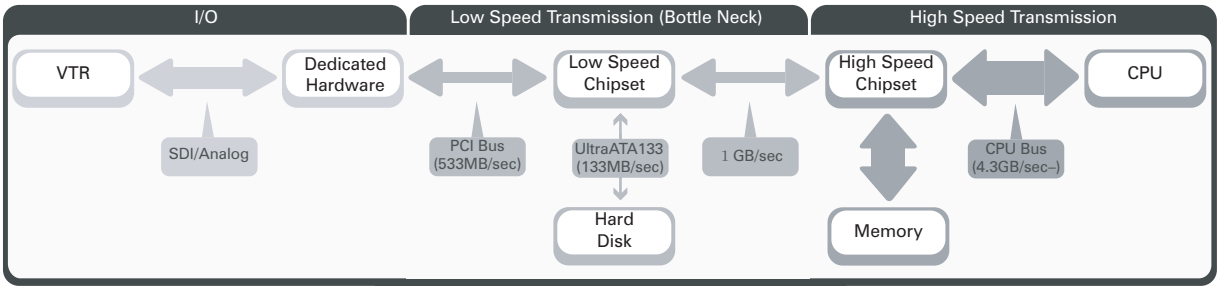
As a result, Canopus systems depend not on hardware, but on software for much of the arithmetic processes, including Codec and video effects. This is how scalable technology was born, where the improvements made in CPU performance are directly reflected on the system performance as a whole.

2. Mechanism for Putting Speed into Practice

Why should the software perform mathematical processes?

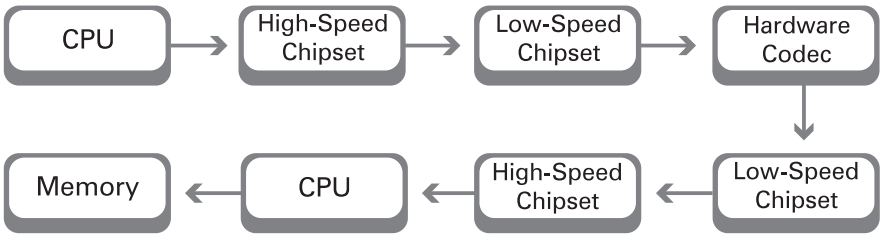
The main advantage for allowing hardware to perform mathematical processes (for example, codec encoding/decoding) is that it takes the processing burden off of the main CPU, freeing it up to perform other tasks. This is a point some of our competitors like to state in their comparative advertisements with our products. Why did Canopus decide to go a different way?

The answer can be found by looking at the basic computer architecture as seen in the figure below.
(note that the arrow thickness denotes relative speed)



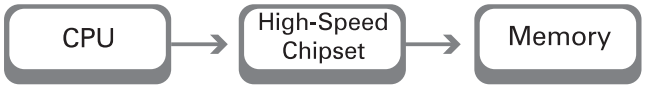
Dedicated hardware and hard disk drives are usually connected on the other side of the I/O, therefore data transmission from the CPU to the hardware must go through the very slow data transmission path between the CPU and I/O. When processes require transmission between the CPU and memory only, data is transmitted at high speed therefore the processes can be completed in a very short time.

Let's look at an example where codec processes are executed on hardware and the effects this has on software.
For image data to be decoded, processed, and encoded, the following round trip route will be taken:



For images to be processed in both the hardware and CPU, even if it is only being decoded, large amounts of data must be transmitted through the PCI bus twice. Additionally, each node must consider the timing of the transmission, which cannot surpass the speed in the bottleneck (lowest-speed) area.

On the other hand, the route the image data needs to take when a software codec is used and all processes are executed on the CPU is as follows:



In this scenario, all processes can be completed in the high-speed transmission area so high-speed CPU and memory performance can be fully utilized.

Compared to the data transmission speed between CPU and I/O, the transmission speed between the CPU and memory is 50 times faster. Valuable time is not wasted when a software codec is used.

This is especially important in the HD video industry where very large amounts of data are processed. With the improvements made in CPU performance nowadays, executing some of the processes on high-speed hardware will only increase needless time spent on data transmission and decrease performance of the system as a whole.

** However, it is necessary that the CPU handle the software codec at a sufficient speed. Canopus extensively studied image compression of DCT base images and thus have developed a superior software codec.*

In HD video editing, 150MB/sec for video and over 100MB/sec for HDD, for a total of 250Mbytes/sec of I/O bandwidth is required. The system requires other devices (i.e. gigabit network), which also use the PCI bus bandwidth.

Unfortunately, PCI bus usability is much lower than expected. If it goes over 70%, it is said to be very efficient. With this number in mind, when image processing is executed in devices on the PCI bus, the system will not have much power remaining for executing other processes.

This is another reason why data transmission with hardware should be minimized.

Flexibility is lost when all processes are executed on the hardware

You may think, “If executing only some of the processes on the hardware is inefficient, why not execute all processes on the hardware?” That is a good point.
Suppose there is an ideal hardware that can execute all processes, from codecs to effects, including various composites. Then, the PCI bus transmission will only be required for input and output; therefore the bottleneck will be eliminated.
This, however, will not only be very expensive, but will force the system capabilities to be fixed at the design stage without flexibility to allow changes in the system after it has been set up.

How long do you plan on using this implemented system? Go back however many years you answered and remember how things were then. Is the “latest hardware” on the market then still hot on the market now? With this market making remarkable progress every day, upgrade costs need to be considered more than initial costs.

Compared to hardware, software can respond with more flexibility to the changing times requiring a shorter development time without “limits” on making functional improvements. In other words, scalability in software applies not only to speed but also to its functionality.

Pursuing optimal balance between hardware and software processes

Please note, though, that Canopus editing systems do utilize hardware in selected parts of our systems. Importing and exporting from external devices cannot be executed without hardware.
You may be concerned about the bottleneck it may generate, but Canopus has come up with ways of making good use of hardware without getting in the way of the high-speed software by fully understanding the structure of the data flow. As long as the slow transmission between CPU and I/O is minimized, the bad effects of using hardware on the system as a whole w ill be minimal.
For processes that can be completed between I/O hardware and external devices, they are all entrusted to hardware (including scaling of image data, digital filter processing, and adjustment of quantifying bit numbers). These processes can be executed without intervention of the CPU, therefore will not increase data transmissions between the CPU and I/O. By working out such allocation of processes between the software and hardware, a high-speed system can be configured.

System performance can be improved even more by utilizing a buffering network, which absorbs the differences between the video transmission rate of the external I/O and processing rate of the software, the mechanism to ensure efficient data transmission to the hardware. This is another reason why Canopus systems are superior to the other systems available in the market today.

3. Software Technology for Maintaining Speed

In-house development

Canopus develops and engineers all of its own systems, including hardware designs, in house. This is why large optimization of the system as a whole, including hardware architecture, codec, and disk I/O, is possible. For plug-ins, we are pursuing speed without sacrificing accuracy by optimizing at the algorithm level.

Peephole optimization methods (local optimization) are normally used in optimizing software, but that alone cannot drastically speed up the process. However, by optimizing at the architecture or algorithm levels, dramatic speed improvements can be achieved. Canopus has achieved this level of optimization by developing the whole system in house.

Maximizing CPU performance

The algorithm is optimized by fully understanding the CPU. Most applications do not make use of SSE and MMX, which are multi-media command sets (even when they are used, areas used are limited, for peephole optimization only).

Canopus has developed our own architecture design for EDIUS to speed up the rendering path to its limit, which is optimized using SSE and MMX in most cases. “3D Now!” is also used where applicable.

Maximizing disk performance

By reducing “seek” in optimal scheduling of disk I/O, reading HD broadband data was made possible on IDE software RAID. This is also valid for those editing only DV footage. Being able to read HD streams means being able to read four DV streams.
All this allows multi-layered composites and editing on slow, fragmented disks. Unnecessarily high-speed hard drives no longer need to be used.

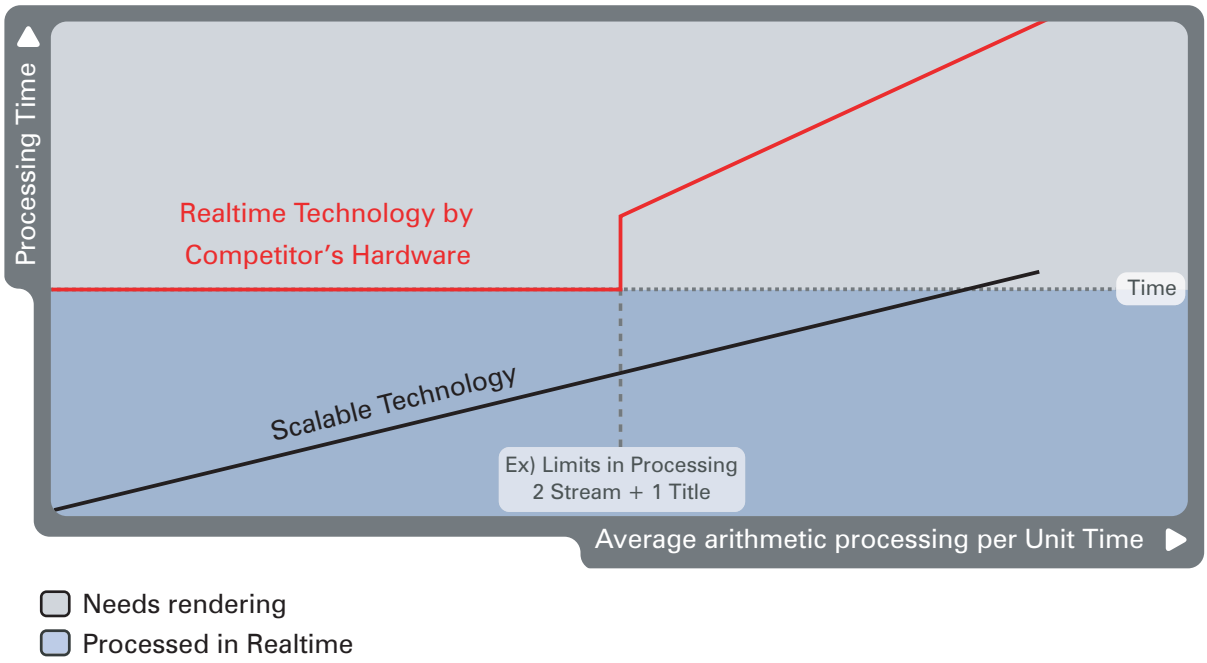
Reducing memory access

Adjusting memory access will improve efficiency somewhat, but this optimization method is to be expected. What is more effective in improving speed is to stop unnecessary copies.
For example, in a system where programs for reading data from the hardware, for processing images and outputting from the hardware are run separately, many unnecessary copies will be made even though it may look nice from the source code point of view. Many of the editing software packages out in the market now are designed this way. However, full-frame playback of HD is difficult with this kind of technology.
EDIUS was designed with consideration to the “data flow” from input to output, resulting in systems that do not make copies of the video data.

4. Characteristics of the Scalable System

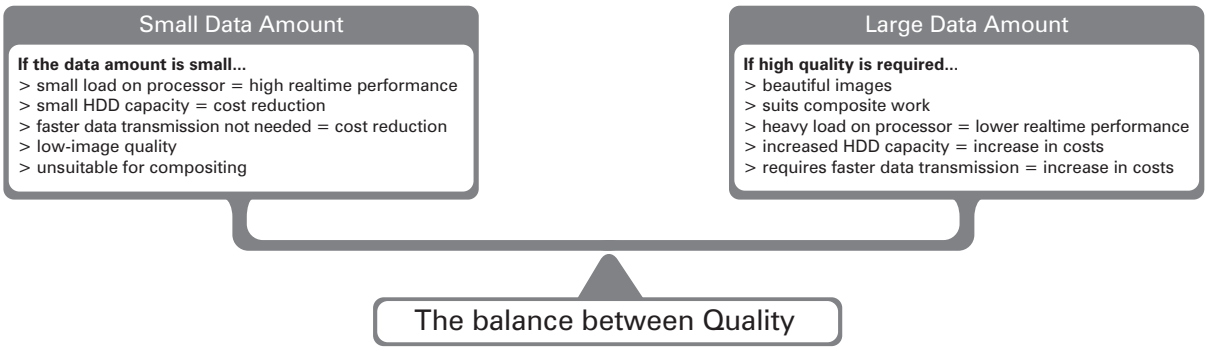
Realtime processing features in scalable technology

A system that executes realtime processing of two video streams + one title by utilizing hardware and a realtime processing system based on scalable technology are compared in the graph below. Realtime processing can be executed in the area below the horizontal realtime line.
As the process becomes heavier, the processing time becomes longer in the scalable technology system, and when it reaches a certain point, realtime processing is longer available. The load, though, is basically stable.
On the other hand, the hardware processing system can execute processes up to two video streams + one title in realtime up to a limit, but when it goes over that limit, rendering is needed and the processing speed suddenly drops. After that, since this system was not designed for executing processes using software, the speed drops at a much steeper rate compared to the system using scalable technology.



Norms for System Design, Keeping the Total Workflow in Mind

For speed, it is apparent that faster is better, but for “image quality,” there is a demerit that when accuracy is improved, the amount of data increases. Increased amounts of data means increased storage costs and lower throughput.



As you can see, it is important that the NLE system be designed with optimal components and is not “over-spec’ed.”
Of course, without considering costs, the ideal system may be one that can process huge quantities of data and a high-speed PC. In reality, return on investment (ROI), is a very important aspect of an editing solution that needs to be considered. You should think about the system in its entirety, ensuring the optimum specifications are achieved for the right ROI.

Here, the important feature is compression technology. Compression technology that can produce small quantities of data without any degradation is ideal and is the only way to achieve the balance between quality and data size. Canopus compression codecs achieve this balance.

1. Norms based on the Workflow

How can the “optimal design norms” be determined for an editing system? Canopus came up with the answer from examining the total workflow in video production, from shooting, editing, to delivery. Here is what we found.

With the performance (image quality) of VTRs as the norm, input / output of images with higher quality is possible and can be edited with minimal degradation.

Norms based on VTRs

There is hardly ever a time when a camera or a VTR is not used in the workflow of post-production or broadcasting stations, including coverage, editing, and distribution.
When such users select editing machines or transmission devices, they will be looking for products that meet the image or product quality-levels of a VTR or a camera. In other words, in a workflow using VTRs and cameras, the image quality-level lies in the VTR or the camera used, and that level can be secured as long as the performance levels of the peripherals are equal to or higher than those of the VTR or the camera. Even the quality of computer graphics depends on the VTR image quality when they are recorded on tapes for distribution.
In that sense, the capabilities of the editing machine become important; it should be able to perform without degrading the VTR performance and image quality.

Design based on usage

There are times when the best image quality available is required, for example in compositing. Canopus systems have been designed for efficient editing of images shot using video cameras, and therefore do not cover composite editing. In composite editing, multiple tracks must be processed simultaneously, so the highest quality images must be processed at high-speed on multi-tracks. In our competitor’s system, high image quality editing has been adopted, but it can only process 2 streams + 1 track in realtime. For multiple tracks exceeding this limit, rendering must occur. In that case, it is more efficient both functionally and cost-wise to use dedicated compositing software. The bottom line is that purchasing an over-spec’ed system without true consideration for its actual use will render the system useless.

2. Accuracy for Preserving the Beauty of the Original Images

There are times when the Canopus codec, with its 8-bit, 1440 resolution, is said to be insufficient when compared to the standard 10-bit, 1920 resolution. The current specification has been chosen, based on careful studies of sufficient balance without becoming over spec'd.

Quantifying Bit Numbers

Quantifying 8-bit numbers for the following VTRs:

MPEG IMX, BetacamSX, DVCAM, DVCPRO50,
D-1, D-2, D-3, D-6,
DVCPRO HD, HDCAM (8 bit when compressed)

These are VTRs are widely used in broadcasting stations. This means that even the broadcasting stations agree that 8-bit is enough for high-quality performance. Thus, increasing quantifying bit numbers to 10-bit for improving quality in images used during the editing process can be considered over-spec'ed in a workflow assuming the usage of VTRs.

Increasing data amounts from 8-bit to 10-bit means making increases by 20%. That will lead to requirements for increased storage capacity and higher data transmission speed. Another reason 8-bit is appropriate for high speed processing is that computer technology tends to be based on multiples of eight. Processing 10-bit data requires 16-bit bus and registers, which ends up requiring double the standard 8-bit load.

Video effects processing is designed for the final results to have 8-bit accuracy. For example, chroma key requiring advanced interpolation, 32-bit accuracy may be needed for international calculations. Computing with unnecessary accuracy requires large amounts of memory and slows down the process. Therefore, eliminating waste by careful consideration of the algorithm implementation with sufficient accuracy is important. Canopus systems guarantee accuracy at each level of effect processing due to careful planning & design.

Pixels and sampling methods

The same can be said about pixels.

	DVCPRO HD	HDCAM	Canopus HQ Codec
Brightness pixels	1280 x 1080	1440 x 1080	1440 x 1080
Color difference pixels	640 x 1080	480 x 1080	720 x 1080
Sampling method	YCbCr 4:2:2	YCbCr 3:1:1	YCbCr 4:2:2
Bit rate	100Mbps	140Mbps	Variable (max 300Mbps)

The Canopus codec exceeds that of the two very popular VTR systems and can edit by oversampling. Some internal computations, for example composites, are executed in 4:4:4 sampling, minimizing degradation during processing.

YCbCr as the standard format

RGB is widely used as the norm in PCs, but YCbCr is the norm used in video equipment formats. Many editing systems include software to convert to RGB for easier processing on PCs. In such systems, color-related problems, such as images over 100IRE being blown-out or discoloration of rendered parts, frequently occur.

Canopus editing systems simply use YCbCr to avoid unnecessary problems. Images shot on cameras include elements over 100IRE, therefore being able to process them correctly is crucial. Such problems will not occur while using our specialized video editing systems.

32-bit audio processing

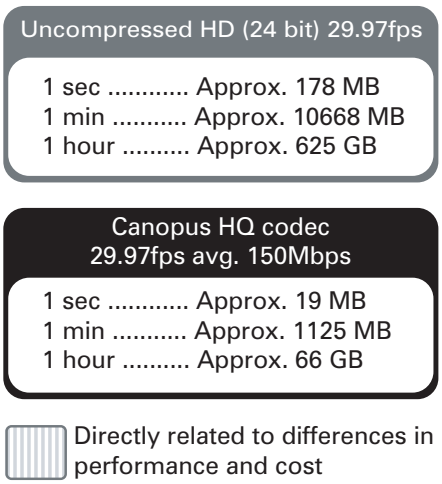
EDIUS Pro processes floating 32-bit audio, matching audio-dedicated software. SDI can I/O maximum of 24 bit of quantifying bit numbers, therefore floating 32-bit, which will cover this specification, has been chosen.

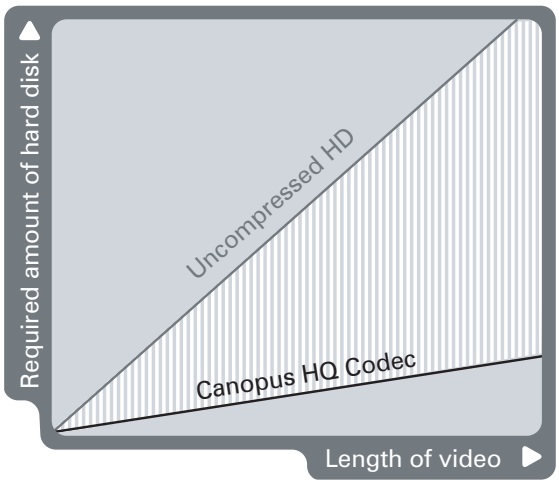
3. Reasons for Adopting Compressed Codec

First, we wish to make it clear that Canopus products can process uncompressed data and full HD with alpha channel (1920x1080i). However, there are reasons for Canopus emphasizing its compressed codec over uncompressed data.

Why compressed data?

Please calculate the amount of data for compressed HD images. With larger hard disk capacities and faster transmission, it still is too much to handle realistically speaking.





Directly related to costs

In uncompressed HD editing systems, over half of the total system costs go to storage. Not only is large capacity needed for storing enormous amounts of uncompressed HD data, but also products with the best performance and interfaces to meet the very tight requirements for transmission speed in realtime must be created. In many cases, the costs for this kind of storage and development go way over that of the editing machine itself.

The high-speed and high-quality Canopus codec contributes to a large reduction in total costs whilst maintaining quality.

Directly related to performance

In HD video editing on PCs, enormous amounts of data are transported between the HDD to I/O, CPU, and memory. For uncompressed data, huge amounts of data are transmitted on every bus, especially between HDD and I/O, which becomes a bottleneck. Using compression, CPU power is used for compressing and expanding, however they are done on the high-speed bus between the CPU and memory, and therefore the amount of data being transmitted on the low speed bus between HDD and I/O is 1/7 compared to the uncompressed data. This, as you can tell, has great effects on the system as a whole. When an editing system is configured on the network in the future, data compression will be a must. Even with the fastest fiber channel server system available today, it is very difficult to playback three uncompressed HD streams on five editing machines constantly in realtime.

In addition, since Canopus's editing software (EDIUS) is designed in-house together with our Codec, the software is able to fully harness the Codec's capabilities.

Excellence of Canopus HQ codec

The Canopus HQ Codec provides image-quality stabilization by keeping the average bitrate low, dynamically adjusting compression rates between accurate images and simple images and using variable bitrates, which can be decoded by frames. Additionally, to maintain minimal CPU load for compression and expansion, Canopus's original technology has been introduced to the mathematical methods of the CPU. While many of the other HDV editing systems are forced to reduce the quality and compress image data to even realize pseudo-realtime processing, EDIUS users can go on with their editing processes without worrying about decreased image quality.