

DVS Whitepaper

SAN in Postproduction Environment: Requirements and Solutions

2006

1. Preface

In Digital Intermediate (DI) production <u>SAN</u> technology is on the move and with the worldwide implemented <u>RoHS</u> regulations, suppliers of <u>SAN</u> storage units will be changing to <u>SAS</u> (serial attached <u>SCSI</u>) or 4 Gb <u>Fibre Channel</u> (FC) by mid-2006. <u>SAS</u> has the double advantage with higher speed and lower price compared to 2 GB <u>FC</u> technology.

Taking these developments into consideration, this whitepaper investigates the new <u>SAN</u> technology. It will take you on an interesting journey from the history of <u>postproduction</u> to its predicted future. On this journey you will learn different <u>SAN</u> definitions, you will know why a <u>SAN</u> can solve challenging production problems and you might recognize, too, how to enhance the output of your facility. The day-to-day business requires flexibility, future-oriented thinking and innovative concepts. This whitepaper will help you in the decision making process and provides an informative grounding in general <u>SAN</u> technology as well as specific configuration setups and solutions.

Feel free to contact us in case of questions.

Kind regards,

The DVS Product Management

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2. Postproduction Business: History and Future

Traditional <u>postproduction</u> of films was ruled by chemicals and optical and mechanical processing. However, production of commercials have made use of video techniques for a long time. Editing was done by cutting the film and putting the pieces together manually, and video sequences were copied between multiple video tape recorders. Some special effects like wipes and dissolves could be achieved with special effects mixing devices which worked in <u>real time</u>. For this the original film had to be scanned and converted into an <u>SD</u> video signal at least once. Further processing was done with the video material. In most cases the final result was printed back to film.

This development was boosted by digital techniques in the 1970s. Digital video tape recorders (VTRs) and digital disk recorders (DDRs) replaced the analog VTRs due to the fact that disk recorders provided a faster access with almost no roll time and less wear. The serial digital interface, SDI, soon



Image 1 (Copyright: Pam Roth. Source: Wikimedia)

became the interface of choice. Today, <u>HDTV</u> is becoming the technology of every day business, being used in commercials and TV dramas, and even for the <u>postproduction</u> of some high-quality feature films. In addition to <u>real-time HDTV</u> equipment, digital computers and workstations are used for special effects work. These generally don't have a video interface but work with data files.

Video signal processing needs to work exactly at the speed of the video clock. If the task is too complex for a given processor, the task cannot be done at all. If the processor has more power than is required for the current task, the video clock will slow the processing down and the additional processing power cannot be used.

Future workflows will be based on data files where processing can be done at any speed. Complex tasks may be slower than <u>real time</u>, but simple tasks may be much faster. Processing speed is only limited by the power of the processing device which may be a specialized sequence processor or a standard workstation. Video equipment working in either <u>SD</u> or <u>HDTV</u> will be used less and less.

Image 2 (Copyright: DVS)

Key Facts: History

From celluloid to digital data, the history of film and video <u>postproduction</u> has undergone severe changes. Today's requirement for high data rates and data quantities imposes impressive challenges on the industry.

3. Definitions and Configurations

The <u>postproduction</u> of feature films and high quality commercials is typically done with uncompressed material. There is a tremendous amount of data when films are processed in <u>HDTV</u> or in cinema <u>resolution</u> with two or even four thousand pixels per line. Often multiple workstations need to work on the same project either to speed up processing or because different workstations are required for different software packages. Copying data between workstations via ordinary network structures is time-consuming. To avoid processing being slowed down by copy tasks, each workstation can be equipped with a local storage, to which large parts of the project are copied to, for example, over night. Now the workstations can access all frames quickly on the local storage.

This procedure has several disadvantages. The total storage of the individual workstations will be much bigger and much more expensive than a single storage holding the complete project. Copies of the same image may be needed on different workstations for different processing steps which may lead to coordination problems. If one operator has to wait for the result of another, then time for copying has to be added to the processing time.

Therefore a central storage, which can be accessed simultaneously by all workstations, may help to save time and money.

3.1 Central Storage with a Server-Client Configuration and NAS

The traditional solution for a centralized storage is a <u>server-client</u> configuration. The <u>server</u> is the only computer to which the storage drives are connected directly. All other workstations, the

clients, are connected to the server via network. There is no direct connection between clients and the server storage. Of course, each client may still have its individual local storage directly attached. Nevertheless, every client can access the storage of the server. Hidden to the user, the communication is always between client and server, but to the user it looks as if he has direct access to the files on the central storage.

Nowadays this configuration is also called <u>NAS</u> (Network Attached Storage) and often the storage and the <u>server</u> are mounted into a chassis not much larger than a normal desktop computer, making cabling and installation easy. While the standard



Image 3: Typical client-server configuration (Copyright: DVS)

network <u>server</u> also provides print services, naming services as well as others, a <u>NAS</u> system is dedicated to file services only.

In any case, the bandwidth of the <u>server</u> processor and the speed of the network connection can become a bottleneck, which makes a <u>client-server/NAS</u> configuration not suitable for <u>real-time</u> video and digital film applications.

3.2 Central Storage in a SAN Configuration

A so-called <u>SAN</u> (Storage Area Network) provides faster access to the data. All <u>clients</u> of a <u>SAN</u> are directly connected to the hard disk storage. The data transfer always takes place between <u>clients</u> and storage directly and there is no <u>server</u> that distributes the data which eliminates one bottleneck.

In practice the storage devices do not have enough connectors to connect many clients directly. Therefore so called switches are used to increase the connectivity. A <u>metadata</u> server helps to synchronize all clients. A more detailed description of both devices is given below.



Image 4: Typical SAN configuration (Copyright: DVS)

3.3 Main Components of a SAN

A <u>SAN</u> normally consists of a combination of various components. The most important components are explained in the following text.

3.3.1 The Storage

The most important component, of course, is the storage itself which consists of a chassis with a <u>RAID</u> controller and a number of removable hard disk drives. Magnetic tapes, magneto-optical and optical devices are used for archiving purposes only, as their access time is too slow. Solid-state disks, though fast and reliable, are too expensive to be used for mass storages. There are two different types of hard drives.

Hard Drives for Home and Office Applications

These drives are optimized for high capacity and low price. Capacities go up to 500 GB and rotational speed is up to 7.200 rpm. The data rate of the media is between 30 and 65 MB/s with an access time of 8 to 9 ms. The number of reads between non-recoverable errors is about 100 times lower with it is as hard drives for <u>servers</u>.

The interface is either a parallel <u>ATA</u> (<u>IDE</u>) interface or its serial successor <u>SATA</u> and <u>SATA-2</u>. Many drives are available with either interface, but the technical data of the drives are identical.

Hard Drives for Servers

Hard drives for servers have to be much more reliable than hard drives for home and office applications, because they have to endure more accesses to the same data in everyday use. With these drives reliability, high data rate and low access times have the highest priority. The high data rates and low access times are achieved by higher rotational speeds. 10.000 and 15.000rpm are standard, 20.000rpm have been announced. Typically a manufacturer offers two rotational speeds and three different capacities for each speed, wherebye the capacities of the faster group have only half the capacity of the slower ones.

Overall, the higher reliability has to be paid for with lower capacities and higher price compared to the desktop drives. Whilst the capacity is only about half that of the desktop drives, the price per byte is about as twice as high. But the time between unrecoverable errors or the <u>MTBF</u> (mean time between failure) is about 100 times better. In addition they are recommended for 7/24 operating times, which is not always the case for desktop drives.

Depending on the manufacturer the drives are available with up to three different types of interface, namely the <u>SCSI</u> interface, the <u>SAS</u> interface and the <u>FC</u> interface. Again, the other drive specifications remain similar.

		Overview o	of Hard Disk	Interfacing Techr	ologies	
	Home / O	ffice			Servers	
	ATA 133	SATA	SATA-2	SCSI U320	SAS	FC
Max. Capacity [GB]	500	400	500	146/300	146/300	146/300
Rotational Speed [rpm]	7.200	7.200	7.200	15.000/10.025	15.000/10.025	15.000/10.025
Interface Data Rate [MB/s]	133	150	300	320	320	425
Media Data Rate [MB/s] (Value for 15K drive)	65-31*	61.4-29.8*	65-31*	142-85*	142-85*	142-85*
Media Data Rate [MB/s] (Value for 10K drive)	65-31*	61.4-29.8*	65-31*	89.3-46.8*	89.3-46.8*	89.3-46.8*
Access Time [ms]	8.5	8.5	8.5	3.7/4.7	3.7/4.7	3.7/4.7
Error Rate	1 in 10 ¹⁴	1 in 10 ¹⁴	1 in 10 ¹⁴	1 in 10 ¹⁶	1 in 10 ¹⁶	1 in 10 ¹⁶
GB = 10 ⁹ , MB = 10 * first block – last b	lock.					

Image 5 (All data taken from data sheets from Hitachi Ltd. and Seagate Technologies)

3.3.2 RAID Controller

The <u>RAID</u> controller, where <u>RAID</u> stands for Redundant Array of Independent Disks, combines the hard disks of a storage unit. To the computer they look like one large drive. But the <u>RAID</u> controller also stores additional information, so-called parity information, on the drives. This makes it possible to recover the data of any disk if it fails. Of course, the information needs space and reduces the net capacity. Combining multiple hard disks could improve the speed, but the calculation of the parity also takes time. Therefore, most <u>RAID</u> controllers are slower than a simple <u>stripe set</u> as provided by many <u>file systems</u>.

If a drive fails, the original data can be recalculated using the parity information. With many <u>RAID</u> controllers the access time is slower than in normal operation when all drives are operational.

If a drive failure has been detected, the defective drive needs to be replaced. This can be done by swapping the drive manually or by switching automatically to a so-called <u>hot spare</u> drive seated amongst the other drives and unused so far. Then the <u>recovery</u> run will start and recover the data of the lost drive, writing it back to the new one. As described above, during <u>recovery</u> the data can still be read but at a reduced speed.

3.3.3 Metadata Server

A <u>SAN</u> does not need a <u>server</u> that transfers the data to the <u>clients</u>. But it needs a <u>metadata</u> <u>server</u> which makes sure that all <u>clients</u> use the same directory information. Every time a <u>client</u> creates or deletes files, all other <u>clients</u> need to be informed about this event.

The <u>metadata server</u> is a software package that can either run on a dedicated computer or on one of the <u>clients</u>. For <u>real-time</u> applications and if high reliability is required, the <u>metadata</u> <u>server</u> should run on a dedicated computer. This computer then is the <u>metadata server</u>.

As the <u>metadata server</u> does not actually move any data, it is less likely to become a bottleneck. But in <u>real-time</u> applications the reaction time will be critical.

The <u>metadata</u> that is handled by the <u>metadata server</u> should not be confused with the <u>metadata</u> that is used in video and film applications. All additional information to film and sound material is called <u>metadata</u> as well. It may include any information collected during shooting or <u>postproduction</u>. Some of the most important <u>metadata</u> are timecode and keycode, which provide a unique time stamp to each captured image and help to match video with audio. This type of <u>metadata</u> is treated like all other data by the <u>metadata server</u>.

<u>3.3.4 Interfacing – Fibre Channel</u>

<u>Fibre Channel</u> is the de-facto standard for the connection between <u>clients</u> and storage. It is a point-to-point connection that transmits via the <u>SCSI</u> protocol. Though the name implies an optical interface there are also copper versions available. For connections between disk units normally an optical interface is used. Inside a chassis the copper version is used, for example, <u>Fibre Channel</u> hard drives have a copper <u>Fibre Channel</u> interface.

There are interfaces for 1, 2 and 4 Gbps speed. Interfaces of all speeds can be mixed together. The actual transfer speed will be the speed of the slowest interface.

3.3.5 Fibre Channel Switches

As <u>Fibre Channel</u> is a point-to-point connection, switches are required to configure complex networks where one storage is connected to multiple <u>clients</u>. The most common switches have 8 to 32 ports. Some of them have expansion ports to combine two or more of them to operate as a single switch with multiple ports.

For each port the routing can be configured individually defining the ports that can be accessed from another one. This way it is possible that some <u>clients</u> can communicate with all storages to the switch while other <u>clients</u> can access only one storage.

The data rate of a switch may be limited and may be below the total data rate of all ports. Then, a switch may become a bottleneck. But it is easier to increase the data rate of a switch by combining switches via expansion ports than to increase the data rate of a file server; typically the bottleneck in client-server configurations.

3.3.6 SAN File System

'Normal' <u>file systems</u> have no integrated <u>metadata server</u> function. Therefore, either an extension to the <u>file system</u> is required or a special <u>SAN file system</u>. An extension to the file system adds to the communication between the clients but leaves the control of how the data is stored on the hard drives to the native file system. Typically no dedicated <u>metadata server</u> hardware is required, but one <u>client</u> has a kind of master function. DVS tests have shown that the master <u>client</u> has the highest priority and gets the best performance, which is a problem if more than one real-time stream is required. Another disadvantage may be that file system extensions are limited to the operating system of the native file system. Only clients with the same operating system can use them.

If <u>clients</u> with different <u>operating systems</u> need to be integrated to a <u>SAN</u>, a dedicated <u>SAN file</u> <u>system</u> may be a better choice. The SAN file system is a complete file system on its own, but it can be accessed from the <u>clients</u> in the same way as their native one. The most popular <u>SAN file</u> <u>systems</u> for video applications are <u>ADIC</u>'s SNFS (Stor Next File System) and SGI's CXFS (Clustered Extended File System). Both are available for <u>clients</u> with various <u>operating systems</u> and both usually require dedicated <u>metadata server</u> hardware.

Some other <u>SAN file systems</u> and file system extensions on the market are detailed in the following table (in alphabetical order):

StorNext	from ADIC
Xsan	from Apple
SAN File System	from DataPlow Inc.
TotalStorage SAN File System	from IBM
Lustre	from Linux
GlobalFileSystem	from Linux Red Hat
ImageSAN ²	from Rorke Data Inc.
Melio	from Sanbolic
CXFS	from SGI
QFS for Solaris	from Sun
SANergy	from Tivoly

I Image 6 (Copyright: DVS)

3.3.7 Miscellaneous

The communication between the <u>clients</u> and the <u>metadata server</u> takes place via a normal network. For optimum performance there should be a dedicated network for this purpose. An additional network for maintenance and diagnostic may be suitable. These networks will require network switches and network cables as any other standard computer network.

Fail-over configurations for the metadata server need remote controlled power switches.

All these components must be provided with space in the rack and should not be forgotten when the rack space is planned.

Key Facts: What is a SAN?

A <u>SAN</u> is a Storage Area Network. Several setups are possible – from a classic <u>server-</u> <u>client</u> configuration to a <u>Fibre Channel</u> setup. Depending on the individual requirements in a facility, different configuration solutions have to be taken into account. The <u>DVS-SAN</u> offers a wide range of possibilities. Both its design and its software setup enable the facility to handle large amounts of data with flexibility on a rock-solid platform.

4. Special Requirements for a real-time SAN

If the technical director of a post house is considering using a <u>SAN</u>, he normally knows the required storage capacity and probably how many workstations need to access the data. But buying a <u>SAN</u> for <u>real-time</u> video or digital film applications is not a simple question of "How many gigabytes do I get for my money?"

4.1 How much Storage do I need?

The calculation of storage capacity seems to be easy but has some pitfalls and is worth consideration.

The first thing to know is the resolution of the material. It is obvious that <u>HD</u> files are larger than <u>SD</u> files, and film <u>resolution</u> with two thousand or four thousand pixels per line take even more space. The file <u>format</u> has an enormous influence on the size of the files. Of course, compressed <u>formats</u> require less space than uncompressed <u>formats</u>, but color coding and <u>quantization</u> also affect the size.

Film projects typically will be stored in <u>RGB</u> <u>4:4:4</u>. Video material in general is <u>YUV</u> <u>4:2:2</u>. Nevertheless, it may be necessary to use an <u>RGB</u> storage <u>format</u> for video projects. Maybe the software used does not support <u>YUV</u> <u>4:2:2</u> or some processing steps require an <u>RGB color</u> <u>space</u>. Depending on the file <u>format</u>, <u>RGB</u> <u>4:4:4</u> requires about 50% more storage than <u>YUV</u> <u>4:2:2</u>.

<u>Quantization</u> is another factor that has to be considered. Some file <u>formats</u> or some programs always use a multiple of 8 bits per color <u>component</u> rather than a compressed <u>format</u> even if the file <u>format</u> supports packed storage. TIFF files for example normally use 8 or 16 bits per color though the <u>format</u> specification allows for 10 bits. This requires about 50% more capacity than using <u>DPX</u>, which uses only 32 bits to store a 10 bit <u>RGB</u> pixel.

File Size	s and Storage Requiren	ients	
Formats	Net size per image	Typical Storage requ	irement for one hour of
		Net size	DPX File Size
	[10 ⁶ bytes]	[10 ⁹ bytes]	[10 ⁹ bytes]
SD, 720x486, 30 fps, YUV 4:2:2, 10 bit	0.8748	94.45	101.74
HD, 1920x1080, 30 fps, YUV 4:2:2, 10 bit	5.1840	559.87	598.08
HD, 1920x1080, 30 fps, RGB 4:4:4, 10 bit	7.7760	839.81	896.68
Film, 2048x1080, 24 fps, RGB 4:4:4, 10 bit	8.2944	716.64	765.12
Film, 2048x1556, 24 fps, RGB 4:4:4, 10 bit	11.9501	1032.49	1102.03
Film, 4096x3112, 24 fps, RGB 4:4:4, 10 bit	47.8003	4129.95	4405.28

Image 7: File sizes and Storage Requirements. (Copyright: DVS)

<u>DVS-SAN</u>, of course, can handle all file <u>formats</u>, while DVS video applications like <u>CLIPSTER</u>[®], <u>Pronto2K.2</u> and <u>ProntoHD.2</u> support a variety of them in real time, including compressed and uncompressed <u>RGB</u> and <u>YUV</u> formats.

Sometimes it may be necessary to have old versions of the project available as the customer may change his mind and may want to revive an old version that was discarded some time ago. So additional storage should be reserved.

The parity of a **RAID** configuration and hot spare drives, which are all available for **DVS-SAN**, increase safety and reliability but reduce the net capacity and should be taken into consideration if this kind of data protection is required. <u>RAID 1</u> would need twice the net capacity. <u>RAID 3, 4 or 5</u> need one additional drive per RAID pack. Mostly the size of the **RAID** packs can be configured. Large **RAID** packs need less overhead, but makes it more likely that another drive fails before a recovery is completed. Of course, the RAID pack size can be configured for the **DVS**-SAN. Normally the size is chosen as a compromise between overhead and reliability.



Image 8: DVS-SAN: grows with your requirements (Copyright: DVS)

But even the best planned estimation of storage capacity changes as the workflow changes or even better, if the business grows. To cater for the DVS-SAN can be expanded easily at any time. In most cases new storage can be integrated without having to delete and reformat the existing storage.

4.2 How many Clients shall be connected to the SAN and who needs real-time Access?

This question is not too difficult to answer, but has an impact on costs. Every <u>client</u> that is connected directly to a <u>SAN</u> needs a <u>SAN</u> license <u>file system</u> and at least one port on the <u>FC</u> switch. <u>Clients</u> needing higher data rates for <u>HD</u>, <u>2K</u>, <u>4K</u> film resolutions may require additional ports, as two or more links may be necessary for a single data stream.

If a large number of <u>clients</u> need non-real-time access, a file <u>server</u> may be a cost-effective solution. The file <u>server</u> is a <u>client</u> of the <u>SAN</u>. It is connected directly to the storage and needs a <u>SAN file system</u> license, too. But all <u>clients</u> that are connected to the file <u>server</u> neither need a <u>SAN</u> license <u>file system</u> nor a port on the <u>FC</u> switch. Both can help to reduce costs.

<u>DVS-SAN</u> optionally offers file <u>servers</u> to keep costs down in applications where many workstations or render nodes need access to the data simultaneously but not in <u>real time</u>.

4.3 Which Data Rate does my SAN need?

This question is the most difficult to answer. Probably there will be data that needs <u>real-time</u> access. But there may also be data where speed is not an issue. If both types of data are stored on the same storage, the non real-time access may interfere with <u>real-time</u> transfers. To avoid dropped frames the storage should be over-specified in terms of data rate. As a fast storage for <u>real-time</u> access is more expensive than a slow storage, it is a good idea to split the storage into <u>real-time</u> and non <u>real-time</u> or near-line storages. The non real-time data does not occupy the expensive real-time storage and costs for over-specifying the data rate are avoided. This can reduce costs substantially.

Visit <u>www.dvs.de</u> and check the data rate calculator (see 'Tips & Tricks').



Image 9: DVS-SAN configuration with multiple real-time volumes and a separated near-line storage (Copyright: DVS)

	Typical Data Rates	
Format	Net* Data Rate [10 ⁶ Bytes]	Gross* Data Rate [10 ⁶ Bytes]
SD, 720x486, 30 fps, YUV 4:2:2, 10 bit	26	28
HD, 1920x1080, 30 fps, YUV 4:2:2, 10 bit	156	166
HD, 1920x1080, 30 fps, RGB 4:4:4, 10 bit	233	249
Film, 2048x1080, 24 fps, RGB 4:4:4, 10 bit	199	212
Film, 2048x1556, 24 fps, RGB 4:4:4, 10 bit	287	306
Film, 4096x3112, 24 fps, RGB 4:4:4, 10 bit	1,147	1,224

* Gross data rate is calculated for a storage format where 30 video bits are occupying 32 bit, as most file formats like DPX, TIFF and others do. Net data rate is assuming there is no overhead in the storage format.

Image 10: Typical data rates (Copyright: DVS)

4.3.1 Peak and sustained Data Rate

Peak data rate is the data rate that can be achieved for a very short time only but not continuously. Sometimes it is defined as the data rate that will never be outperformed. Data sheets often specify peak data rates.

<u>Sustained data rate</u> is the average data rate over a longer period. Mostly it is not defined exactly how long. So it is not guaranteed that the actual data rate does not drop below the sustained data rate for a short time. In <u>real-time</u> applications this may cause problems. It cannot be recommended to use a standard benchmark application in order to measure the data rate of a storage. It is rather useful to run the storage with the intended software application which will be used in the future and then to measure the data rate of the running system. Then, the data rate given will be exact.

4.3.2 Real-time Storage

The necessary data rate of the <u>real-time</u> storage of a <u>SAN</u> is mainly defined by the data rate of the <u>real-time clients</u>. A first guess for the data rate requirement would be to sum up the data rates of all <u>real-time clients</u> and use a benchmark program to select a <u>SAN</u> that is fast enough.

Unfortunately in reality this may not give a reliable result. Reading or writing a single stream in large blocks will result in a much higher data rate than reading or writing small blocks in random order. Some applications use file <u>formats</u> like <u>QuickTime</u> or <u>AVI</u> that store a complete sequence including several audio channels in one file. If the file is not <u>fragmented</u> this comes close to the benchmark with sequential read or write in large blocks. But if two or more independent reads or writes take place at the same time, the total possible data rate usually drops. One data stream with 250MB/s is easier to achieve than five independent streams with 50 MB/s each.

Things may get more complicated if the video sequences are stored in a large file sequences, each containing just one frame, as in a typical DI workflow. If the files are stored continuously in one large block on the drives, the possible data rate is about the same as in the case of a sequence that is stored in one file. But if the files are scattered all over the hard drives, the data rate may drop dramatically. Scattering or <u>fragmentation</u> typically takes place during <u>postproduction</u> when single files are modified for retouching or when the sequence of the images is changed during editing.

While standard de-<u>fragmentation</u> tools can easily make sure that each file lays more or less continuously on the drive, there is no standard tool that takes care about scattered file sequences where every frame is at a different location on the hard drives.

Unfortunately many tools used in the <u>postproduction</u> of digital films use single frame file <u>formats</u>. It makes handling of large sequences much easier and programs that have been developed for still pictures can be used on single frames or sequences without file conversion.

To avoid problems caused by scattered files, DVS has developed a tool that comes with $\underline{\text{DVS}}$ -<u>SAN</u> to "de-scatter" file sequences. Moreover, the innovative data manager by DVS, SpycerTM, is an interesting solution in the defragmentation process. See chapter <u>6.2 SpycerTM</u>.

Audio also may reduce the usable data rate. The 750kB/s (2 x 24 bit/sample, 48 kHz) of a stereo audio stream is very low compared to the several MB/s of video or digital film, but the additional seeks will need waiting time when no data can be transferred to or from the hard drives. Some <u>real-time</u> applications like <u>CLIPSTER</u>[®] and <u>Pronto2K.2/ProntoHD.2</u> allow one independent file for each audio track and 16 or more tracks can be used for a single video timeline. The greater flexibility has to be paid for with a higher data rate requirement for the storage.

Video applications such as <u>CLIPSTER</u>[®] that provide <u>real-time</u> transitions even in <u>2K resolution</u> will double the data during the transition.

Sometimes 'unexpected' data rates may occur which can jeopardize a <u>real-time</u> transfer. 'Unexpected' data rate can be caused by a scheduled copy process running in the background from time to time, which the operator of a <u>real-time</u> transfer is not aware of. To detect data rate overflows due to 'unexpected' transfers, <u>DVS-SAN</u> provides automatic e-mail notification if the data rate of all current transfers gets close to the maximum for which the storage is designed for.

Besides pure data rate, latency is another important point that influences the <u>real-time</u> performance of a <u>SAN</u>. The access time of a certain block of data is not exactly predictable as hard drives include mechanical parts. Depending on whether a seek is necessary and where on the next track the requested data is located, additional time consuming revolutions of the disk may be necessary. Retries to recover read or write errors may add additional delays. Professional <u>real-time</u> video systems will buffer some of these unpredictable delays. But larger buffers will result in slower response times to user commands. Remote controllers for <u>VTRs</u> and <u>DDR</u>s sometimes require a limited response time which reduces the maximum buffer size of a <u>DDR</u> that reads its data from a <u>SAN</u>.

So even if the average data rate is high enough, it may happen that the <u>real-time</u> transfer is disturbed by occasional high latencies. Tests at DVS have shown that <u>SATA</u> drives, which commonly have higher capacities per disk surface and therefore need more accurate tracking, suffer more from occasional higher latencies than <u>FC</u> or <u>SAS</u> drives.

Some well-designed video systems like <u>CLIPSTER</u>[®] and <u>Pronto2K.2/ProntoHD.2</u> will use dynamic buffer sizes to optimize user-friendly response times with robustness against latency of the drives.

To minimize latency of drives and to give the highest reliability <u>DVS-SAN</u> always uses <u>FC</u> or <u>SAS</u> drives for <u>real-time</u> storage applications. <u>SATA</u> drives are used for near-line storages only where fast access is desired, but here occasional latencies do no harm.

When configuring a <u>SAN</u>, it may be wise to have two or more volumes on independent storages that can handle one <u>real-time</u> stream rather than a single storage that can handle two or more streams in <u>real time</u> (see image 9). Independent storages make sure that there is no interference between the transfers, providing additional safety against accidental data rate overflows. The disadvantages are that the storage is split into two or more segments and the

user has to decide which storage should be used for which project.

<u>DVS-SAN</u> provides storage capacities and data rates in a granularity that makes it easy to configure. Configurations can either provide a single volume with high data rate to handle multiple <u>2K</u> streams including audio in <u>real time</u>, or independent volumes, each with just one high <u>resolution</u> stream, without too much overhead in data rate and costs.



Image 11: DVS-SAN (Copyright: DVS)

4.3.3 Near-line Storage

Per definition the data rate of the near-line storage is less important. But as it is mostly used for archiving no compromise should be made regarding data protection. The consistent low latency of <u>FC</u> or <u>SAS</u> drives is not necessary. <u>SATA/SATA-2</u> drives that offer a much better price per byte are a suitable choice, but <u>RAID</u> protection should not be omitted.

Of course, there are near-line storages of <u>DVS-SAN</u> available at an attractive price, providing always the same reliable <u>RAID</u> technology and remote diagnostics as the <u>real-time</u> storage.

4.4 How do I organize my Data?

A <u>SAN</u> normally provides a lot of storage capacity that can hold a huge amount of data. This may lead to the problem of how to find data. A first approach will be to store clips into folders named by project and subfolders with the names of the clips or a processing step. But sometimes the name of the clip is not known; the user just remembers the content. Or a user needs a clip of a particular timecode or keycode or is looking for a file type. In all these cases tools are helpful that can search for various meta information and show a thumbnail preview of a clip.

Also moving data with standard copy programs is not always efficient.

<u>DVS-SAN</u> comes with the powerful <u>Spycer^M</u> that does all the above plus many other useful functions. See <u>chapter 6</u> for more information.

4.5 What operating Systems can my Clients use?

A typical <u>postproduction</u> house uses many different tools that run on different workstations. Normally not all of them use the same <u>operating system</u>. So the <u>SAN</u> should support all <u>operating systems</u> that are used by the customer.

<u>DVS-SAN</u> can be connected to all common <u>operating systems</u> including <u>Windows</u>[®] XP, <u>Windows</u>[®] Server 2003, 32 and 64 bit <u>Linux</u>[®], <u>IRIX</u>[®] and other UNIX versions, and <u>MacOS</u>. <u>Clients</u> with all <u>operating systems</u> can be connected at the same time and access the same data.

4.6 How to handle Failure

Even the most reliable system may fail at some time. The most common is a drive failure. Therefore, <u>DVS-SAN</u> uses <u>RAID 5</u> protection by default. If a drive fails, an alarm will sound but the data will still be available for processing. <u>Real-time</u> performance may be reduced though. <u>Hot spare</u> drives make sure that the <u>recovery</u> run can be started immediately after the drive failure was detected with no immediate need to replace the broken drive. Once the <u>recovery</u> run has finished, the system will be back to full performance and the failed drive can be replaced at a later time.

On request DVS can provide configurations that have no loss of performance even in the case of a drive failure. This is done by using <u>RAID</u> controllers that always omit the slowest drive of a <u>RAID</u> pack and always work in data correction mode. This way it does not matter if one drive is just a little slower or does not work at all. The performance will always stay at a maximum.

As mentioned above, <u>FC</u> and <u>SAS</u> hard disks have a lower error rate than <u>SATA</u> drives. So using a <u>SAS</u> or <u>FC</u> configuration is another way to improve reliability. <u>DVS-SAN</u> is usually configured with <u>FC</u> or <u>SAS</u> drives for <u>real-time</u> applications and with <u>SATA</u> drives for near-line and archiving applications.

Additional safety can be achieved by using dual controller configurations and a redundant <u>metadata server</u> with <u>fail-over</u> capability. If one controller or one <u>metadata server</u> fails, another one will take over automatically. Of course, <u>DVS-SAN</u> can provide both.

Fibre switches normally are backed up in a cold spare configuration. If a switch fails, only few cables need to be reconnected and the <u>DVS-SAN</u> will work as before.

4.7 What Support can I expect if my SAN fails?

If there is a problem, fast diagnostics and problem solving is essential. The diagnostics can be a major problem in a <u>real-time SAN</u> environment with attached video systems from different manufacturers. In general, storage manufacturers don't have much experience with <u>real-time</u> video systems and video manufacturers don't always have a lot of experience with <u>SAN</u> storage configurations. In case of a problem, it may happen that storage and video manufacturers blame each other! DVS is a manufacturer who has many years of experience in video <u>and</u> storage equipment manufacturing and who understands the workflows and requirements of <u>postproduction</u>. Remote diagnostic over <u>Ethernet</u> and automatic e-mail notification by the <u>DVS-SAN</u> help to keep down-times to a minimum.

Key Facts: Why do I need a DVS-SAN? There are several demands on a real-time SAN expects several requirements. Of course, it is essential to know how much storage is necessary. But there is more to it than the famous money versus storage calculation. There are more questions to be asked and answered: How many <u>clients</u> will have access to the SAN? Is the SAN needed with a realtime storage or a near-line storage? What is the best way to organize the data? Are there different operating systems in use? Is there any protection against failure – and what support is available when needed? Only if these questions are considered, can a suitable SAN solution be implemented that meets your requirements and enhances your workflow.

5. Application Examples

5.1 A virtual Telecine

A <u>SAN</u> is a very flexible unit. There are almost endless possible applications to fit any requirement.

Below is shown a relatively simple setup with just one <u>real-time</u> film or video stream. This application example is a virtual <u>telecine</u> configuration. The <u>SAN</u> must deliver a <u>sustained data</u> <u>rate</u> even when all other <u>clients</u> are accessing it.



Image 12: A SAN configured as a virtual telecine (Copyright: DVS)

The film is transferred by a film scanner to the central storage via a data interface in non <u>real</u> <u>time</u>.

While being transferred from the scanner, the images can already be used by other devices. Here for example, a <u>CLIPSTER</u>[®] which is doing the conforming of the transferred reels. After the conforming the material can be played out in <u>real time</u> for inspection or color grading.

Also shown here is an archive that could be a near-line storage, a tape library or a \underline{VTR} . In parallel a FileServer can make the images available for authorized network <u>clients</u> which could be for example, the control station of the film director or DRS workstations.

5.2 Real-time SAN and near-line SAN

A significantly bigger application is shown in this example. Here the DVS <u>real-time</u> and near-line <u>SANs</u> are the center points for several departments of a facility.

The media is collected either by a <u>real-time</u> ingest from <u>VTRs</u> via an ingest station like e.g. <u>ProntoHD.2</u> or as data from a film scanner or a <u>telecine</u>. Full <u>resolution</u> and proxy versions of the data can be stored on the <u>real-time</u> or near-line <u>SAN</u> as well. The proxy will be used for the offline editing afterwards where an <u>EDL</u> is created.

Once the data is transferred to the <u>SAN</u> and the <u>EDL</u> from the offline editing is available, the conforming and finishing devices can directly access the full <u>resolution</u> data, concurrently in <u>real</u> <u>time</u>.

Applications with lower speed requirements like render farms or digital restoration systems can access the data in parallel. Also the parallel access of multiple network <u>clients</u> via a DVS FileServer is available. The requirements for the <u>real-time SAN</u> in this case would be multiple <u>real-time</u> streams of <u>HDTV</u> or <u>2K</u> film in parallel for the ingest, conforming and finishing, while having multiple non-<u>real-time</u> access to the same storage space. The only copy processes needed would be the transfer of the data from the render stations to the <u>SAN</u>.



Image 13: Real-time and near-line SANs as center points (Copyright: DVS)

Key Facts: Application Examples

These application examples might give you an idea on how to set up a <u>SAN</u> in your facility – or how to improve the setup. The <u>DVS-SAN</u> is a flexible unit: define your requirements and your goals – and the <u>DVS-SAN</u> will undoubtedly fit in your requirements!

6. Innovative Data Management – a Solution by DVS

Not only data storage is essential in the day-to-day running of a <u>postproduction</u> facility, but effective data management as well. The following paragraphs deal with a completely new concept in <u>SAN</u> management. The application <u>Spycer</u>^M is an integral part of <u>DVS-SAN</u>. With this innovative data manager <u>postproduction</u> businesses worldwide can move to a higher level of efficiency.

6.1 Summary of Requirements

So, in review, there are several important facts to consider when implementing a SAN in your <u>postproduction</u> business. A quick re-wrap will prepare you for the next steps. First, **collaboration**.

A <u>SAN</u> allows for the collaboration of working groups or complete facilities. <u>DVS-SAN</u> is configured for access of many users using the data. Therefore a high and <u>sustained data rate</u> is an absolute must for a <u>DVS-SAN</u>.



Image 14: Collaboration – everyone can work on the same material in the different stages of a production (Copyright: DVS)

Secondly, **customizing the system**. Customer customizations needs to be reflected in the <u>SAN</u> design, as the <u>SAN</u> is the information hub for several workflows, or for all workflows of a facility. The DVS team works closely together with the customer to collect all requirements that are then turned into a <u>SAN</u> configuration. Different hardware components from different OEM manufacturers are an issue, as well as insight knowledge of the <u>file systems</u> used. Topped with DVS own software components a <u>DVS-SAN</u> results in exactly the right configuration. Only an

inside knowledge of video and IT engineering can result in the best possible performance and reliability.

Scalability is another main issue. Requirements for storage size and speed might change just a few weeks after the initial purchase of the unit. In the configuration stage future expansion must be taken into consideration. <u>DVS-SAN</u> is easily expandable in size, data rate and the number of concurrently accessing <u>clients</u>. Therefore the technology can grow as the business grows.

Its **flexibility and independence** is second-to-none. Usually a workflow includes different systems from different manufactures running on diverse <u>operating systems</u>, using different media file <u>formats</u>. The used <u>SAN file system</u> allows connected <u>Irix[®]</u>, <u>Linux[®]</u>, <u>Mac</u> and <u>Windows[®] clients</u> to the <u>DVS-SAN</u> and to use the storage concurrently. For each workstation the <u>SAN</u> will look like a storage volume of its own <u>file system</u>.



Image 15: Independence - No need to choose a specific operating system (Copyright by Apple®, Linux® and Microsoft®)

And last but not least, **reliability** is fundamental to any <u>SAN</u> system. This includes accessibility (low or even zero down-time), reliable data rates, as well as data protection. Utilizing <u>fail-over</u> configurations, a system with <u>no single point of failure</u> can be achieved. But also a <u>fail-over</u> for certain critical parts of the system e.g. the <u>metadata server</u> can be offered. The data itself is <u>RAID</u> 5 protected. Even a disk failure will not result in a loss of data. After <u>recovery</u> the data will be recreated on the <u>hot spare</u> or exchanged disk and the <u>SAN</u> is still accessible with the same speed and data as before.

With the <u>SAN</u> in its final configuration, fitting the requirements perfectly, the next step is to think about how you can manage all the data that will be stored there. DVS can provide an innovative solution – <u>SpycerTM</u>. The intelligent content management system manages hundreds of terabytes of data, possesses useful search functions and browsing tools and a sophisticated defragmenter (See also chapter <u>4.3.2 Real-time storage</u>). The next paragraphs will give insight into <u>fragmentation</u>, file handling as well as content and network technology.

6.2 Spycer[™] – the innovative Data Manager

Fragmentation of image sequences: In a digital intermediate process or digital cinema production, clips are stored as uncompressed file sequences. This means that a large amount of files are stored on a <u>SAN</u>. Most <u>SAN</u> solutions do not provide efficient defragmentation software for these file sequences. Common defragmentation applications just defragment single files and are "not aware" of the relationship between files. For <u>real-time</u> play-out, it is not enough to have just single defragmented files. The whole sequence of files must be stored contiguously in large blocks on the storage and not scattered all over it.

File Format	Defrag	Size	Resolution	Color Depth
DPX	99%	1.02 GB	1920 × 1080 Pixel	
DPX	0%	2.32 GB	1920 × 1080 Pixel	
DPX	3%	3.56 GB	1920 × 1080 Pixel	10
DPX	100 %	395.90 MB	1920 × 1080 Pixel	
YUV8	100%	197.75 MB	1920 × 1080 Pi×el	
DPX	100%	1.37 GB	1920 × 1080 Pixel	
DPX	100 %	594.14 MB	1920 × 1080 Pixel	
DPX	100 %	594.14 MB	1920 × 1080 Pixel	
DPX	100%	534.73 MB	1920 × 1080 Pixel	
DPX	100%	475.08 MB	1920 × 1080 Pixel	
BMP	100 %	183.94 MB	1920 × 1080 Pixel	
BMP	100 %	282.75 MB	2048 × 1556 Pixel	
DPX	100%	1.16 GB	1920 x 1080 Pixel	10
DPX	100 %	1.36 GB	1920 × 1080 Pixel	
BMP	100 %	995.97 MB	1920 × 1080 Pixel	
DPX	100%	942.24 MB	1920 × 1080 Pixel	10

Image 16: A data manager must show the current defragmentation status of scattered sequences (Copyright: DVS)

Another important point is, that the storage data rate should not drop when a defragmentation job is launched and running as a background process. A defragmentation tool has to be aware of the current workload.

Spycer[™], the new content management software from DVS, is able to defragment any file and to analyze and de-scatter file sequences. A monitoring process updates the current defragmentation status of every sequence and keeps the user up-to-date. Spycer[™] is "aware" if a workstation is under heavy load for real-time play-out and halts the defragmentation process if necessary.

File handling: Users require dependable copying and renaming processes for such masses of data. Fast copying mechanisms should be easy to use for the creative staff at their workstations. This means that drag'n'drop procedures must be available instead of cumbersome command line tools. DVSCopy, a fast copy tool that avoids <u>fragmentation</u>, is integrated in the <u>GUI</u> of <u>SpycerTM</u>. Users see two browsing windows which show either source or destination storage of the files.



Image 17: Browsing windows with two directories in parallel provide for easy drag'n'drop use (Copyright: DVS)

With a built-in renaming function for file sequences, it is very easy to change the naming index or the whole naming pattern. SpycerTM goes through all files and renames them according to the given pattern automatically.

🖨 Rename		? 🔀
× Name Pattern	Extension	dp×
Color-Test-###		
Start Number: 1 😤	Case	Name & Ext : Lowercase 📑
Replace		
Case sensitive		
Old Name	New Name	
ColorCubeStep.0000.cin	Color-Test-001.ci	
ColorCubeStep.0001.cin	Color-Test-002.cir	
ColorCubeStep.0002.cin	Color-Test-003.cir	n

Image 18: File sequences require a good renaming function (Copyright: DVS)

Finding the content: project-based file hierarchy vs. search engine and project <u>metadata</u>. For data handling and tracking, users need intelligent software which monitors every change made in a directory. It is not always possible to find an ideal hierarchical directory structure for a

project in which everyone can find requested material on a big central <u>SAN</u> easily. In order to find a specific file, instead of browsing through several directories manually, it is faster to use a search tool which provides specific attributes for the search query. This is a new working paradigm. In <u>Spycer</u>TM a powerful retrieval engine is implemented. This holds important <u>metadata</u> attributes to localize data fast on the whole network.

Every <u>Spycer™</u> application monitors its own volumes and provides automatically extracted <u>metadata</u> to the SpycerNet. A distributed content management network consisting of individually installed <u>Spycer™</u> applications, is an ideal tool for the <u>postproduction</u>, where content is spread over different storage systems.

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Image 19: Stored metadata help to find the right content. (Copyright: DVS)

Network technology: <u>Client-Server</u> System vs. Distributed Content Management-Network It is hardly ever the case that a central <u>SAN</u> or <u>NAS</u> is the only storage where all data is stored and can be accessed from everyone involved in the project. In the majority of cases, <u>postproduction</u> facilities deal with several islands of storage solutions for security, performance or economical reasons.

In a traditional IT structure there exists a central storage and a central database where all information is administrated. The problem is that a lot of media files never get recorded in the database. This is especially true if an ordinary <u>client-server</u> structure forms the basis for a content management system (<u>CMS</u>). Often a client software provides just a <u>GUI</u> for the database of the <u>CMS</u>. The user has to enter all data manually. For automatic <u>metadata</u> extraction, files have to be stored on the central system where background processes running around the clock can continuously update the database. Such systems are often limited in scalability and performance due to a single <u>server</u> and database being responsible for all files.

What if several databases and active software applications are used on every workstation? Imagine a distributed content management solution where every workstation automatically provides its information to a shared network. Every file gets a record in one of the databases which is available to all others in the company network. This is how a scalable system should work. According to the rights provided to an individual user, the user can find any media file in the network effortlessly by using common metadata information.

<u>Spycer</u>[™] works exactly that way. Via SpycerNet several <u>Spycer</u>[™] applications communicate with each other for browsing, data retrieval and file handling purposes. <u>Metadata</u> is automatically extracted and can be used for search and retrieval in the network. The distributed content management system grows with every additional <u>Spycer</u>[™] application added to the network.

Rights management: in such a distributed content management network rights management is important. Scanning your own files and using available <u>metadata</u> from others on the network for a fast search function does not necessarily mean that other users have the right to view your files! For this, <u>Spycer</u> provides rights management for all <u>metadata</u> and files.



Image 20: Client-server system: a centralized approach (Copyright: DVS)



Image 21: SpycerNet – a truly scalable distributed content management (Copyright: DVS)

Key Facts: DVS-SAN and Spycer[™]

The intelligent configuration of <u>DVS-SAN</u> deals with any kind of <u>postproduction</u> workflow requirement. Collaboration on a customized system and the scalability of <u>DVS-SAN</u> offer the best possible performance and reliability. Its flexibility and independence are enhanced with a new innovative application: <u>Spycer™</u> is able to analyze and defragment large clips. A monitoring process updates the current defragmentation status of every sequence and keeps the users up-to-date.

7. DVS: Innovations for the Film and Broadcast Industry

For more than 20 years DVS with its headquarters in Hanover, Germany, has been a leading manufacturer of high-performance digital video products for film, TV, <u>postproduction</u> and R&D. DVS offers a wide range of premium software and high-end video turnkey workstations – from disk recorders and storage systems to conforming and finishing systems for Digital Intermediates. DVS software and hardware are recognized as a reference for quality, reliability and performance.

In addition to its award-winning DI workstation <u>CLIPSTER</u>[®] DVS has presented another milestone in its software development: at NAB 2006 DVS unveiled the content management system <u>Spycer</u>TM. In 2006 a new line of disk recorders came to market: <u>Pronto2K.2</u> and <u>ProntoHD.2</u> enable <u>real-time</u> multi-<u>resolution</u> capture and play-out combined with full conforming. The company has a large OEM customer base, too: numerous leaders in the industry integrate DVS' powerful video I/O boards into their own products. Moreover, DVS has teamed up with ARRI, Kodak, Imagica and The Mill.

A complex technical setup like a <u>SAN</u> needs a competent partner with video and storage knowhow. This starts with the configuration of the system and is continued with the installation on site. A plan for setup and replacement must be in place in case of a component failure. For the best possible support, DVS offers advanced replacements of the parts, spare parts stored at the customer site and has a worldwide service partnership for on-site replacements. Different service packages allow up to 24/7 phone and remote diagnostics support, covering every time zone and on-site maintenance visits.

With more than 20 years of experience and high-quality products DVS hardware and software solutions are strongly sought after amongst industry leaders.

Key Facts: DVS Quality

The DVS quality and experience is wellknown and appreciated in the industry. Flexibility and innovative concepts from DVS have provided the industry with major milestones.

On top of that, DVS offers support packages to suit all user requirements.

8. Conclusions

From celluloid to digital data, the history of film and video <u>postproduction</u> has undergone rapid changes. Today's requirement for high data rates and data quantities impose interesting challenges for the industry.

A <u>SAN</u> is an excellent solution to handle the large quantities of data and the requirement for collaborative workflows in the <u>postproduction</u> facilities. A <u>SAN</u> is a Storage Area Network. <u>SANs</u> are easily scalable and expandable in regard to speed, size and number of connected <u>clients</u>.

Depending on the individual requirements in a facility, different configurations have to be taken into account. <u>DVS-SAN</u> offers a wide range of possibilities. This can start with a simple near-line storage attached to two <u>clients</u>, up to configurations with dozens of <u>clients</u> connected to huge amounts of storage with several <u>real-time 2K</u> data streams in parallel. Both its hardware design and software setup enable the facility to handle the amount of data simply and reliably.

There are quite a few questions to be answered when considering investment in a <u>SAN</u>. Of course, it is essential to know how much storage is needed. But there is more to it than the famous money versus storage calculation. And there are more questions to be asked and answered: How many <u>clients</u> will access to the <u>SAN</u>? Is the <u>SAN</u> in the need of a <u>real-time</u> storage or a near-line storage? What is the best way to organize the data? Are there different <u>operating systems</u> in use? Is there any protection against failure – and what support is available when needed?

<u>DVS-SAN</u> has unrivaled flexibility. This is enhanced with a new innovative application: <u>Spycer™</u> is able to analyze and defragment large clips. A monitoring process updates the current defragmentation status of every sequence and keeps the user up-to-date. DVS quality and experience is renowned in the industry. Flexibility and innovative concepts from DVS have provided major milestones to the industry. On top of that, DVS offers various support packages to suit all user requirements.

Undoubtedly, a <u>SAN</u> is a perfect solution for many <u>postproduction</u> facilities. Sustaining highest data rates and <u>real-time</u> capabilities is what is required. Faster network technologies will allow a wider use of distributed storage and <u>real-time NAS</u> storages in the future. Nevertheless, <u>DVS-SAN</u> is a future-proof investment since it seamlessly integrates with <u>NAS</u>, <u>DAS</u> (Direct Attached Storage) and data networks.

9. References

- Apple: <u>http://www.apple.com/pr/products/</u> and <u>http://www.apple.com/downloads/dashboard/games/applelogo.html</u>
- DVS: <u>http://www.dvs.de</u>
- Hitachi: http://www.hitachi.com/
- Linux[®]: <u>http://www.isc.tamu.edu/~lewing/linux/</u>
- Raid: http://searchstorage.techtarget.com/gDefinition/0,294236,sid5_gci214332,00.html
- RoHS: http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l 037/l 03720030213en00190023.pdf
- Seagate: <u>http://www.seagate.com/</u>
- Windows[®]: <u>http://www.microsoft.com/presspass/gallery.mspx</u>
- Wikimedia: http://commons.wikimedia.org/wiki/Image:Film reel and film.jpg

10. Glossary

2K

Abbreviation for resolutions of image and video, e.g. 2048 x 1536 and 2048 x 1556 pixels. This resolution is recognized as the minimum resolution that is suitable for cinema presentations. In order to obtain other aspect ratios or to be compatible with technologies like HD-SDI, further formats like 2048 x 1080 and 2048 x 858 are common. As 2K is used for film production mainly, the color coding is mostly RGB 4:4:4, which gives a better quality than YUV 4:2:2.

4:2:2/:4

This is a term commonly used for a component digital video format. It represents a certain ratio of sampling frequencies used to digitize color difference components (Y, R-Y, B-Y) of a video signal and the luminance. 4:2:2 describes that for every four samples of Y, there are two samples each of B-Y and R-Y, increasing chrominance bandwidth in relation to luminance compared to 4:1:1 sampling. 4:2:2:4 is identical to 4:2:2 with a further channel for key channel that is sampled four times for every four samples of the luminance channel.

4:4:4/:4

Quite similar to 4:2:2 with one exception: luminance and chrominance are sampled with the same rate. 4:4:4 is often used with RGB color coding, but YUV color coding in conjunction with 4:4:4 sampling is also common. 4:4:4:4 is similar to 4:2:2:4. Here as well, for every four luminance samples, the color and key channels are also sampled four times.

4K

Abbreviation for an image and video resolution of 4096×3112 . This resolution is recognized to be of the same quality like a high-quality cinema presentation. To obtain other aspect ratios or to be compatible with technologies like HD-SDI or DVI, further formats like 4096 x 2160 and 4096 x 1714 are common. The 4K resolution is higher than the one of a HDTV signal. As 4K is used for film production mainly the color coding is mostly RGB 4:4:4 which gives a better quality than YUV 4:2:2.

ADIC

A company providing data storage solutions, Advanced Digital Information Corporation.

ATA

Advanced Technology Attachment. See IDE.

Cache

A cache is an especially fast memory. It is a collection of duplicated data values stored in a memory.

Centaurus®

Centaurus[®] is the industry standard for high-end uncompressed video I/O hardware. Based on PCI-X bus architecture this DVS video I/O board combines the technology of DVS' SDStationOEM and HDStationOEM. Centaurus[®] is equipped with RS.422 remote control, wordclock, GPI interface, and a real-time hardware mixer. The board is ideal for compositing, title generation, virtual studio, color correction, and simple video I/O. Its successor, Centaurus II, will be on the market in late 2006 and is then available in a PCI-X 133 and PCI Express version.

Cineon®

This is a file format that was specifically designed to represent scanned film images.

Client

A computer system that wants to access a service – sometimes a remote one – on another computer is called a client. Typically this happens within a network.

Client-Server Architecture

Network structure which separates server applications from client applications. A central server manages all data for different clients and provides them with the required data. The system's scalability depends on the server performance and the expandability of its hardware resources.

CLIPSTER[®]

CLIPSTER[®] is a turnkey solution by DVS. It is a one-stop Digital Intermediate solution for conforming and finishing uncompressed SD/HD/2K/4K data in any workflow. Moreover, this DI workstation carries out real-time effects, enables multi-resolution and is an open platform. CLIPSTER[®] offers stunning hardware power and innovative software for unrivaled flexibility and can be used in any video or film post-production environment. The high performance is to be seen in its real-time effects with up to 2 x 2K RGB 12 bit, its real-time playback of 4K RGB 10 bit DPX file sequences and its support of multiple video formats with real-time converting. Additionally, CLIPSTER[®] can handle real uncompressed video up to 4K RGB 16bit and runs real-time effects in 16 bit, with original native content being used for real-time processing. CLIPSTER[®] is an open platform: the Windows[®] XP workstation captures directly to NTFS and it possesses real-time support of graphic file sequences like DPX, TIFF, Cineon[®], TGA, BMP, etc. Of course, an OpenFX plug-in interface is part of CLIPSTER[®] as well.

CMS

A Content Management System is a software that helps storing content and tracking changes made by users. It supports the organization of content via a database.

Color space

This term describes the color range between specified references. Normally, references in television are quoted in the following way: RGB, Y, R-Y, B-Y, YIQ, YUV and Hue Saturation and Luminance (HSL), and XYZ. Common for these color spaces is that three values are used to represent a color. In print, Cyan, Magenta, Yellow and Black (CMYK) are used. It is possible to convert images between these color spaces, but due to the accuracy of processing involved care is required. When operating across the media – print, film, TV, as well as between computers and TV equipment – conversions in color space are needed.

Component

Each color of an RGB or YCbCr signal is transmitted via an indivual cable. This would be called a component color signal in opposed to a composite signal, where the three components are transmitted via one cable.

Compositing

Simultaneous multi-layering and design for moving images. Modern designs often use different techniques in combination, such as retouching, rotoscoping, painting, keying/matting, digital effects and color correction as well as multi-layering in order to create complex animations and opticals in promotions, title sequences, commercials as well as in program content. Besides the creative element there are other important applications for compositing equipment such as image repair, glass painting and wire removal - especially in motion pictures. The quality of the finished work, and therefore the equipment, can be crucial. This is especially true where seamless results are demanded. For example, adding a foreground convincingly over a background - placing an actor into a scene - without any telltale blue edges or other signs that the scene is composed.

DAS

Direct Attached Storage. A storage unit directly attached to the device recording the data.

DDR / digital disk recorder

Systems that record video or audio programs on one or more hard drives. They are mostly used in broadcast or radio broadcasting when editing or recording is required. The benefit of these systems: they offer immediate access to the material that was recorded before, without requiring pre-roll/post-roll or expensive maintenance of tape heads.

DPX

Abbreviation for Digital Picture Exchange. This file format can be found in digital film work and is considered an ANSI/SMPTE 268M standard. DPX files can store image data and additional metadata in their file header.

DVS-SAN

DVS-SAN is a high-performance central storage system for uncompressed video and digital film. It has been designed for use in the film and HD postproduction environment, where large amounts of data must be accessed in real time by multiple workstations. DVS-SAN meets the special demands of digital intermediate work and HD projects requiring ultrahigh data rates and fast access times. With DVS-SAN, several workstations can access the same data, concurrently and in real time, eliminating the need for copying and exporting. The system is upward-scalable to hundreds of terabytes and so offers enough storage capacity for several film projects.

EDL

Edit Decision List, a file that describes how video or film sequences shall be assembled. In general it contains four columns with time code information. Two columns define the source position and two the destination position of the clip. EDLs can contain additional information about special effects and others.

Ethernet

Ethernet is a network technology for data transmission. A star-topology with twisted pair wiring is the most popular form. Common data rates are 10 Mbit/s (Ethernet, 10 Base-T), 100 Mbit/s (Fast Ethernet, 100 Base-T), 1000 Mbit/s (Gigabit Ethernet, 1000 Base-T) and 10,000 Mbit/s (10 Gigabit Ethernet).

Fail-over

This term describes the capacity to automatically switch over to a redundant system, network or computer server, when a failure or abnormal termination of the active system, network or server occurs.

FC-drives

See Fibre Channel. These drives use the copper version of the Fibre Channel interface with a SCSI protocol. The maximum data rate is 4 Gbps.

Fibre Channel

A Fibre Channel is a universal, high-speed data link that can handle up to 4 Gb/s on a fibre optic cable. It originates from computer technology but is used in the video industry as well. The industry shows great interest in products using Fibre Channel, e.g. so that hard disks can be connected. Fibre Channel can be transmitted optically via optical fibre or electronically via copper cable.

File System

When storing and organizing computer files and their accompanying metadata, a popular method to use a file system. A file system might possibly have a storage device (e.g. hard disk) and then maintaining the physical location of the files is of importance. The file system will translate the file name used by the user to the physical address on the storage device. Another option is that the file system grants access to data on a file server – then acting as clients for a network protocol. File systems might be virtual, too, and then only exist as an access method for virtual data.

Format

(1) The size, resolution, aspect ratio, color space, bit depth, format rate, etc. for a given image.

- (2) The file format for a given image.
- (3) The physical medium (such as film, video, etc.) used to capture or display an image sequence.
- (4) A multitude of additional variations and subcategories of the first three definitions.

Fragmentation

(Data) fragmentation occurs when a piece of data in memory is divided into several parts being physically far apart. Generally, this is the result of attempting to insert a large block of data into several small free spaces on the storage.

GUI

Graphical User Interface. An interactive graphic displayed on a screen, being a means of operating a software.

HD

High-definition. Sometimes used as a short form of HDTV.

HDTV

Collective term for television and video formats of a resolution higher than standard TV. There are various proposals and standards. The most common formats that are standardized by SMPTE and others have 1280 x 720 pixels (SMPTE 296M) and 1920 x 1080 pixels (SMPTE 274M). In some countries they are already used for broadcasting television programs. Besides television applications the HDTV equipment is also used in production and postproduction of feature films. Both formats can be used with frame rates from 23.976 up to 60 frames per second. While 1920 x 1080 typically is used with interlaced scanning, in this case with a maximum frame rate of 30 fps, 1280 x 720 is always progressive but with frame rates up to 60 fps, i.e the frame rate of the 1280 x 720 format is normally twice the frame rate of the 1920 x 1080 format. With the above said, the data rates of both formats are about the same. That is why most HDTV devices support both formats. If 1920 x 1080 is used with 50 or 60 fps in progressive mode the data rate is about as twice as high.

Hot Spare

In order to provide reliability in different system configurations, a hot spare can be installed that works as a fail-over mechanism. The hot spare is connected but not actively working. If one part fails, the hot spare part will take over its job.

IDE/ATA

Integrated Device Electronics / Advanced Technology Attachment. IDE and ATA are used synonymously. Since the introduction of SATA (Serial ATA) it is sometimes called P-ATA to avoid misunderstanding. IDE is a parallel hardware interface for storage devices with point-to-point connection. The maximum data rate is 133 MB/s. As the cable length is limited to 40 cm, this interface cannot be used for interconnections where computer and hard disk are housed in different chassis. Therefore, the external connection usually is done with SCSI or Fibre Channel interfaces.

I/O

Abbreviation for input/output. The I/O usually describes the process of sending or receiving data signals from different devices.

lrix[®]

Unix based operating system created by the company SGI.

Linux®

Linux[®] is an open source Unix-type operating system originally created by Linus Torvalds. Due to the open source concept the development is done by contributions from volunteer developers from all over the world. Though the sources themeselves are free, some compilations from different providers may have a price.

Mac OS

Operating system of Apple Macintosh computers.

Metadata

Data that describes other data. Generally, structured information that describes a (possibly unstructured) set of data. For example, a title can be a metadata item of a movie which is stored as a clip in a file. The frame rate and resolution of a clip are metadata items, too.

MTBF

Mean time between failure. A statistical value for the reliability of a device. Higher numbers mean higher reliability.

NAS

Network Attached Storage. Data storage technology that can be connected directly to a computer network to provide centralized data access and storage to heterogeneous network clients. Storage space is usually made available through regular network connections. Due to the standard interface technology it is relatively inexpensive, but does not deliver sufficient data rates for real-time HD or film transfer.

Non-linear editing (NLE)

This term describes a form of the editing process. Here, the recording medium is not a tape, therefore, editing can be performed in a non-linear manner, i.e. the editor is independent of the sequence of the program. NLE has the advantage of editing with quick access to source clips and record space (e.g. on computer disks). Moreover, it removes the need of winding and pre-rolling of VTR operations and hence speeds up work. Even greater speed and flexibility are possible when real-time random access to any frame (true random access) is applied. The term NLE is mostly used when discussing offline editing systems storing highly compressed images, but increasingly online non-linear systems are available as well. Nowadays quite a range of systems claim online quality with video compression. Still, prospective users have to judge the suitability of the results for their application and bear in mind that for transmission/ distribution the signals will be decompressed and re-compressed again.

No single point of failure

Describes a configuration in which at least one of each component may fail without loosing the functionality or data of the system.

Operating system

Every computer needs a base program, the so-called operating system that manages the computer and grants control of various functions. Common examples are MS DOS and Windows[®] for PCs, Mac OS for Apple[®] Macintosh and UNIX for Linux[®]. On top of the operating system, specific applications are installed. General purpose operating systems allow a wide range of applications to be used, they do not necessarily allow the most efficient or fastest possible use of the hardware for the application.

Postproduction

The stage in the preparation of a film or video program after the original footage has been shot. Can include editing, encoding, computer program authoring, etc.

Pronto2K.2/ProntoHD.2

The Pronto2K.2 and ProntoHD.2 are DVS products. These DDRs are fully configured turnkey systems that process uncompressed SD, HD and 2K (2048 x 1556) in real time. They are perfect for displaying HD as well as 2K and for theater screening. Pronto2K2.2 adds uncompressed 2K (2048 x 1556) in real time and 4K 5psF. The DI and postproduction business will benefit from the dual-link HD-SDI interface which can capture and play RGB 4:4:4 12 bit material plus keycode. In these future-proof DDRs new video formats can be added easily and both systems can be adapted to a range of high-end postproduction applications. The integrated Spycer™ application provides powerful content management capabilities.

Quantization

When converting an analog signal to a digital one, the process is called quantization. It measures a sample to determine a representative numerical value that is then encoded. There are three steps in analog-to-digital conversion: sampling, quantizing, and encoding. The representation of the coded values typically is done with binary numbers. Video signals are often coded using 8 or 10 bits, which allow 256 and 1024 different values respectively. Audio uses 16 or 24 bits with 65536 and 16777216 different values. For video and audio coding, increasing the bit number does not increase the maximum or minimum values but the number of steps between minimum and maximum which normally gives a better quality.

QuickTime

A QuickTime file works as a multimedia container file. It contains one or more tracks, each of which stores a particular type of data, like video, audio, effects, or text (for subtitles, for example). Each track in turn contains track media. This might be either the digitally-encoded media stream (using a specific codec, e.g. JPEG, MP3, DivX, or PNG) or a data reference to the media stored in another file or elsewhere on a network. An "edit list" indicates what parts of the media to use.

RAID / RAID 3 / RAID 0

Abbreviation for Redundant Array of Independent Disks. In order to create a higher performance of individual drives, a grouping of standard disk drives are combined into a RAID, that then act as one disk. RAID is primarily designed for operation with computers. RAIDs offer very high capacities, fast data transfer rates and increased security of data, too. The increased data security is achieved through disk redundancy resulting in the possibility of detecting and correcting disk errors or failures. Different series of RAID configurations are defined by levels, starting from zero.

The most popular RAID types are (source of the following RAID paragraphs: <u>www.searchstorage.com</u>)

- RAID-0: This technique has striping but no redundancy of data. It offers the best performance but no fault-tolerance.
- RAID-1: This type is also known as *disk mirroring* and consists of at least two drives that duplicate the storage of data. There is no striping. Read performance is improved since either disk can be read at the same time. Write performance is the same as for single disk storage. RAID-1 provides the best performance and the best fault-tolerance in a multi-user system.
- RAID-2: This type uses striping across disks with some disks storing error checking and correcting (ECC) information. It has no advantage over RAID-3.
- RAID-3: This type uses striping and dedicates one drive to storing parity information. The embedded error checking (ECC) information is used to detect errors. Data recovery is accomplished by calculating the exclusive OR (XOR) of the information recorded on the other drives. Since an I/O operation addresses all drives at the same time, RAID-3 cannot overlap I/O. For this reason, RAID-3 is best for single-user systems with long record applications.
- RAID-4: This type uses large stripes, which means you can read records from any single drive. This allows you to take advantage of overlapped I/O for read operations. Since all write operations have to update the parity drive, no I/O overlapping is possible. RAID-4 offers no advantage over RAID-5.
- RAID-5: This type includes a rotating parity array, thus addressing the write limitation in RAID-4. Thus, all read and write operations can be overlapped. RAID-5 stores parity information but not redundant data (but parity information can be used to reconstruct data). RAID-5 requires at least three and usually five disks for the array. It's best for multi-user systems in which performance is not critical or which do few write operations.
- RAID-6: This type is similar to RAID-5 but includes a second parity scheme that is distributed across different drives and thus offers extremely high fault- and drive-failure tolerance.
- RAID-7: This type includes a real-time embedded operating system as a controller, caching via a high-speed bus, and other characteristics of a stand-alone computer. One vendor offers this system.
- RAID-10: Combining RAID-0 and RAID-1 is often referred to as RAID-10, which offers higher performance than RAID-1 but at much higher cost. There are two subtypes: In RAID-0+1, data is organized as stripes across multiple disks, and then the striped disk sets are mirrored. In RAID-1+0, the data is mirrored and the mirrors are striped.
- RAID-50 (or RAID-5+0): This type consists of a series of RAID-5 groups and striped in RAID-0 fashion to improve RAID-5 performance without reducing data protection.
- RAID-53 (or RAID-5+3): This type uses striping (in RAID-0 style) for RAID-3's virtual disk blocks. This offers higher performance than RAID-3 but at much higher cost.
- RAID-S (also known as Parity RAID): This is an alternate, proprietary method for striped parity RAID from EMC Symmetrix that is no longer in use on current equipment. It appears to be similar to RAID-5 with some performance enhancements as well as the enhancements that come from having a high-speed disk cache on the disk array.

Real-time

Real-time is the idea or concept of a system, that responds and reacts to signals as fast as they happen. One popular example is located in the games industry: when an operator moves a joystick and the video image on the screen seems to react at the exact same time, the processes that were needed to make the images move are said to be in "real-time".

Recovery

Recreation of the original stored data in a RAID storage system. For example, after a hard disk failure. The missing data is recreated from the stored parity information.

Resolution

In a reproduced image, a measure of the exact details can be seen or "resolved". The number of the pixels in this image influences the display: high-definition is defined at approx. 2000 x 1000 pixels, SDTV at approx. 720 x 576 (PAL) or 720 x 487 (NTSC). Still, the number of pixels does not define the resolution itself, since the resolution is the result of the whole equipment interacting, i.e. the quality of the lens, the display tubes, film scanners, film processes, edit system, etc.

RGB

The abbreviation for the Red, Green and Blue signals, the primary colors of television. Cameras and telecines have red, blue and green receptors, the TV screen has red, green and blue phosphors illuminated by red, green and blue guns. Much of the image monitoring in a production center is in RGB. RGB is digitized with 4:4:4 sampling which occupies 50% more data than 4:2:2.

RoHS

EC directive EU/95/2002 for the "Restriction of Hazardous Substances" in electronic components.

SAN

Storage Area Network.

SAS

SAS is the abbreviation for Serial Attached SCSI (Small Computer System Interface). SAS is a market replacement for parallel SCSI. It is a serial interface, that has the same electrical specifications as SATA, but uses SCSI protocol and two SATA links for a data rate of 300 MB/s

SATA/SATA-2

Serial ATA (Advanced Technology Attachment). A further development of ATA, also known as IDE. SATA is the successor of ATA, but it is a serial interface, resulting in easier cabling and fewer errors. The maximum data rate is 150 MB/s for SATA and 300 MB/s for SATA-2, a newer version of SATA.

SCSI

Abbreviation for Small Computer System Interface. It is a parallel interface with up to 16 bit. A connection of up to 15 drives to one interface port are possible thanks to the BUS architecture. The maximum data rate is 320 MB/s.

SD

Standard-definition.

SDI / serial digital interface

SDI is the abbreviation for Serial Digital interface. It is based on a 270 MB/s transfer rate. The interface is based on 10 bit, scrambled and is polarity independent. Common scrambling for ITU-R 601, composite digital video and four channels of (embedded) digital audio are possible. The SDI interfaced is included in most newer broadcast equipment (digital), in that installation is simplified as well as signal distribution. SDI uses standard 75 ohm BNC connector and coax cable, since this mostly is used for analog video and the signal's transmitting range hits up to 60 feet (200 meters).

SDStationOEM II

SDStationOEM II is a DVS OEM board and a solution for uncompressed SDTV video and AES/EBU audio I/O. It enables solution providers to build their own customized A/V systems: for editing, compositing, CG or virtual sets. As a half-length PCI board, the SDStationOEM II is the most flexible solution on the market, taking full advantage of the PCI 64-bit bus. The SDStationOEM II provides rock-solid performance with a proven SDK design enabling customers to create the innovative systems the market requires.

SDTV

SDTV is the abbreviation for Standard Definition Television and refers to television formats as standardized in ITU-R 601 and SMPTE170.

Server

When a computer provides services to other computing systems (clients) over a network, it is defined as a server. Most complex computer systems today require a server, but the term can also refer to the software or hardware elements of such a system.

Spycer™

Spycer[™] is an innovative data management software from DVS that has been integrated in all DVS turnkey solutions. It provides a solution for dealing with large amounts of video data and its accompanying metadata. Spycer[™] provides editors, colorists and directors with a wide range of browsing, search and management tools.

Spycer[™] offers more transparency in DI workflows since it assists by managing, searching and viewing content and metadata and also by browsing directories within the context of the current project. Fast data retrieval and high-speed copying are other key features of this application.

Stripe set

A stripe set is a storage that consists of multiple hard drives. The total capacity is the sum of the individual drives. The performance in general is higher than the performance of a single hard drive. A stripe set has no redundancy and is the same as a RAID 0 configuration.

Sustained Data Rate

Sustained data rates are the average of data rates measured over a longer period. The best way to measure data rate of a storage is to run the same application being intended to be used with the storage.

Telecine

A telecine can rapidly convert motion picture into a digital video format. Newer devices will be able to produce it in HDTV resolution. The telecine is faster than a film scanner, but the quality might not be the same.

VTR

Video Tape Recorder.

Windows®

Operating system for IBM compatible PCs developed by the company Microsoft.

WMV

Microsoft developed a set of video codec technologies called Windows[®] Media Video (WMV). WMV is part of the Windows[®] Media framework.

YUV

YUV is the abbreviation for the differential brightness and color signals. It is the color space used by NTSC and PAL video systems. While the Y' is the luma component, the U and V are the color difference components. Some may mistake the Y'UV notation for Y'CbCr data. Most use the YUV notation rather than Y'UV or Y'U'V'. Technically correct is Y'U'V' since all three components are derived from RGB'. YUV is also the name for some component analog interfaces of consumer equipment.

11. Contact

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12. Notes