SONIC SOLUTIONS

Publishing in the Age of DVD

Second Edition

A Primer

for Creating

Content

for DVD

by Mark Ely
and Dave Block

About Sonic Solutions

Sonic Solutions is a leading developer of production tools for digital media workgroups. The company has three major product lines: DVD production systems, digital audio workstations, and high-speed networking solutions for digital media production. Sonic's focus is providing professional tools with an emphasis on productivity, creative flexibility, power, and media workgroup solutions.

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After several years of intense development and cross-industry cooperation among consumer electronics companies, computer manufacturers, and the entertainment industry, the DVD format has arrived — and with it a new era of consumer entertainment. For the first time, high-quality digital video as well as surround sound audio can be delivered to the consumer on a single interactive compact disc. Playable on the set-top or the desktop, DVD bridges the worlds of consumer video and personal computing in a single, unified format.

While DVD promises to be a highly-successful consumer electronics format, preparing content ("premastering") for DVD can be a very complex process. And like most new formats, DVD requires new tools and techniques to create rich and satisfying content that make the most of the medium.

Working with DVD requires an in-depth understanding of the format, production process, and tools required to bring titles to market. By understanding DVD and all that it entails, professional media developers can exploit its rich potential. This book is designed for those who are interested in the DVD format, want to create titles, and wish to understand the tools and technology required for DVD production.

THE FORMAT

Where did DVD come from?

Since the introduction of the audio compact disc in 1982 and the CD-ROM in 1985, the CD has become a universal carrier for music, data, and multimedia entertainment. It has become the most popular consumer media format ever, yet it soon may be overshadowed by DVD.

Since the CD format first appeared on shelves, consumer electronics and CD manufacturing companies have been working on new techniques to increase the density of the standard 74-minute/650 megabyte optical media format. In 1993, Nimbus Technology and Engineering debuted the first double-density CD format with two hours of MPEG-1 video playback. This was the first demonstration that CD technology could carry high-quality video as well as audio and that a new format might be on the horizon.

By 1994 cable, satellite, and video-on-demand services were making strong inroads into the home market, competing for the consumer's time and money. The home video industry, seeing increased competition for VHS sales and rentals, recognized the need for a new consumer video format which could deliver superior quality pictures and sound. A consumer format based on the compact disc, which had revitalized the recording industry years before, could provide the solution that Hollywood sought. An advisory committee was formed to create a set of requirements for such a format.

Their recommendations included:

High-resolution video (CCIR-601 broadcast standard)
133-minute movie to fit onto one side of a high-density disc
High-quality audio — stereo and six or more channels of surround sound
Three to five language streams
Up to 30 subtitle streams
Copy protection
Parental lock for adult-oriented titles
Multiple aspect ratios — 16:9 wide-screen; 4:3 pan-scan and letterbox

Table 1: Hollywood DVD recommendations

By January of 1995, two digital video disc formats were unveiled: the Super Density (SD) format by Toshiba and a consortium of partners, and the Multi Media Compact Disc (MMCD) by Philips and Sony. With the prospect of a "Beta vs. VHS" format war looming on the horizon, consumer electronics manufacturers and studios formed the DVD Consortium to agree upon a single unified specification for the next generation Compact Disc. In December of 1995, a general agreement was reached and the DVD was born.

In light of all the possible uses for optical media storage systems, the DVD Consortium has broken down Digital Versatile Disc into several "books" labeled A through E. These books are:

A	DVD ROM
B	DVD Video
C	DVD Audio
D	DVD Recordable
E	DVD RAM

Table 2: DVD "Books"

At present, Books A: DVD-ROM and B: DVD-Video have been completed and lay the foundation for the DVD media format. Books D: DVD Recordable and Book E: DVD RAM have recently been announced, and Book C: DVD-Audio is expected to be available in 1998.

Physical Specifications

DVD is enabled by technical advances in both optical media data capacity and digital video compression algorithms. On the optical media side, DVD achieves its superior data capacity by increasing the density of the pits on the disc surface as well as by using a more efficient error correction scheme. Increased pit density means more bits are available for storage and better error correction results in more of those bits being available for program or data storage. DVD and CD optical media specifications are as follows:

	DVD	CD
Disc diameter	120 mm (5 in.)	120 mm (5 in.)
Disc thickness	1.2 mm (2 bonded .6mm layers)	1.2 mm
Track pitch	0.74 µm	1.6 µm
Laser wavelength	650 or 635 nm red laser	790 nm red laser
Numerical aperture	0.6	0.45
Minimum pit length	0.4 µm	0.83 µm
Error correction	RS-PC	CIRC
Signal modulation	8-16 (EFM+)	8-14 (EFM)
Reference scanning velocity	3.49 m/s (single layer) 3.84 m/s (dual layer)	1.2 to 1.4 m/s
Data capacity	DVD-5 single sided,single layer; 4.7 GB DVD-9 single sided,dual layer; 8.5 GB DVD-10 double sided,single layer 9.4 GB DVD-18 double sided,double layer 17 GB	650 megabytes
Maximum data rate	10.00 Mbps (Megabits per second)	1.4112 Mbps

Table 3: DVD and CD physical specifications

Capacity

DVD ranges in capacity from 4.7 Gigabytes up to 17 Gigabytes. Two sizes for the DVD media are available: 12 cm compact disc size, or 8 cm CD-single size. A DVD can be manufactured four ways: single-sided, double-sided, single-sided with dual layers, double-sided with dual layers

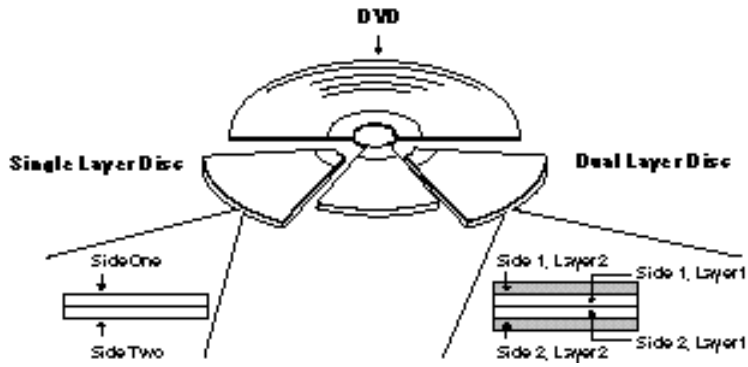

Figure 1: DVD Disc Layers

Even though most DVD discs manufactured today are DVD-5 (single-layer, single-sided discs), all DVD discs, regardless of capacity, are made up of two platters bonded back-to-back. This double-sided manufacturing technique increases the rigidity of the media and minimizes warpage.

All compact disc media exhibit some type of warpage. When the plastic used to make a CD cools, it takes on a slight curvature as one side typically cools more quickly than the other. Slight warpage does not present a problem for the laser beam being able to read the pits. However, if the warpage is extreme, the laser will not be able to read the disc at all. Due to the increased pit density of the DVD format, the discs are more sensitive to warp in the media and must therefore be as flat as possible. One easy way of solving this problem is to bond two separate discs back-to-back. This results in improved rigidity and the slight curvature induced in manufacturing is offset by the bonding.

All DVD players have the ability to read all of the DVD capacities, from DVD-5 to DVD-18. However, DVD players are not required to read both sides without removing the disc. This means that a single movie can seamlessly extend across an entire side of a disc, and even across dual layers, but seamless playback of a movie that extends across two sides is not possible. In order to play back a second side, the disc must be ejected and flipped over. Some DVD player manufacturers have indicated that they will create players with two lasers, one for the top and another for the bottom, so that a double-sided disc can be read without removing it from the player.

DVD-Video Features and Functionality

Following the recommendations of the Hollywood advisory committee, the DVD Consortium included specific audio and video formats as well as interactive functionality into the DVD 1.0 specification. This is a major advantage that DVD maintains over CD-ROM. In CD-ROM, there is no single specification for audio, video, or a file system. This has led many multimedia developers to invent their own audio/video formats for delivering interactive content. Unfortunately, there is no guarantee that content authored and developed for one configuration of a CD-ROM-equipped computer will work with other models. Since DVD has specific audio formats, video formats, and a file system, content authored for DVD has the advantage of cross-platform compatibility. The specific features and requirements for DVD follow.

MPEG Video

MPEG-2 and MPEG-1 are defined as the video formats for DVD. Depending on the country in which a DVD title is released, it will be in either 525/60 (NTSC) format or 625/50 (PAL) format. Player manufacturers are not required to support both NTSC and PAL DVD discs in a single player, so either separate DVD discs must be created for each format, or a disc can be created with PAL on one side and NTSC on the other (assuming that the content fits on one side of a disc). Some manufacturers, however, are introducing combination NTSC and PAL players in the European market.

	NTSC	PAL
Compression format	MPEG-1 and MPEG-2	MPEG-1 and MPEG-2
Picture resolution	720 x 480 704 x 480 352 x 480 352 x 240	720 x 576 704 x 576 352 x 576 352 x 288
Pictures in Group of Pictures (GOP)	Fewer than 36 fields	Fewer than 30 fields
Aspect ratio	4:3 or 16:9	4:3 or 16:9
Bit rate (maximum)	9.8 Mbps*	9.8 Mbps*

* Maximum bit rate for audio, video, and subpicture program data

Table 4: MPEG and video formats for DVD

For movie playback on DVD, the MPEG-2 format will typically be used, allowing over two hours of high-quality video to be stored on a single-sided, single-layer DVD. MPEG-1 video may also be used for DVD. Because MPEG-1 video is defined as one-quarter the resolution of a full CCIR-601 video stream, its bit-rate requirements are far less than MPEG-2 (1.856 Mbps is the maximum MPEG-1 bit rate). This enables up to four times as much video, roughly eight hours, to be stored on a single-sided, single-layer DVD. Due to the lower quality, the primary applications for MPEG-1 video on DVD would be long training or informational DVD titles, and in most cases MPEG-2 is expected to be the preferred format.

Aspect Ratios

In the early film era, a 4:3 aspect ratio was used for filming content. This is the same aspect ratio as 35mm film. When television was invented, the same aspect ratio was used. As film technology improved, wider aspect ratios such as Cinemascope became popular as a means of differentiating film from television. Meanwhile, television has retained its 4:3 aspect ratio, forcing movie makers to change the

aspect ratio of their film for display on television. One way to do this is a pan/scan process where the wide aspect ratio film is tracked across the narrow 4:3 display area of the video. This results in a video image which is cropped but tracks the most important elements of the program.

The other approach is to "letterbox" the movie by scaling down the film aspect ratio to fit within the confines of the 4:3 aspect ratio. This results in black bars at the top and bottom of the television screen. In an effort to support the aspect ratio standards of film, a 16:9 aspect ratio was developed for DVD. This is not an aspect ratio actually used in film, but is a close compromise and is the same used in the HDTV format. With 16:9 wide-screen televisions and projection systems becoming more popular in home theaters and with the objective to deliver a cinema-like experience, the architects of the DVD format included 16:9 support.

If the source video used for the disc is anamorphic (vertically expanded to fit a 16:9 aspect ratio onto a 4:3 video source) it may be viewed as a full-screen image (not letterboxed) on a wide-screen television. If the same content is played back on a standard 4:3 television, the user can select between vertically expanded (everyone looks tall and narrow), letterboxed (black bars appear at the top and bottom of the screen), or pan/scan (the image is full screen but the sides are cropped and the viewable area pans and scans the action). In order for the player to correctly pan/scan the MPEG-2 anamorphic image across the screen, the pan/scan vectors must be encoded into the data stream. Pan/scan vectors can either be created by a producer or imported with a source file, and are encoded into the data stream during authoring.

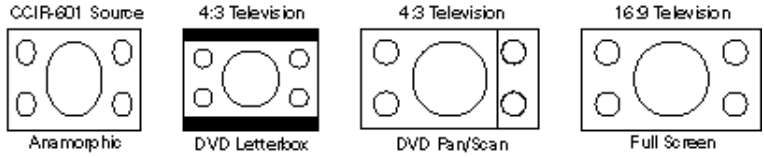

Figure 2: DVD aspect ratios

Angles

One of the unique aspects of the DVD format is the ability to place multi-angle video streams on a disc. Up to nine angles may be present within a video program. This feature provides multiple points-of-view for sporting events, music videos, and movies. For example, with a single click, the viewer can instantly change angle without any break in video or audio continuity. From a production standpoint, the maximum bit-rate of each of the video streams must drop slightly to accommodate the data interleaving required, but the overall quality of each angle still remains very high.

Audio

While the initial emphasis on DVD has been video, the industry has been quick to understand that high-quality, multi-channel audio dramatically differentiates DVD from all other video formats. No other media allows for switching between languages or enables such a range of compressed and non-compressed audio delivery formats.

The three primary audio formats for DVD are PCM (pulse code modulated), Dolby Digital, and MPEG. For NTSC countries and discs, PCM and Dolby Digital may be used with MPEG audio as an option. In PAL countries, PCM and MPEG audio may be used with Dolby Digital as an option. Additionally, the DVD specification includes both DTS (Digital Theater Systems) and SDDS (Sony Dynamic Digital Sound) as options as long as a stream of PCM, Dolby Digital or MPEG audio is present.

	PCM	Dolby Digital	MPEG-1	MPEG-2
Max bit rate	6.144 Mbps	448 kbps	384 kbps	912 kbps
Frequency	48/96 kHz	48 kHz	48 kHz	48 kHz
Channels	4/8*	6	2	8

* Up to 8 channels of 48 kHz; up to 4 channels of 96 kHz

Table 5: Audio formats for DVD

The DVD format supports up to eight independent audio streams on a single disc. Each stream may be stored in any of the available DVD audio formats (with the regional PAL/NTSC caveats noted above).

The viewer can use the DVD remote control to switch between audio streams, which may contain different language versions of a soundtrack, a different mix, or a different format.

Still Images

To deliver high-quality still images, as well as enable the menus that are required to navigate through interactive elements, the DVD specification allows single frames of video to be encoded in full-color and full-resolution. Although primarily used for menu backgrounds, still images can also be used for still shows and slide shows. A still show is a sequence of video images that can be advanced manually by the user while a slide show is fully automated. In both cases, still images may have audio, even full surround sound, associated with them.

Subpicture Overlays

To enable the multi-language subtitling capabilities required by the entertainment industry, the DVD specification includes subpicture overlays – images which are generated by the DVD player on playback and can be keyed over background video or still images. To increase flexibility, subpictures are not limited to text information but may be any bitmap graphic up to the 720x480 (NTSC) or 720x576 (PAL) resolution. Uses for subpictures include subtitles, karaoke lyrics, buttons, animations, instructions, etc.

Subpicture overlays can be changed on a frame-by-frame basis and may fade in or fade out, wipe in color or transparency, or scroll up and down the screen. There is a limitation in the number of colors that can be represented, however – only four single-bit color layers are available. Each of these colors is mapped based on a 16-color palette chosen for each program chain (more on program chains later).

Parental Control

DVD is the first video format that can actively change the content based on movie rating. Using the same mechanisms that enable the format to switch between a director's cut of a movie and the theatrical

release, the DVD format allows a rating to be assigned to a particular movie clip. When a DVD is placed into a player, the rating level of the movie is mapped against the rating levels set in the player; a DVD player set to play only PG movies will automatically switch to a PG version of the movie. If an R-rated DVD does not have a PG variation of the movie, the player will refuse to play the disc.

Copy Protection

One of the entertainment industry's most important requirements for DVD was copy protection. With both VHS piracy and CD bootlegging threatening worldwide entertainment media sales, major movie studios were unwilling to release near-master quality video and audio on a digital format which could be easily copied with no generation loss.

With the contribution of the cross-industry Copy Protection Technical Working Group (CPTWG), several methods of asset protection were included in the DVD format. The protection is both analog and digital: Macrovision is used to prevent copying the high-quality analog video output from the DVD player onto a VHS deck, and an encryption scheme is used to scramble the digital data streams. Encrypted data can only be decrypted with a hardware chip in the DVD player or through specially-designed software for PC-based DVD decoding.

Regional Coding

The movie industry often selects different release dates for theatrical films and videos for different areas of the world. This may be done so that the VHS version of a film doesn't debut before the theater version or to allow time for the feature to be re-edited or dubbed into a new language for the target country.

In order to ensure that entertainment companies have control over the international distribution and timing of high-quality DVD title releases, the DVD specification divides the world into six regions:

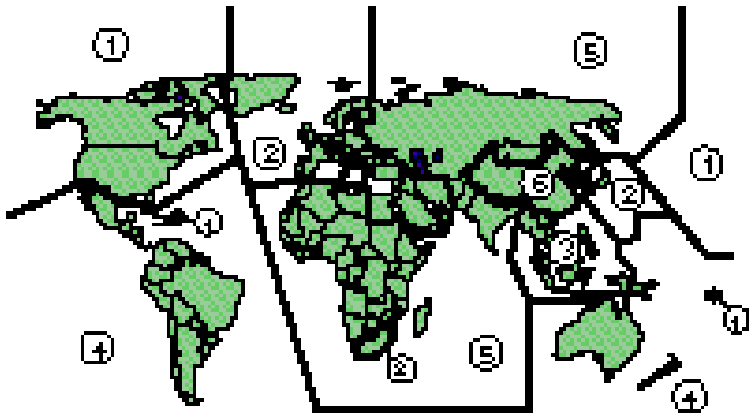

Figure 3: Regional coding

Each DVD player is hardware-coded for a single region and every DVD title is coded for one or more regions. For a DVD disc to play back, the regions of the title and the player must match; for example, DVD titles encoded as region 2 for Japan will not play back in U.S. players, which would only play discs encoded for region 1.

Compatibility

All DVD-Video players will play CD-Audio discs. Additionally, all DVD-ROM readers will play CD-ROM discs. Depending on the manufacturer, DVD-Video players may also include support for VideoCD and LaserDisc, but this is not a required element of the DVD specification.

For DVD-Video discs to play back in DVD-ROM-equipped personal computers, the PC must contain both a DVD-ROM reader and hardware or software to decode the audio and video formats in the DVD specification. Due to the complexity of MPEG-2 video decoding and the audio output requirements for Dolby Digital audio, most PC manufacturers have elected to use hardware-based DVD decoding technology. It is possible for DVD content to be decoded in software but it requires an extremely fast CPU optimized for multimedia. While this may be an option for DVD-equipped PCs in the future, those who wish to upgrade their existing PC will need to rely on DVD-specific hardware in the form of an add-in card.

The Structure of DVD-Video

The File System

The DVD format cleverly defines a specific file system for all types of DVD applications. To overcome the problems of multiple file systems in the CD format, DVD specifies a single file format across DVD Books A through D. This file system is the UDF/ISO-9660 Bridge Format. UDF (Universal Disc Format) was designed specifically for optical media and is an evolution of the ISO-9660 format. The benefit of this single file system is the ability for DVD media to be compatible across set-top players and personal computers with DVD-ROM readers.

The Volume Structure

The top level of organization on a DVD disc is a volume. The volume is made up of the UDF Bridge file system, a single DVD-Video Zone which contains all of the data elements for the set-top video title, and a DVD Others Zone which can be used for non-DVD-Video data elements like desktop computer applications.

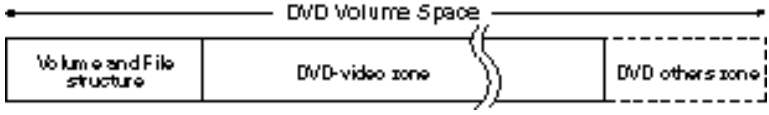

Figure 4: DVD volume structure

The DVD-Video Zone begins with a Video Manager, which is a master directory for the data elements on the disc, followed by 1 to 99 Video Title Sets which include the video and audio elements. The Video Manager usually contains an introductory clip of video and audio, such as an opening logo, and a title menu which allows for navigation to the Video Title Sets. When the Title button on a DVD remote control is pressed, it will take the user back to this Title menu.

Video Title Sets and Video Objects

Following the Video Manager are the Video Title Sets; these usually comprise the bulk of the DVD disc. A DVD can contain multiple title sets, but most feature films would include only one, for the movie. A Video Title Set (VTS) is made up of a VTS Menu and one or more Video Titles. Titles, in turn, can be broken down into Part of Titles (PTT), which are akin to chapters in LaserDisc.

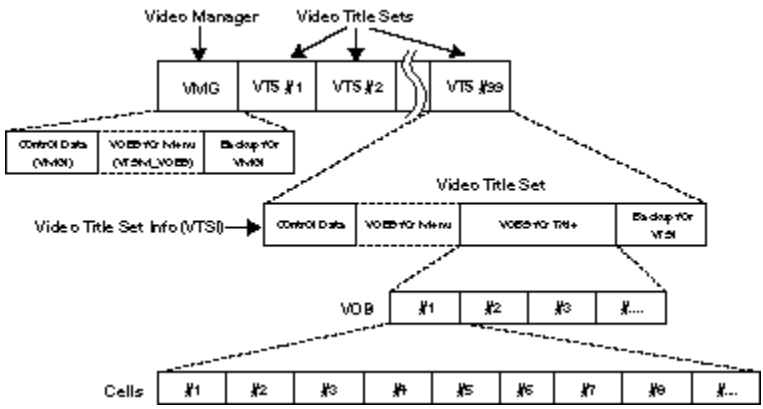

Figure 5: DVD-video zone structure

The data within the Video Title is made up of Video Object Sets (VOBS), which are themselves made up of one or more Video Objects (VOB). A video object is made up of the video, audio, subpictures, and navigation data for a program. It is the VOB which is the fundamental media file element of the DVD disc.

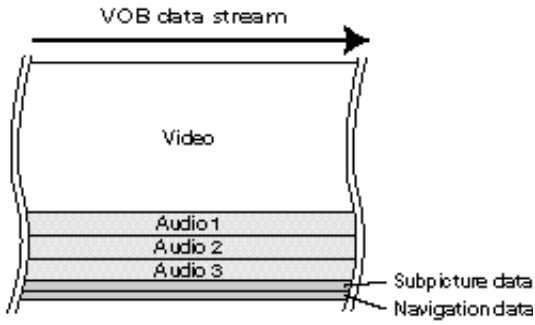

Figure 6: VOB data stream

The lowest branch of the DVD structure is the Cell. Each VOB can be broken down into one or more Cells. A Cell may be as large as the entire movie or as small as an MPEG GOP (more on MPEG GOPs later). This is the smallest unit that can be addressed by interactive playback.

As an example of the above structures, let's consider a simple movie with twelve chapters. The movie would have one Video Manager, one Video Title Set, one Title, one VOBS made up of one VOB, and twelve Cells.

The reason for having multiple Title Sets and VOBS becomes apparent when highly-interactive titles are created. For example, a DVD might include an interactive music video program with fifteen artists, each with five music videos, artist bios, and slideshows containing album covers with surround-sound music in the background. In this case the disc would have: one Video Manager, fifteen Video Title Sets, multiple Titles for each music video, as well as the artist bio and slideshow. The reason for this division is that the DVD remote control has both Title and Menu buttons. The user would click the Title button to return to the main DVD menu to select a title, or click on the Menu button to go to the menus for the particular title being viewed.

INTERACTIVITY

As evidenced by the data structures described above, DVD can be a highly-interactive format. It is interactive both in the range of controls the user has in selecting the data presented and in the way the format has been structured to enable multiple story lines and interactive games. As a descendant of the Video-CD format, DVD has inherited much of the VCD hierarchical branching-menu style of interactivity allowing a user to navigate through a disc by jumping from menu to menu or video to video. Most LaserDisc-style DVD movies will have basic interactivity, limiting the user to menu choices such as language, biographies of the actors, or a chapter menu to jump into the disc at various points.

On a deeper level, DVDs can be authored for extensive user interaction during the course of a disc's play. A good example would be an interactive movie requiring the user to choose the outcome of each scene. By selecting a direction on the remote control, the user can tell the DVD player to move up, down, left, or right. The player then branches to the appropriate video scene and continues to play.

User Interface

The user interface to the DVD player is a remote control. All DVD player manufacturers are required to have similar buttons and functionality on their remotes, including: **play, stop, pause, next program**, **previous program**, **title menu**, **root menu**, **up**, **down**, **left**, **right, enter,** and **return**. Additionally, remotes must include a numeric keypad for number entry, although this may be hidden in an access panel within the remote control.

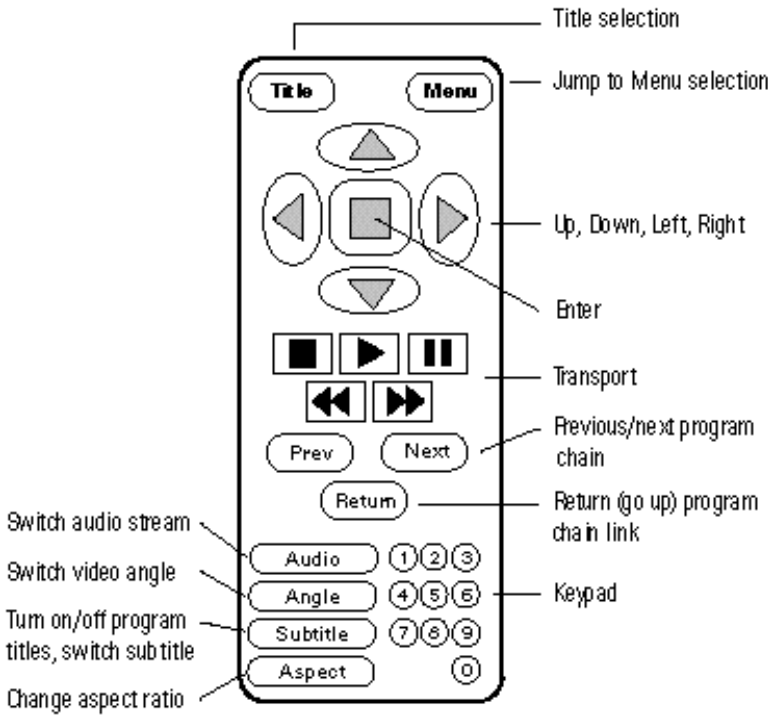

Figure 7: DVD player remote control

Presentation and Playback

Program Chains

The way in which a DVD plays back video is directed by Program Chains (PGCs). While the VOBs represent the multiplexed audio, video, and subpicture overlay, the PGC instructs the DVD player on how those VOBs should be played back, under what conditions they should play, and in what order. Program Chains are the maps used by the DVD player to navigate through the data on the disc.

Each Program Chain in made up of a *pre-command*, a group of programs, and a *post-command*. The pre-command sets the condition for the VOBs which follow, such as which audio stream will be played, or whether a program has recently been viewed. This is followed by a list of cells within the VOB to be played back. Lists of cells are similar to

Edit Decision Lists (EDLs) in that two different programs may reference the same Video Objects, but include different subsets of cells, such as an R-rated program and a PG-rated program. In the example in Figure 8, PGC-1 shows a video clip with rain and lightning while PGC-2 shows only rain, even though both program chains are playing back the same video and audio streams.

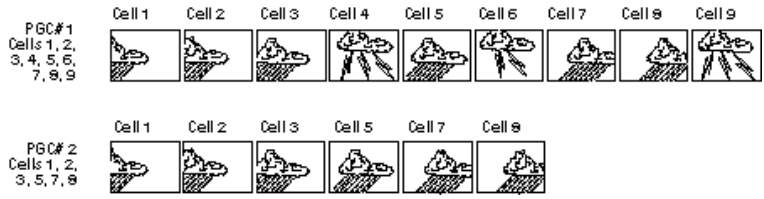

Figure 8: Program chain composition

After the programs have been presented, a post-command can be used to set a link to another program chain, return to a main menu, or any one of up to 128 possible commands from the DVD command set which make up the the navigation control for DVD presentation.

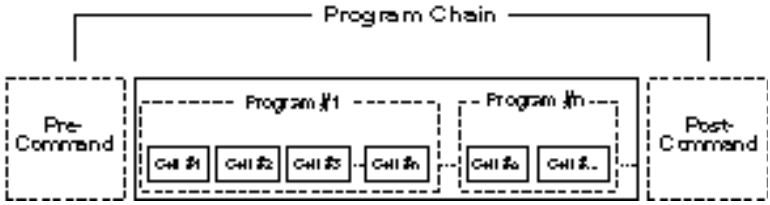

Figure 9: Program chain structure

Navigation Commands

The 128 navigation commands which can be used in the program chain are broken down into a few basic categories: Jump and Link, Calculation, Comparison, Parameter Setting, and Program Flow. Through the use and combination of these commands, complex functions can be performed, such as keeping a game score, randomizing title playback, or ensuring that a unique ending is chosen for a movie. To group multiple commands together or move between Video Title sets, Dummy

Program Chains can be used. These Dummy PGCs do not hold any VOBs and are only used for their pre- and post-command areas.

Menus

Virtually all DVD titles will use menus as a way for users to interact with the program content. Menus are comprised of a background image (either motion video or still frames), a subpicture overlay, a button highlight area, and sometimes even audio. If the DVD is set up for a 16:9 aspect ratio, three different sets of buttons and highlights must be created, one set for each possible display mode: wide-screen, letterbox, and pan/scan.

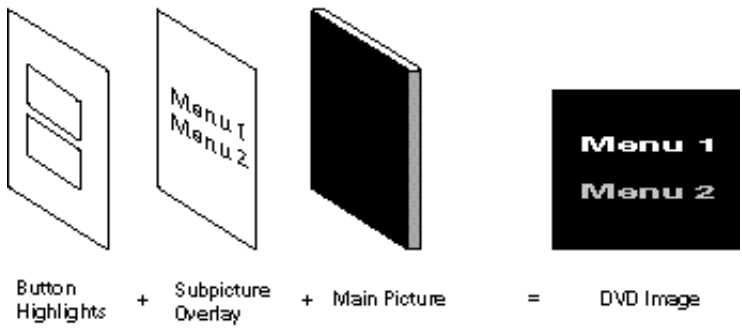

Figure 10: DVD menu composition

Menus can be designed in many different ways. A background image can be a motion video or a 24-bit color still. Choices displayed on-screen can be created as part of the background image to take advantage of the 24-bit color depth or they can be created as subpicture overlays using the four possible colors. In either case, a button highlight is superimposed on top and can represent the selection and action of a button. Using subpicture overlays provides the fastest navigation; however, background images can be changed if greater color depth or image variety is desired.

A button highlight is defined as a rectangular region of the screen which can have a color and transparency for both a selection and an action. The highlight region can also key a highlight color over a prede-

termined color in a background image or subpicture. For example, a text selection may be in black, but when it is selected, the letters turn green. This allows the highlight region to color complex shapes, even though the highlight area is limited to x and y coordinates that define a box.

The DVD specification defines a certain number of menus available to the user through the press of a button on the remote control. These are known as systems menus and are defined as: Title, Root, Part-of-Title, Audio, Angle, and Subpicture.

- The Title menu resides in the Video Manager and is used to access Titles on the disc. It may be accessed with the Title DVD remote button.
- The Root menu resides in each Video Title Set and can be accessed with the Menu DVD remote button.
- Audio, Angle, and Subpictures menus reside within each VTS and can be used to change audio stream, video angle, and subpicture stream.

Whenever a system menu is accessed, the DVD player remembers where in the video stream it was playing and can then return to the same location after the viewer is finished looking at the menu or making a selection, such as a language or subpicture stream.

Although there is an area in the Video Title Set and Video Manager for menus to be placed, all of the interactivity, subpictures, and highlights are also available within the course of VOB playback. In this sense, there in no conceptual difference between a movie and a menu. The main difference is that by placing menus in the Video Manager and Video Title Set, the user can quickly jump to them using the remote control. By thinking of a movie as a menu, one can conceptualize the rich set of user interactions that are possible. For example, a movie may be playing back when a subpicture appears, indicating a choice the user can make in the direction of the story. By clicking the left or right button on the remote, a highlight command indicates the selection,

while pressing Enter links to a new program chain. These types of in-play menus can have a specific time associated with them and continually change as the movie plays on.

System Parameters and General Parameters

DVD players are equipped with two kinds of memory parameters, System and General. The System parameters are used by the DVD player to remember default settings such as language, aspect ratio, and parental rating level. These parameters can be set by the user or by the DVD title in play.

In order to increase the interactivity of a DVD title, the DVD specification requires players to have sixteen 16-bit memory locations that can be used for basic computations or value storage. These are known as General parameters and can only be addressed by the DVD disc in play. One example of the use of General parameters is the storage of values, such as the number of game lives or the previous direction of a story for interactive titles and games.

TITLE EXAMPLES

Given the flexibility of the DVD format, a wide range of possibilities exists for title design. The following example shows a simple DVD title with a Title menu, a PTT (Chapter) menu branching to multiple chapter points, a Language menu stemming to an Audio menu and a Subtitle menu, and a still image for the actor's biographies. Many of the Hollywood-style DVD movies are using templates similar to this.

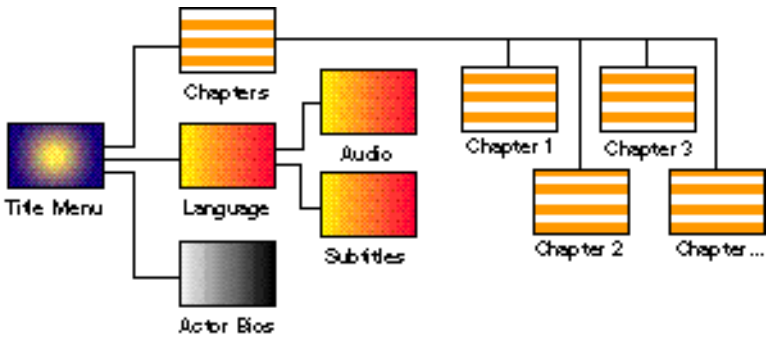

Figure 11: Basic movie DVD

An example of a slightly more complex title would be a DVD of music videos featuring different artists. In the template below, the title begins with a Title menu which branches into a list of titles, an audio menu, and a Subtitle menu. The menu listing each title is used to branch to individual Title sets (VTS) on the DVD, one for each artist. Within each VTS, there is a choice of videos or artist biography. By laying out a title in the manner below, a user can select the DVD remote control's Title button to return to a list of all artists on the disc while selecting the Menu button will return to information about the artist currently being viewed.

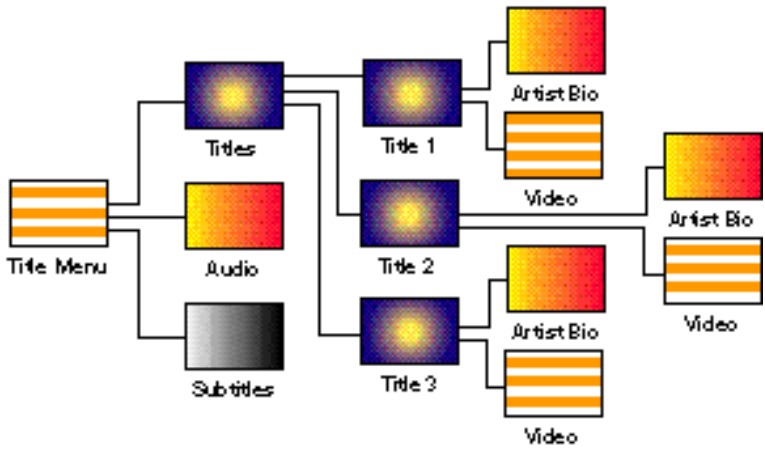

Figure 12: Music video DVD

DVD titles can quickly become quite complex. Once motion video menus are included, general parameters are used, and multiple story-lines are devised, the template for a highly-interactive title can fill a blackboard. Other possible DVD titles include: interactive training manuals, multi-language education, archival video and audio storage, interactive movies, games, and hybrid DVD-ROM and DVD-Video titles.

DVD-ROM and DVD-Video

There are several ways to approach DVD-ROM. It can be thought of as a way to store general information, as a platform for reissuing older CD-ROM titles with MPEG-2 video and surround audio, or as a whole new medium for title development leveraging off of the flexibility of the DVD-Video format.

As was discussed earlier, DVD-Video includes a “DVD Others Zone.” This area of the DVD disc may be used to store standard computer data files, creating a hybrid DVD disc which can be played back on both DVD set-top players as well as PCs equipped with DVD-ROM readers. This type of hybrid disc can have both set-top interactivity and video while sharing files with an application written especially for a personal computer. An example of DVD hybrid title would be a feature film which, when placed

in a set-top DVD player, had simple interactivity but when placed in a DVD-ROM equipped PC, had additional games and links to the movie studio's web site. These type of Hybrid DVD discs are already in production and will undoubtedly bring additional value to the format.

DVD PREMASTERING

The process of taking video and audio assets and turning them into a final DVD disc image is called DVD premastering. In this segment, we will explore the tools and techniques required to premaster a DVD.

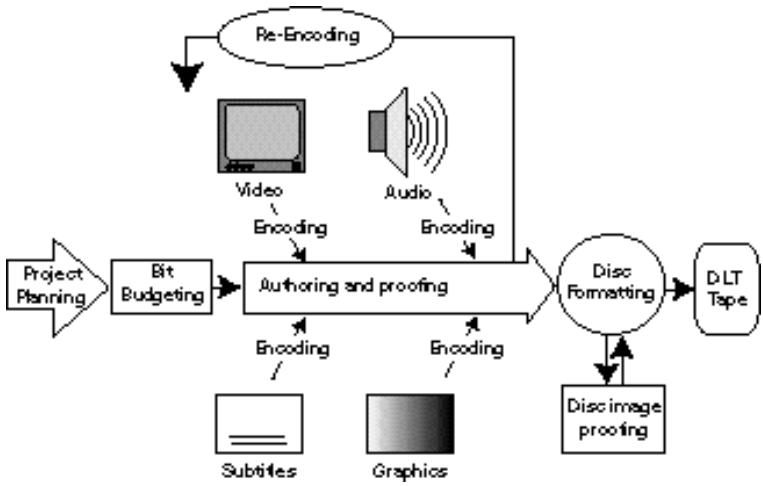

Figure 13: DVD production workflow

The DVD premastering process can be broken down into several key steps: project planning, bit budgeting, asset capture, authoring, proofing, and formatting. Each of these steps relies on the others for complete title production. While some of the different processes involved are not required to be in the same physical location, the more tightly they can be integrated and controlled, the more efficient the title production process becomes.

PROJECT PLANNING

The first step in DVD production is to define the scope and basic structure of the project. This may range from a simple movie with limited interactivity to a multi-angle, multi-story adventure game. By determining the level of interactivity required, the premastering facility can begin to create a DVD flowchart or project template which will be used to guide the premastering process. Building a project template begins by asking the right questions.

Questions To Ask

How Interactive Is The Project?

If a DVD project is a straightforward, linear-play title, interactivity is not a major concern in the project planning stage. A simple flowchart can be designed to represent the Title and Root menus. If, however, a title requires intense interactivity, such as a video game, an elaborate project template must be created. The more interactive a title, the more time and resources it will take. If multiple video angles and General Parameters are used, additional time must also be spent on video preparation and authoring.

How Many Languages Are Required?

Multi-language discs may be handled in several ways. First, multiple soundtracks may be placed along with the video. Second, subtitles may be used to represent languages other than those used for the soundtrack. Third, different menu structures may be generated for each language to correspond to the default language programmed into the System Parameters of the DVD player. Depending on the level of language support, more or less resources will be required.

What Is The Look And Feel Of The Project?

A DVD title's look and feel is most often determined by the art direction taken in menu design and remote control interaction. The more elaborate the title design, the longer it can take in production. For example, motion menus with surround sound are much more exciting than static still frames, yet they require more disc space and greater authoring skills. On the other hand, using few still menus might not make a title intriguing from an interactive standpoint, but it can make title production faster.

Once there is a clear idea of the scope of the DVD title, the bit budgeting process can begin.

Managing Assets

From the Project Template, a list of required source assets can be derived. Assets will include: video sources, audio sources, graphic files and subtitle files. For a basic 120-minute movie with English, Spanish, and French audio tracks, subtitles, and graphical menus, one would need the following source assets:

Video	• Digital video source tapes for the movie and any associated trailers
Audio	• English surround source • Spanish stereo source • French stereo source
Graphics	• TIFF graphic files for every menu in each language (average of about 20 files)
Subtitles	• Bitmap files for each subtitle graphic (approximately 1500 subtitles per movie per language)

Table 6: Asset List for DVD Production

Once the general project plan is complete, the next step is to allocate the 4.7 GB of data (on a DVD-5) to audio, video, subpicture, etc. We call this process "bit budgeting."

BIT BUDGETING

Although DVD storage capacity is significantly greater than CD-ROM, it is still limited to 4.7, 8.5, 9.4, or 17 GB of data storage depending on the number of sides and layers of the disc. Because space is not unlimited, the capacity of the DVD disc and the length and type of title dictate how much audio and video can be stored and the relative bits that can be allocated to each. A standard DVD player has a maximum data delivery rate of 10.00 Megabits per second (Mbps) for video, audio, and subpictures. Given the length of the program, the audio configuration, and the size of the disc, one can calculate how the bits will be delegated for video, audio, subpictures, and interactivity.

The Bit Budgeting Process

Since one of the original goals of DVD was to store an entire movie on one side of a disc, we will use DVD-5 (4.7 GB) in the following example. Let's imagine that you had a 120-minute movie with three audio soundtracks, four subtitle tracks, and some limited interactivity. With some simple calculations we can determine what our Bit Budget™ is going to be for the program.

First, let's look at the total delivery capability of DVD-5.

While the DVD specification uses Gigabytes to describe the storage capacity of a disc, it does so differently than the computer industry. Gigabyte in the DVD specification refers to 1.0 billion bytes (1000^3). while in computer terminology, a Gigabyte is defined as 1.073 billion bytes (1024^3). Thus when the DVD specification defines a DVD-5 as having 4.7 Gigabytes of capacity it means 4.7 billion bytes, which in computer industry terms is actually 4.37 Gigabytes. To remain consistent with DVD convention, we will use DVD specification terminology.

To continue with our calculation of a bit budget for a DVD-5:

Step 1

4.7 GB (DVD-5) x 1000^3 (bytes/GB) x 8 (bit/bytes)/ 1,000,000 (bits/megabit) = 37,600 Megabits per disc

To be safe, we should allow some room for overhead; let's say in this case, we reserve four percent of the disc for menu graphics, navigation information, and extra cushion.

37,600 Megabits per disc x .96 = 36,096 Megabits per disc

Step 2

To determine what our average data rate should be for a 120-minute movie, we divide the total capacity (net of our reserve for overhead) by the number of seconds of our program material.

36,096 Megabits/(120 mins. [or length of program] x 60 sec/min) = 5.01 Megabits per second

So, to fit our 120-minute movie onto a DVD-5 which holds 4.7 GB, the average data rate for our program material must be 5.01 Mbps or less.

Step 3

Now that we've determined our average bit rate per second across the entire program, we must decide how to allocate this capacity between video, audio, and subpicture overlays.

In our example, we chose to have three language soundtracks. Let's assume that the first is in English in Dolby Digital surround, the second in Spanish in Dolby Digital stereo, and the third in French in MPEG stereo. With this configuration, the following bits would typically be allocated to audio:

Audio stream	Bit rate
English - Dolby Digital surround	0.384 Mbps
Spanish - Dolby Digital stereo	0.192 Mbps
French - MPEG-1 layer II	0.192 Mbps
Total	0.768 Mbps

Table 7: Audio Bit Rates

Step 4

Subpictures (or subtitles) don't consume much space, but we still have to factor them into the equation. For subtitles, we would reserve .040 Mbps per track. With four subtitles, an average bit-rate of .16 Mbps must be allocated.

Step 5

Note that audio and subpicture tracks are encoded at a constant bit rate across the entire program (though there is some discussion about variable bit rate audio encoding for the future). Let's combine them and figure out the allocation for video.

	Bit rate (Mbps)	
Average total bit rate for 120-minute program		5.01
• All audio tracks (English,Spanish, French)	.768	
• Subpicture	.160	
Less:		.928
Average bit rate available for video		4.08

Table 8: Video Bit Rate

After deducting the bit rates for audio and subpicture overlays, we have determined that we can encode our video at an average of 4.08 Megabits per second.

To determine the maximum bit rate, subtract the audio and subtitle overhead from the maximum DVD bit rate of 9.8 Mbps. In this case, the maximum bit rate would be 9.8 - 0.93 = 8.87 Mbps.

To ensure the highest quality, it's always advisable to use as much of the space on a DVD disc as possible, because in DVD, the average data rate for video affects the quality of the picture – encoding at a higher bit rate will give you a higher quality picture.

Now that we have allocated our bits among overhead, graphics, audio, subpicture, and video, we can begin capturing our assets. For long programs such as the 120-minute movie in this example, most publishers would use variable bit rate encoding (more on this below) to achieve the highest-quality video across the entire program.

One important thing to note about the DVD format is that the average bit rate allocated to the video stream will vary depending on the length of the program. For a DVD-5 disc, this means that the shorter the program, the higher the possible bit rate allowed for encoding (up to the maximum of 9.8 Mbps).

Assuming that we kept the same audio and subpicture configuration (three language tracks and four subtitle streams), the table below shows how the average bit rate for video would vary depending on the length of the program.

Length of program (minutes)	Audio/Subpicture (Mbps)	Video (Mbps)	Average bit rate (Mbps) across total program
60	0.928	8.872	9.800
90	0.928	5.756	6.684
120	0.928	4.085	5.013
150	0.928	3.083	4.011

Table 9: Average bit bate variance

Since a DVD set-top player can play a maximum of 9.8 Mbps, short programs (60 minutes or less) could be encoded at a constant bit rate of 8.8 Mbps. As the program increases in length, the overall average bit rate declines, and hence variable bit rate encoding should be used to yield higher overall image quality.

Note that these bit budgeting examples are based on the capabilities of standard DVD set-top players. Though many PCs will have DVD cards,

for PC playback you may need to lower the average bit rates further to accommodate the limitations of software decoding. For hybrid discs, you would need to reserve space for the “DVD other” files before allocating the remainder to audio, video, and subpicture.

Without an accurate bit budget, premastering can be a little like shooting in the dark – you just hope you come in at or below your maximum size when you create your disc image. If you go over, you throw away the disc image (and the hours it took to create it), re-encode one or more assets at a lower bit rate and hope that on the second (or later) try you get it right.

You can also manually calculate your bit budget, then check and add all the pieces up as you encode them to make sure that you don’t go over, but this is tedious and time-consuming, if it gets done at all. In order to facilitate the bit budget calculation process, a built-in Bit Budget display that tracks the project as you assemble your assets to help you stay within the budget can be a valuable tool.

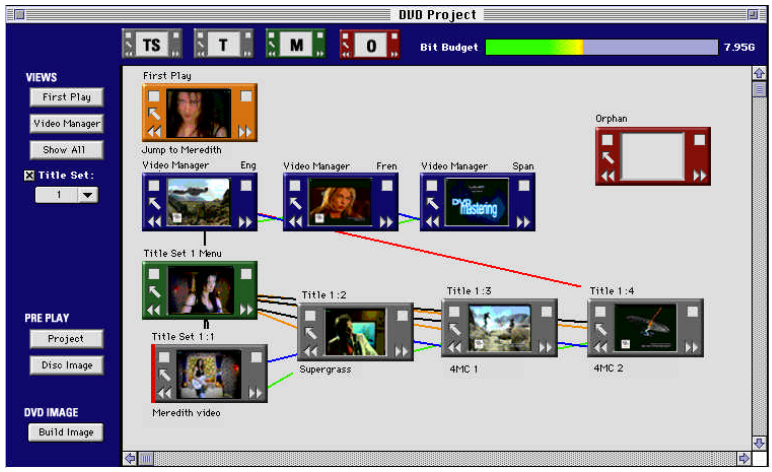

Figure 14: Sonic DVD Producer with bit budget display

Multi-angle Considerations

In order to enable multi-angle video streams in DVD, the Video Objects must be interleaved. This process allows up to nine video angles to co-exist, with the viewer able to switch seamlessly between them. One might imagine that multiple video angles in a data stream would drastically cut into the maximum bit-rate for the Video Object. This, however, is not the case. To play back multiple angles, the DVD player skips over blocks of data which contain information that is not being viewed. This skipping process allows the bit rate for each of the angles to remain relatively high. The restrictions for multi-angle video are a maximum bit rate of 7.0, 7.5, or 8.0 Mbps for video, audio, and subpictures combined. The difference in maximum bit rate is determined by the location of the VOBs on the DVD disc and the maximum jump distance.

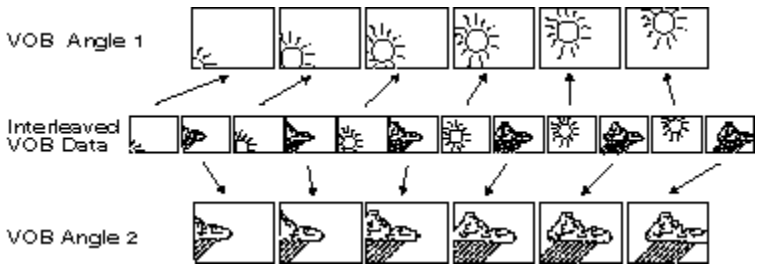

Figure 15: Interleaved video angles

ASSET CAPTURE

MPEG-2 and Video Compression

High-quality video compression is the enabling technology for DVD. To illustrate the level of compression required for two hours of high-quality video, consider this: the raw data rate for uncompressed CCIR-601 resolution 4:2:2 serial digital video is roughly 20 MB per second. For a 120-minute movie, this would require 144 GB of storage space, before accounting for audio. With DVD capable of storing 4.7 GB of data, compression ratios of roughly 32:1 are required in order to fit the video for a feature film along with audio and subtitles on a single-sided DVD-5 disc.

To address this compression problem, the Motion Picture Experts Group developed MPEG-2 video compression. This data compression scheme is based on the principle that temporal and spatial redundancy in motion pictures makes up the majority of the visual information that humans perceive. By comparing changes from frame to frame and removing as much of the "same" information as possible, data storage and transfer requirements are reduced.

GOP Structures

An MPEG-2 stream is made up of three types of frames, defined as I-frames, B-frames, and P-frames, Of the three frame types, only I-frames contain the complete pixel information of a video frame, thus providing the "backbone" of the MPEG-2 video stream. A standard sequence of I-B-B-P-B-B-P-B-B-P-B-B-P-B-B-I would have a Group of Picture (GOP) of 15, with 15 representing the interval at which I-frames repeat.

I -Frames	Intra-frames are single compressed frames that contain all of the spatial information of a video frame.
P-Frames	Predictive frames are computed based on the nearest previous I- or P-frame. P-frames are more highly compressed than I-frames and provide a reference for the calculation of B-frames.
B-Frames	Bi-directional frames use both a previous and a subsequent frame as a reference to calculate the compressed frame data.

Table 10: MPEG picture definitions

I-frames are the building block of the MPEG-2 sequence. B- and P-frames are based on the notion that the video sequence will not change drastically between I-frames, which would impair the B- and P-frames from accurately representing the motion of pixel information from one I-frame to the next. In video production, however, rapid scene changes and excessive motion can have negative impacts on the quality of the compressed video. Thus, the sequence of I-B-P frames must often be modified. This is usually done by adding or "forcing" I-frames, usually on scene cuts. In this way, each new scene can start with a fresh I-frame which is then used for the calculation of subsequent B and P frames.

By definition, I-frames contain much more information than B- and P-frames. As I-frames are inserted into the picture sequence to accommodate scene changes, the data requirements and the bit rate for MPEG video increase.

DVD requirements for PTT (chapter points) and Cell boundaries also make demands on the GOP structure of the MPEG video. Any time an entry point for a chapter designation is needed in an MPEG-2 stream, a GOP header must be present. A GOP header exists at the beginning of each group of pictures and contains information about the MPEG structure which follows. This may require that the GOP structure be changed so that an exact entry point can be made. For example, a chapter entry may need to start at the first video frame following a scene change. If the MPEG GOP sequence places a B- or P-frame at that same location,

it will force the entry point to move to the nearest GOP sequence header, which will be wrong. To avoid the situation, the GOP structure must be changed for that area of the video stream and re-encoded.

VBR Encoding

Video source material can vary dramatically in its complexity. As the video information changes throughout the course of a movie or video, so will the demands on the MPEG encoding process. As the difficulty of the source material increases, the quality of the resulting MPEG video decreases for a given bit-rate. Difficult material includes grainy or noisy source footage, rapid scene changes, and areas of high detail. Because MPEG compression is based on spatial and temporal redundancy, any video content that is highly non-redundant can be difficult to compress.

There are two solutions to the problem of varying video complexity: increase the bits allocated to the video or decrease the complexity of the source. By raising the bit-rate, more bits are allocated per frame and the picture quality is maintained. Alternatively, the video may be pre-processed to reduce redundancy and image complexity. For optimum MPEG picture quality, a combination of both is often required.

MPEG-2 video running at a bit-rate of 4.0 Mbps is required to place a 120-minute movie onto DVD-5. Depending on the source material, this bit-rate may not be high enough to maintain a constant quality. This limitation may be overcome, however, by maintaining an average bit rate of 4.0 Mbps and raising or lowering the bit-rate over time to suit the complexity of the source material. By allowing the bit rate to vary up to a maximum of 9.8 Mbps in difficult areas, the DVD specification takes into account the need for short bursts in the data rate to accommodate complex scenes where additional I-frames or higher overall bit allocation are necessary to prevent visible compression artifacts. This is compensated for by lowering the bit rate in other, less complex source areas. This technique is known as Variable Bit-Rate (VBR) MPEG-2 encoding, and is critical for optimal picture quality.

Figure 16 shows how changes in source video complexity can affect quality and bit-rate demands of MPEG-2 video encoding.

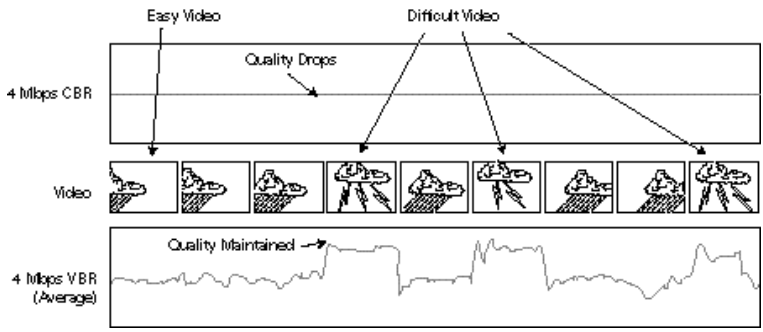

Figure 16: Variable bit rate encoding

Preprocessing

Video noise and frame redundancy are two areas in which the source video may be improved or modified to make compression more successful. Noise in a video stream is the equivalent of random information. Since MPEG-2 is based on detecting similar information between frames, noise represents a problem because it can be totally random on a frame-by-frame basis. Noise can come in the form of grainy film, dust, snow, or extremely detailed textures such as a white stucco wall or a waterfall. By applying a digital noise reducer or low-pass filter prior to encoding, high-energy noise may be reduced, resulting in a video stream which has less random information and is thus "easier" to encode by a temporal compression algorithm like MPEG.

Inverse Telecine

Frame redundancy is another area in which preparation prior to encoding can improve MPEG-2 video. Redundancy of video information is built into every video stream that originates on film. The telecine process, in which film is transferred to video, creates additional redundancy. During telecine, individual frames of film are duplicated at regular intervals during the 3:2 pull-down process which converts 24 frame-per-second film into 30 (29.97) frame-per-second, 60 (59.97) field-per-second NTSC video.

For example, in Figure 17 two fields derived from film frame A are followed by three fields from film frame B, etc. Two video fields are

derived from each frame of film. The ordering of fields is alternated, resulting in a unique pattern that repeats every five video frames.

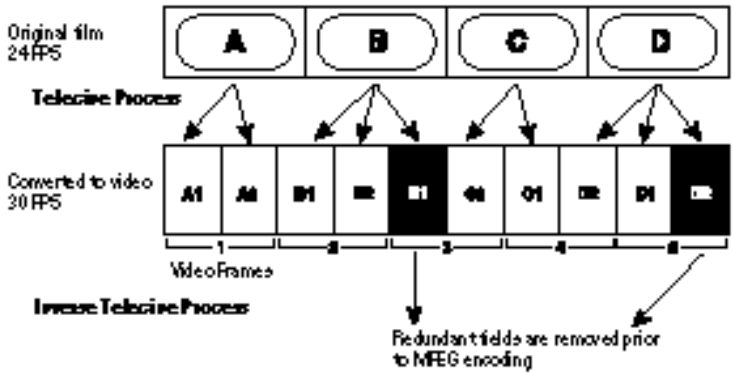

Figure 17: Telecine/inverse telecine

MPEG-2 decoders, such as those on DVD players, can have the ability to read 24 fps MPEG video streams, and turn them back into 29.97 fps video on output. This unique property of converting 24 fps MPEG-2 video back into 29.97 fps video means that prior to encoding, 29.97 fps video may be turned back into the original 24 fps film frame sequence. This removal of redundant frames from a video source which had originated on film is called inverse telecine. Inverse telecine has several benefits: it eliminates redundant fields, allowing the compression system to allocate more bits to the remaining unique frames, and it eliminates any motion artifacts, such as jerky, hesitant pans, that might otherwise occur between fields if the duplicate fields in the 3:2 sequence are left intact.

The Encoding Process

Encoding high-quality video for DVD requires powerful MPEG-2 compression tools. These tools must be able to handle multiple aspect ratio video, variable bit-rate encoding, inverse telecine, video pre-filtering, and make the compression process easy and intuitive for the operator. The quality of the source material directly affects the quality of the final MPEG-2 stream, and the best results will be from CCIR-601 digital video on a D1, Digital Betacam, or DCT tape. A higher quality source, such as an HDTV master is even better.

Although VBR encoding can be done in a single pass, the window of optimization is too small for significant improvements over constant bit rate video. In theory, the more passes that are made, the more carefully the MPEG-2 algorithm can match video content and the better the overall quality. Professional VBR encoders will allow for two- or three-pass encoding, depending on the quality desired and time available for encoding. Optimum MPEG-2 VBR encoding is done via a multi-pass analysis and compression process:

- Pass 1: A pre-processing pass is made through the source video during which the encoding system previews the program material, detects scene changes, and determines the optimum GOP structure. After this initial pass, the operator can make additional adjustments to the GOP structure to force sequence headers at DVD entry points. The result is an Encoder Control List (ECL).

- Pass 2 (optional): The ECL containing the optimized GOP structures is used as the encoder makes another analysis pass through the video. During this pass, the encoder analyzes the entire program and fluctuates the bit rate depending on the complexity of the source material. The result of this pass is a bit rate profile for the video with more bits allocated to difficult areas and fewer bits allocated to easy passages.

  Note that passes 1 and 2 can sometimes be combined, but this assumes I-frame placement and program analysis are done simultaneously during pass 1.

- Pass 3: Finally, the target average and maximum bit rates dictated by the initial DVD bit budget are mapped against the GOP and bit-rate parameters from the ECL, and a third pass is made. This time, rather than dictating the exact bit rates for the MPEG-2 bit-stream, a high-quality MPEG-2 encoder will instead regulate the quantization scale and carefully throttle it to maintain the bit-rate profile for the target numbers. This results in a field-by-field VBR encoding, rather than a GOP-by-GOP encoding, improving picture quality.

Each pass in the VBR process is done in real-time, allowing the operator to view the results of the compression process as it takes place. In a real-time networked production environment with guaranteed bandwidth, the MPEG-2 video stream can be recorded directly to a shared hard disk so that an encoded stream may be accessed across the network by other DVD premastering systems while it is still being encoded.

Segment-based Re-encoding

Although an MPEG-2 VBR encoder can be designed to use the best encoding parameters for a given video source tape, invariably small segments of MPEG-2 video will have to be modified manually for maximum quality. Additionally, the DVD premastering process may dictate changes to the project's Bit Budget after the movie has been encoded, necessitating bit-rate changes to the MPEG-2 video source.

If it is determined that an area of the MPEG-2 video stream needs to be re-encoded, it is critical that the MPEG-2 VBR encoder has the ability to select specific segments of video and re-encode them. Unsophisticated MPEG-2 encoders will often force a user to re-analyze and re-encode the entire movie just so a small change can be made to a GOP structure or a bit-rate level. This is too time-consuming for professional production work. The best systems employ a segment-based approach which allows many small regions to be re-encoded and then spliced into the original MPEG-2 video stream. The streams can be selected, re-encoded in a single pass, and seamlessly reinserted into the encoded stream. This segment re-encoding eliminates the need to re-encode an entire stream for a few small changes and dramatically speeds up the encoding process when changes are required.

Figure 18: Sonic DVD Studio, showing a segment-based re-encode

Still Images and Subpictures

The static graphical images that make up subpicture overlays and still images begin as bitmap graphics. In the case of subtitles, these subpicture graphics begin as a text script which is then converted to bitmap graphic files with the associated timecode of the source movie.

Subpicture overlays and still images are often created with image editing applications, such as Adobe Photoshop®. Subpictures, with a maximum of four colors allowed, are run-length coded for DVD in the authoring application. Still images, which are full color, are compressed as MPEG-2 I-frames. Once all of the still images and subpictures are created, they must be imported into the authoring program.

Audio Preparation and Compression

Some producers may assume that all of DVD's premastering complexity and "magic" is in the video encoding. However, when they delve into the myriad of audio options for DVD, they are surprised to find that

preparing audio for DVD can be even more complex and time consuming than video. This complexity stems not just from the compression processes used, but from the variety and number of simultaneous streams of audio that may be placed on a single disc. This also means that the production tools for DVD audio must be capable of capturing PCM, MPEG, and Dolby Digital audio.

Editing Soundtracks

With Dolby Digital designated as the compressed audio format for NTSC DVD players (with MPEG-2 as an option) content providers must be able to prepare multiple language mixes, either in stereo or in combination with surround. A typical mix might include a single 5.1 surround sound track with two or three Dolby Digital stereo language-dubbed versions and perhaps a single stereo PCM version.

Prior to encoding, the separate language versions must be compared for level, mix, and equalization to ensure that radically different audio is not heard when switching from English to French to Spanish. If audio has been prepped prior to encoding (typically this would be done on full-resolution audio data), Dolby Digital compression can be performed directly on the stored audio data. This streamlines the production process as final mix tracks can be transferred directly to the DVD authoring system.

Dolby Digital

The primary audio format for DVD in NTSC countries is Dolby Digital, both stereo and 5.1 surround. The 5.1 configuration includes three speakers across the front, a stereo pair in the rear, and a low-frequency effects channel. This is often abbreviated LCRSS.

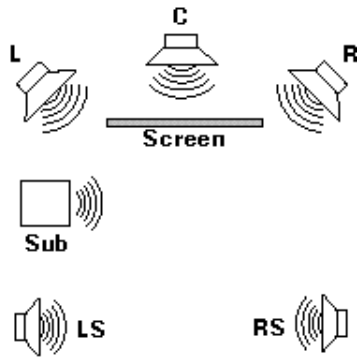

Figure 19: 5.1 Surround listening environment

Dolby Digital is an algorithm which compresses audio by removing sound from frequency bands which, over time, contain limited signal energy. In addition, a noise-shaping scheme is used to remove audio information in frequency areas where humans are less apt to hear missing sound. Dolby Digital also uses a scheme of cross-correlation in which the various channels of a surround or stereo mix are compared, and the difference between the channels is stored while the redundant information is eliminated. The result is a six channel (5.1 surround) audio mix with a lower bit rate and storage requirement than the standard compact disc format of 44.1 kHz, 16-bit stereo audio. By using Dolby Digital compression, the new DVD format has enough space to allow several different Dolby Digital streams to be placed onto the disc.

Dolby Digital audio can run at various bit rates and with different coding schemes based on the source content. In laying out the DVD title, the producer has to decide how many bits to allocate to each audio stream. Once the audio bit allocation has been made, the data rate for a given audio stream is constant (unlike the variable bit rate encoding for video). By utilizing Dolby-certified encoding tools, the DVD premastering system can convert source audio into Dolby Digital, either in real time or in software based on the application.

PCM Capture

From mono to eight channels of sound, DVD is the first consumer format to allow more than four channels of uncompressed audio. Even

more impressive, it can have double the frequency range and much greater bit resolution than audio CD. The PCM audio that is available for the DVD format ranges from mono to eight channels and can be 48 kHz (24-bit up to four channels, 20-bit to six and 16-bit to eight) or 96 kHz (24-bit for stereo, 20-bit for three, and 16-bit for four).

With more than double the sampling rate of CD, 96 kHz audio is able to deliver pristine sound unobscured by the low-pass filter-induced artifacts that traditionally distort the high-frequencies in 44.1 kHz audio. The addition of 24-bit resolution also goes a long way toward improving low-level signal clarity and definition. In order to take advantage of the 96 kHz 24-bit format, DVD premastering systems must be able to encode and format High Density Audio™.

MPEG-2 Audio

The audio standard for 625/50 (PAL) DVD players, MPEG-2 audio is an extension of MPEG-1 Layer II audio popularized as the audio component of MPEG-1 video. MPEG-2 audio can extend from stereo up to eight channels (7.1 surround). It is also able to run at higher compression ratios than Dolby Digital.

Encoding Audio

Because of the flexibility and the complexity of the DVD audio formats, sophisticated production tools are required. Ideally, audio production for DVD should be streamlined, with encoders able to edit and modify soundtracks if need be and automatically process the resulting audio into Dolby Digital, MPEG, or PCM formats.

Source audio for DVD typically comes in on an MDM (Modular Digital Multitrack) format, such as Tascam DA-88. This is the source format most often used for Dolby Digital encoding, and it can hold eight tracks of 48 kHz, 16-bit audio. Professional audio encoding systems enable the source to be transferred in real time in PCM, Dolby Digital, or MPEG audio formats. If the audio needs to be edited – for level, panning, EQ, phase adjustment, or time compression or expansion – it would be captured as PCM, and then processed using integrated audio mixing

capabilities or a digital audio workstation. Once the editing is complete, the audio would then be batch-processed into Dolby Digital or MPEG.

Source audio for DVD has usually been carefully mixed for surround, but the level balancing process doesn't end there. Dolby Digital specifies several different home listening compression levels that can be assigned during the compression process. This allows a viewer to set a listening level where the dialog maintains its volume while louder and softer audio is balanced to match it. This feature of Dolby Digital is convenient for the consumer, but requires that the audio production tools be able to simulate this compression level to ensure the audio system operator that the correct settings have been made. The same is true for channel downmix.

Every 5.1 surround mix for Dolby Digital can fold down to a stereo output. This enables consumers who do not have a 5.1 decoder to hear the audio soundtrack as a stereo mix. While this frees DVD premastering operators from having to place both a stereo and 5.1 mix on the DVD disc, it requires that the operator be able to listen to the 5.1 downmix to ensure that no artifacts or other problems arise in the stereo version.

Once audio encoding is complete, the resulting files must be played back with the captured MPEG-2 video to ensure proper synchronization. This process can be done on either an audio system (if it has an MPEG-2 decoder) or a video system (if it has audio decoding). A separate workstation, called a *proofing station*, may also be used for final quality assurance.

DVD AUTHORING

Much of the excitement around DVD has centered on its application as a new, superior medium for viewing movies at home. As a standardized ROM-type format, DVD has universal applications in audio and computer software as well. Even in "linear" video DVDs, interactivity is involved when pressing Play or hitting Fast-Forward, or Reverse. This is because, unlike consumer VCRs, the navigation command structures are programmed in the authoring stage and embedded in the disc. As a result, compressing audio and video files does not by itself create a DVD; the compression merely provides video and audio files for the authoring process. A sophisticated tool is required to assemble the content and create the interactivity for a title. This is where the real DVD premastering work begins.

Authoring represents the most complex and least understood of the DVD premastering tasks. The term *authoring* includes the processes that are performed after video and audio encoding and before disc replication. It is the process in which all the encoded audio and video are linked together, multiple language tracks are laid out, subtitles are imported or generated, chapter points and transport control functions are introduced, multi-story or multi-angle program chains are created, menus and buttons are designed, and any final MPEG video or audio editing is done. It is also where parental block features, language codes, region codes, and copy protection are introduced.

The authoring process can be broken down into several steps: storyboarding, asset assembly, interactivity editing, proofing, multiplexing, and disc image creation. Each of these steps is highly iterative and requires close integration of the authoring system with the video and audio encoding stations and the emulation station.

Storyboarding

The first authoring step is to lay out the title in a storyboard that shows all of the assets (even if they have not yet been captured or assembled) plus all of the menus and navigation steps that will join the assets together into a seamless title. Storyboarding a title can begin even

before asset capture, and serves three main purposes: to provide a roadmap for multiple operators working on the same project, to avoid errors in asset assembly and menu creation; as a checklist for the producer to ensure that production resources are allocated appropriately and to minimize rework; and finally, as a "preflight check" of the title's navigation to avoid dead ends, confusing or overly-complicated menus, or inconsistent and user-unfriendly disc navigation. The end result of the storyboarding process is a complete roadmap of the DVD title, as well as a Bit Budget and asset capture list.

DVD Title Layout

Storyboarding can either be done manually, or, preferably, in the authoring software using storyboarding templates or project planning assistants that help define the parameters of a project. These can include the size of the disc (DVD-5, DVD-9, DVD-10, DVD-18), number of audio streams and video angles,the regions it will be encoded for, and parental levels, and should take place before the project gets started, rather than as the last step in the premastering process.

To facilitate storyboarding, it is useful to lay out projects before asset capture using placeholder icons that can later be assigned to audio, video, or menus. As assets are imported, you will want to carefully track of the total number of bits used, so that you can make sure that the size of your project will not exceed the capacity of the disc.

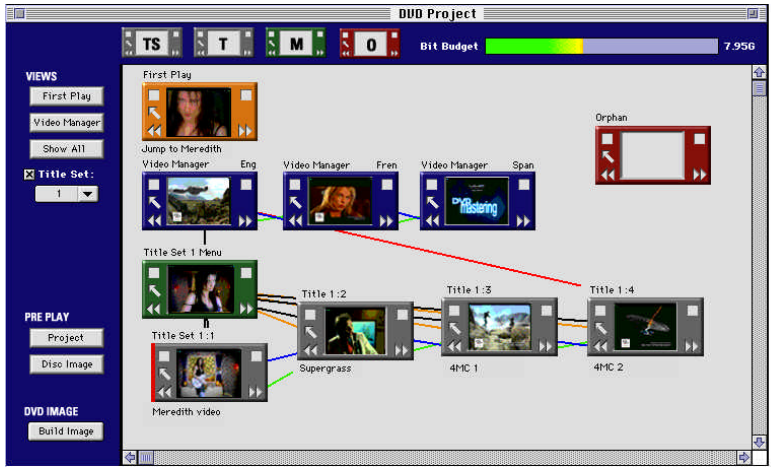

Figure 20: Sonic DVD Producer layout window

Assembly of Assets

The next step is to assemble all of the source assets that have been captured: MPEG video, audio, graphics, subtitles, and subpictures. These elementary files are linked together into objects with one or more video angle files associated with one or more audio clips and subpicture clips. The objects are not multiplexed (interleaved) until the project is complete, however.

During the assembly process, information about Part of Title entry points must be created as well as all of the information for displaying the subpictures: time location, wipe, fade-in, scroll, color, and duration.

Subpicture Assembly and Import

Importing stills for menus and creating highlight areas, colors, and “hot spots” for buttons can be one of the most labor-intensive aspects of authoring. It is essential to have a graphical interface for subpicture assembly that allows you to control features like fades, wipes, button activation times, and highlights quickly and easily.

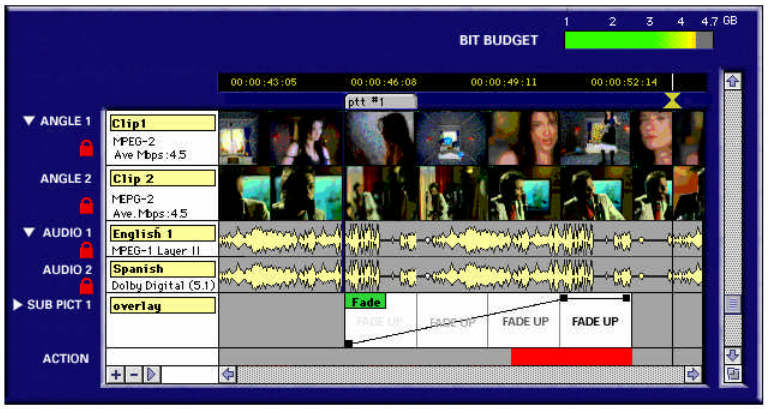

Figure 21: Sonic DVD Producer presentation window

Interactivity Editing

Once all of the objects have been assembled, you are ready to create Program Chains to give the title interactivity. In this process, the pre- and post-commands are set and links are made between the various program chains and video title sets. This is also the time to bring in still or motion video to use as menus. During the authoring process, the it is important to be able to simulate the project that you are working on in order to see the project as it progresses and proof it in real time. You will want to play back VOBs in full resolution during authoring, so that quality control can begin in parallel with authoring and asset capture. This will save you time throughout title production.

Multiplexing

With the navigation data and presentation data complete, you can lay out the final project. In this process, all of the presentation data (video, audio, subpictures) are multiplexed together into the VOBs that are used by the DVD format. The PGCs that have been created for interactivity are placed into the VTSI (Video Title Set Information Area) at the beginning of each VTS and any volume information about the DVD is generated. The end result of this process is a new set of files which comply with the DVD 1.0 format.

Creating the Disc Image

The last step in DVD authoring is to create the disc image. This is the process by which the DVD 1.0 files are formatted for the UDF-Bridge file system. This disc image is created on hard disk and then written out to Digital Linear Tape (DLT). It is also at this stage that analog and digital copy protection flags are set, so that data can be encrypted by the manufacturing plant as it is fed in. A 20 Gigabyte DLT tape is the standard premastering format which is sent to DVD manufacturers today, although With DVD-R and DVD-ROM becoming available, these formats will also soon be used to store the final DVD disc image.

Creating the disc image can be processor-intensive and time consuming, but should not require supervision once the process has been started. In order to minimize operator and workstation time, it is desirable for disc image creation to be able to take place on a data transfer station, so that both the operator and the authoring workstation can continue on to the next project.

Final QC

Once a DVD disc image has been generated, it should be played back prior to replication to proof it for audio and video sync, menu navigation, and video quality. Playback of disc images gives the producer a preview of what the title will look like when it is played on a set-top DVD player, allowing final quality checking to take place on the desktop rather than by manufacturing a one-off test disc.

DVD Manufacturing

After proofing, the final step in the DVD creation process is manufacturing. The DLT premastering tape is sent to the manufacturing facility, where the disc image is loaded onto the hard disk of the mastering system. It is at this stage that data encryption is added to the DVD disc image. The copy protection scheme, regulated by the DVD Forum, looks at the encryption flags set in the authoring process and encrypts the program data accordingly.

PLANNING YOUR PRODUCTION WORK FLOW

Traditionally, audio production work has always been done separately from video production work. The two crafts have developed in parallel but independently, with integration of products at the final edit stage (i.e., soundtracks produced for films) but with little sharing of resources, standards, operating procedures, or personnel.

As a result, the hardware and software tools for audio and video production in first-generation premastering systems can be inflexible – "black box" systems that don't allow much user control – and rarely integrated. A video encoder may not be capable of simultaneous Dolby Digital or MPEG audio capture during encoding. An audio encoder may not allow all versions of encoding, from MPEG-2 to PCM. Assets may need to be physically carried from station to station ("sneakernet") because different systems cannot be tied together over a network. This lack of flexibility and control leads to bottlenecks and inefficiencies in the premastering process.

The Evolution of DVD Production Systems

Today's DVD production requires an entirely different approach to premastering than first-generation systems provided. A DVD producer needs to be able to integrate production of video and audio assets, manage a Bit Budget, control quality during production with proofing, schedule encodes and re-encodes to ensure the highest quality, and process multiple premastering projects at the same time to ensure the highest productivity and efficiency.

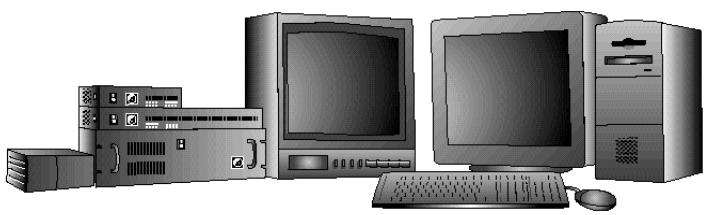

Figure 22: DVD production system

In a smaller DVD premastering system, all of these functions may be performed at a single workstation. In this case, the producer may also be encoding video and audio as well as authoring and proofing the content. Flexibility, ease of use, and speed in performing tasks such as data multiplexing become the most important characteristics of this setup.

DVD production in a single-workstation setup has to be flexible to accommodate a wide variety of production scenarios. Video encoding might have to start with only a rough outline of a storyboard available. A project might begin with extensive authoring, even though no video or audio assets have yet been created. Or a project may be completed section by section, with encoding, authoring, and proofing entirely finished in one area before encoding even begins on the next.

Because all of these tasks will be completed by one or a few persons, each function – from video and audio encoding, to authoring, proofing, and disk image output – must be optimized for ease of use in a single workstation system. If, for example, a video encoder is so complex that only a highly – trained and dedicated operator can maintain proficiency in its use, then it becomes useless in a generalist-based production environment. Tools to assist the operator, such as templates, drag-and-drop functionality, and automated file conversion (e.g., from an Adobe Photoshop file to a menu still image), facilitate the production process.

Finally, in single-workstation environment, processing down-time must be minimized. If the workstation is tied up multiplexing data, for example, no other production can occur until that task is completed. In addition to selecting a DVD production system that encodes, authors, and multiplexes efficiently, a producer can also optimize workstation time by choosing how material is encoded (CBR vs. VBR, two–pass vs. three–pass), and scheduling long encodes and multiplexing during off-peak times or overnight.

In larger, multiple-workstation premastering environments, the traditional dual-system approach in post production, where audio post and video post are done separately, breaks down when confronted with the interdependencies of the media formats for DVD. In order to produce

titles efficiently, production must be done in parallel on a common asset base and information passed back and forth among production systems. Commonly, DVD production will start with simultaneous video and audio encoding, move into authoring, back to encoding to re-capture or process new video, then to proofing, back to encoding, etc... Because these steps are not separate and are intensely intertwined, in larger production systems a workgroup environment is critical.

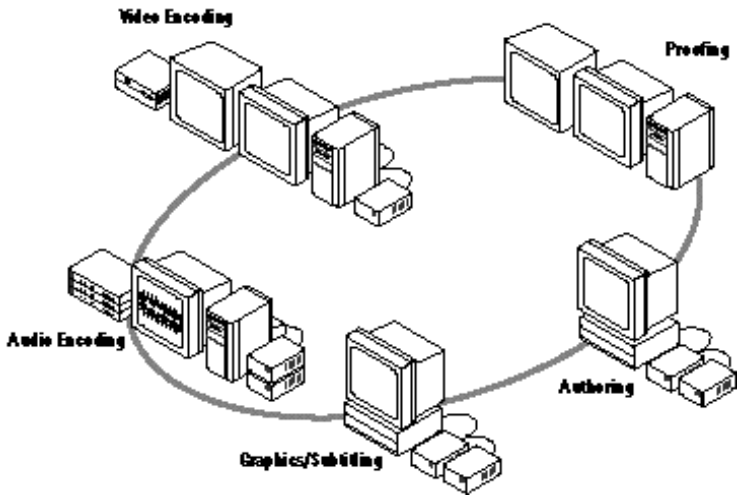

Figure 23: DVD production workgroup

The workgroup allows the various systems to work in parallel: video encoding can take place while an author is laying out a title, audio for a new project can begin while proofing takes place on the previous project, etc. This parallel production process can keep each of the systems productive while more than one DVD project is run through at a time. While a single complex project may take some amount of production time, four complex projects might take 3x hours, not 4x hours as might be expected.

In a networked DVD production environment, a workstation containing both audio and video capture hardware may be located in a machine room for loading of source material while other digital audio workstations can

access and process the sound files remotely. Proofing of encoded assets can take place simultaneously with production, making instant quality information available to the producer. And authoring can be started on one workstation while assets are still being assembled and encoded on others.

For both single workstation and workgroup production environments, the DVD production system should be modular and scalable. This allows additional workstations to be added to the system as user needs grow and maximizes flexibility to changes in customer needs and workflow patterns.

To maximize productivity in premastering, a workgroup for mastering feature films or high-end multimedia production should have the following characteristics:

- Shared resources – hard drives,I/O devices,etc.
- Iterative,non-linear work flow
- Modular and expandable
- Bit Budget planning
- Multitrack 96 kHz High-Density Audio editing
- Multitask/multiproject capable
- Networked by high-speed LAN
- No bottlenecks
- Capacity to edit both audio and video in full resolution
- Seamless playback of files on network with guaranteed bandwidth
- Data transfer station for archiving,formatting,and disc image creation

Table 11: DVD workgroup requirements

PLANNING YOUR PRODUCTION FACILITY

Because DVD and its associated technologies have applications in so many different areas, there is no one "right" way to set up a DVD premastering facility. Planning the design and equipment of a facility begins with defining what it is that the facility intends to do. To help shape a facility to meet specific needs, begin by answering the following questions.

What types of existing and new clients will this facility serve?

A DVD title for a film studio is quite different than a title for a multi-media publisher, and these differences are reflected in the production workflow. While a given facility may eventually be used for a wide variety of DVD production services, it is important to establish an initial target market that will help define the types of services the facility will provide. This kind of planning will help optimize the facility's productivity and ensure that it will meet the needs of its clients.

What types of DVD titles will be produced for the target market?

DVD's versatility allows for a great diversity of title types, and new genres of DVD are likely to emerge as the format matures. Initially, however, most titles will probably fall into one of five general categories, each of which has different production needs.

Feature-Length DVD Titles

These titles contain more than 60 minutes of video material, generally one main program with perhaps one or more associated short subjects. For instance, a 90-minute feature film might be accompanied by a 20-minute "The Making of..." short subject. The emphasis is normally on linear presentation of the video programs, with minimal navigational options within each program. Designed for playback on DVD-Video set-

top players, such titles must be compliant with the DVD-Video specification. Because of the length of the video material, VBR encoding capability will likely be required.

Interactive DVD

An interactive DVD title typically consists of multiple short video and audio clips with a navigational structure that requires the user to choose the order of playback, either through menus or on-the-fly through user input during playback. The DVD-Video specification includes the capability to store user responses, which allows conditional navigation based, for instance, on keeping track of a user's score in a game.

The navigational complexity of interactive titles accentuates the importance of authoring in the title preparation process, and places increased demands on the project planning, interface design, emulation and quality control phases of production. Many interactive titles will probably take advantage of DVD-Video's ability to switch seamlessly between multiple "angles" at playback, thereby increasing the amount of video and the need for VBR encoding.

Music Video and Karaoke

Audio quality is a priority in these DVD-Video compliant titles, which may take advantage of the format's linear PCM capabilities to deliver CD-quality or High-Density Audio™. Both types of titles will normally contain multiple short video and audio clips, accessed through menu navigation, and will perhaps also be designed to automatically play through the clips like tracks on an audio CD. Karaoke titles will likely include at least two audio streams: one with lead vocals and another without, and may take advantage of the multiple "karaoke down-mix" modes within the Dolby Digital AC-3 format.

DVD-ROM

These titles use DVD's tremendous storage capacity to store data for retrieval on a DVD-ROM drive hooked to a computer. This data may include not only files compliant with the DVD-Video specification but

also such general computer data as software applications, databases, or multimedia programs like those currently distributed on CD-ROM.

Hybrid DVD-ROM

These discs are designed to be able to be used in either a DVD-ROM or a CD-ROM drive. Like a DVD-ROM, they may contain DVD-Video files, software, data and multimedia applications. In addition, they contain a separate physical layer that can be read by a standard CD-ROM drive, which may contain the same kinds of data, software, and video files found on CD-ROMs today.

In addition to creating these five types of DVD projects, some clients may be involved in non-DVD activities which use some of the same production technologies. A DVD premastering facility might also serve clients involved in broadcast, Video-CD, video-on-demand, and other applications of MPEG encoding.

What audio formats will the clients be using?

The DVD-Video specification supports a variety of audio formats, including Dolby Digital (stereo or surround), linear PCM (at several different sample rates and bit resolutions) and MPEG II. Up to eight simultaneous audio streams may be used in a title. In practice, the type of audio used will vary depending on the type of title. A facility designed to produce feature-length DVDs will likely need to be able to provide surround-sound encoding in Dolby Digital and (depending on release region) MPEG formats. For premastering of Music Video and Karaoke DVDs, stereo PCM audio capture may be sufficient.

What is the expected volume of work?

Depending on the pace and volume of DVD production work that is expected, the facility may be built up gradually or all at once. The anticipated volume of work will determine the facility's need for through-put, which greatly influences the architecture of the production system.

Low-volume production of a few titles per year, or single-project production (i.e., one title at a time), may only require a single-workstation production system. This type of system may have a very linear workflow, and may only require a single operator who performs all of the various premastering functions on a single workstation. Modular, scalable single-workstation systems allow the workstation to be reconfigured into a workgroup system as premastering needs grow.

High volume production – more than 20 to 30 titles per year – generally demands a workflow that is collaborative and parallel rather than individual and linear. For this type of production, multiple workstations sharing resources over a high-speed network will reduce or eliminate bottlenecks. The number of workstations in the system will determine the specific components chosen for each station. As with a single-workstation system, a modular, scaleable workgroup system will allow the facility to be reconfigured and expanded as demand grows.

What are the current facility's areas of expertise, and in what areas do additional skills need to be developed?

DVD production is not really a single discipline, but rather a process that integrates existing fields such as video post-production, audio engineering, graphic design and multimedia authoring. As with any service business, clients will come not simply for the equipment at the facility but for the skill with which it is used.

If the facility is already involved in media production, it can bring to DVD the expertise particular to its areas of specialization. Because the skill requirements of DVD production are so broad, however, it may be necessary to strengthen the skills of the existing staff to operate the DVD facility effectively. Options for developing the necessary skills include hiring additional staff with the required skills or retraining existing staff via training courses and hands-on experience with the production system.

Listed below are the functions that will need to be covered by a DVD production facility staff. In a large facility, each function may be a separate position. In a smaller operation, individual operators may need to cover multiple tasks. In a multi-station workgroup configuration, one individual may set up and start a process at one station (video encoding, for example) and then move to a different station to continue work on a different aspect of production.

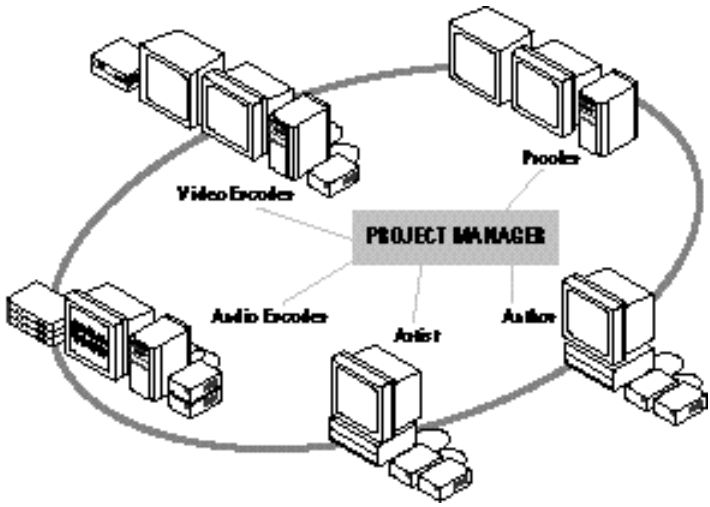

Figure 24: DVD production job functions

Video Encoder

A skilled video encoder might have previous experience with digital video compression systems or in video production. The video encoder can have a substantial impact on the quality of video encoding, particularly if the source material requires pre-processing, filtering, or manual editing such as segment-based re-encoding. Three to six months of hands-on work with the encoding system might be expected before the video encoder develops advanced skills in manipulating MPEG compression variables for the optimal results needed for feature film production. For corporate applications, an individual experienced with

Avid or Media 100 digital video editing systems typically has already developed the expertise needed for this work.

Audio Encoder

Basic understanding of audio formats, interfacing, and audio production are the basic skills that an audio encoder should have, and knowledge of how surround-sound formats should sound when properly encoded is preferred. Ideally, the audio encoder will also know how to adjust Dolby Digital encoding parameters. As with video encoding, the quality of an audio encode can depend highly on the skill of the operator, particularly if the source material requires editing such as level balancing, noise reduction or filtering.

Artist

In a DVD production environment, a graphic artist might be expected to contribute title and menu graphics, as well as still images or slide shows. An experienced artist should have expertise not only in graphic production software, but also with graphical interface design for multi-media. In order to avoid common translation problems, the artist should thoroughly understand television graphic design for both NTSC and PAL (including awareness of safe-area issues). Because the look and feel of a DVD's menus and screens have tremendous impact on the user's assessment of a DVD's content, an experienced and creative artist can add tremendous value to the DVD production process.

Author

The author is responsible for building the navigation structure of the disc, importing graphics and subtitles, programming register usage and setting encryption and parental control parameters. Depending on the size of the facility and distribution of workflow, the author may also be responsible for proofing projects and formatting disc images. Effective authoring depends not only on familiarity with media integration and interactive navigation design, but also thorough knowledge of common component media file formats. Advanced authoring may include increasingly complex disc navigation, register usage for score-keeping or multiple-branching navigation, or DVD-ROM layout.

Project Manager

The project manager is responsible for timely execution of production and the completion of projects within budget. Because the project manager schedules workflow and deadlines, they should have a thorough understanding of each step in the DVD preparation process as well as the relationship between steps. A proficient project manager should be able to efficiently manage multiple complex productions – including tracking progress in different production areas, coordinating parallel processes, scheduling to avoid bottlenecks, and working with clients to ensure that deadlines and expectations are met.

Production System Scenarios

Approaches for organizing a DVD production facility fall into two basic categories. First-generation DVD production systems required a networked workgroup approach with a minimum of two workstations to complete the production process from asset capture through authoring and emulation to master output. Recent advances in technology, however, have made it possible to integrate the entire DVD production process into a single workstation and have broadened the options for system setup.

All-In-One Systems

An all-in-one system is designed for settings where limited space, staffing or capital budget are more important factors than high throughput. For in-house corporate communications departments or multimedia developers that are still primarily focused on the CD-ROM market or are just starting to produce material on DVD, a lower–cost, less–complex premastering system may be enough to meet initial DVD production needs.

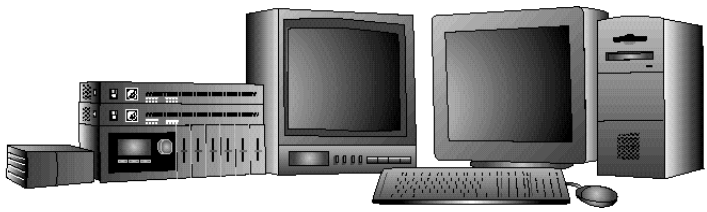

Figure 25: All-in-one system

Recent developments in DVD production technology now allow DVD premastering to take place on a single workstation with a single operator. Using this kind of integrated premastering system, a single user can perform all aspects of DVD premastering on a single workstation, from audio and video encoding through authoring, proofing, and output to a disc image. Second-generation software tools are simplifying the premastering process, not only allowing plug-and-play use that requires little training, but also streamlining the software to allow quick, easy translation of existing content – such as slides created in a presentation software – into the DVD format.

Because of their ease of use, simpler configuration, and lower price, all-in-one systems are an attractive option for many who are interested in producing material for DVD. These systems offer an excellent entry point into DVD premastering and allow consumers to test the waters of DVD production without making a major, up-front commitment of resources. All-in-one systems that are modular and that can be reconfigured to fit into a workgroup production setting offer the greatest flexibility and highest return on investment as production needs grow in the future.

Workgroup Systems

Networked workgroups are the preferred system configuration for any setting in which throughput is a top priority. By distributing production tasks among several workstations, work on different aspects of a title can proceed in parallel, and more than one title can be in production at a time. With efficient scheduling of equipment and personnel resources, a workgroup-based facility becomes capable of both high volume and fast turnaround.

In this model, workstations are connected by a high-speed network to allow fast transfer and sharing of assets. The optimum setup for a network in DVD production is the "distributed server" model, which avoids the performance bottlenecks that can arise from concentrating storage and server functionality in one central server. Ideal performance is achieved by configuring each workstation as a server, with storage disks distributed evenly among the servers and among the SCSI buses of each server. Files most often accessed by each workstation should be kept on that station's local server to reduce network requests.

Depending on the volume and type of titles to be produced, DVD workgroups may be configured in a variety of ways. Facilities oriented toward preparing feature films for the home video market will generally be set up to allow simultaneous production of multiple titles. A minimum of four workstations is recommended for this application: audio capture, video capture, authoring and proofing. In high volume facilities, additional workstations may be added as needed to increase throughput in any or all of these four areas.

In a typical four-station workgroup, the video station might be equipped for CBR and VBR encoding and simultaneous real-time capture of video and stereo audio. The audio station would be used for capture and compression of surround audio in Dolby Digital or MPEG-2 formats. The authoring station would be responsible for menu creation, asset integration, and disc navigation design. The proofing station would be dedicated to quality control and title verification.

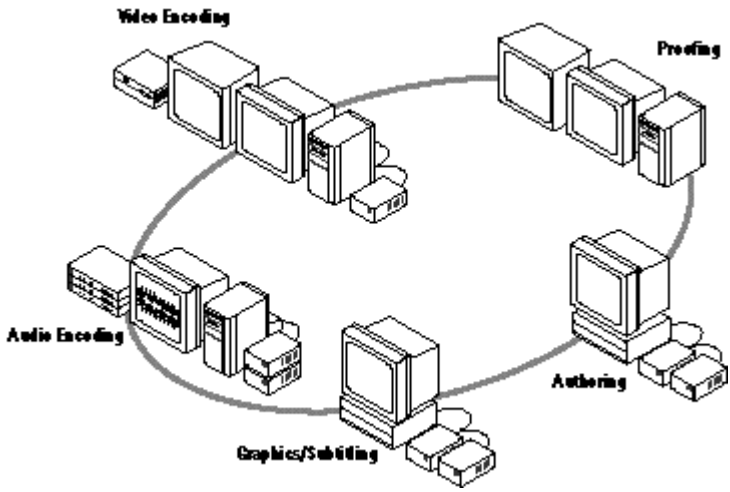

Figure 26: Workgroup system

In some settings, such as facilities designed primarily to produce music video and karaoke titles, surround-sound capabilities may not be required, and a three-station workgroup may be sufficient. In this case, audio and video capture and compression might be combined into one station. In lower production volume settings, authoring and emulation might also be combined into one station.

Peripherals

The two categories of system design share many important features, including the need for peripheral equipment to complete the production system. At the audio/video capture and compression station(s), a video monitor is required for viewing video, as is an audio monitoring system. The minimum audio system would be a pair of speakers driven by a power amplifier. For surround-sound titles a six-channel surround playback system will be needed (left, center, right, surround left, surround right and subwoofer).

Playback decks for video and audio are also required, to play source tapes during capture. The specific formats needed will depend on the formats used by clients. D1 and Digital Betacam are the most likely

formats for Hollywood-style video; Betacam SP or DV (FireWire) video is often used for corporate production. Depending on the video deck employed and the studio configuration, a black-burst to word-sync converter may be required.

If most of the facility's titles will use stereo audio only, the audio may be provided on the audio tracks of the video tape, meaning that a separate audio deck may not be needed. Surround mixes, however, will generally be supplied separately on a digital multitrack format,such as Tascam DA-88, that can accommodate six discrete channels of sound.

Another important consideration is data storage. Each DVD title under production can demand hard disk storage space of three times the size of the finished disc image, or more. For a DVD-5, that works out to nearly 15 Gigabytes per project.

Disk space requirements vary with the efficiency of the authoring software; authoring packages that multiplex and format disc images in a single step are more efficient and can reduce storage requirements to roughly two times disc image size, or roughly 11 GB for a DVD-5. In general, however, it is adviseable to have the following storage capacity available:

Feature–length film production: 45 - 300 GB
Corporate video production: 15 - 100GB
Multimedia presentation transfer: 4 - 10GB

Working Environment

Once the configuration of a facility's DVD production system and peripheral equipment is decided, it is possible to begin thinking about the working environment for DVD title preparation. Considerations include efficient physical layout of work areas (and machine rooms, if any), as well as providing sufficient electrical service, designing light sources for minimal monitor glare and providing adequate ventilation and temperature control for the amount of people and equipment in a given workspace.

The best layout for a DVD premastering workgroup will depend largely on the working style of the production team. A high-speed network allows workstations to be physically separated in different rooms or even buildings, but easy physical access from one operator to another may be preferred where building a cohesive team approach to title development is a priority.

Naturally, adequate physical space must be allowed for each station in the workgroup, as well as for the peripheral gear relating to each station's function. In the case of a video capture station, this may mean allowing for the video monitor to be positioned next to the computer monitor to minimize strain in looking back and forth. The deck for playing source video tapes may be located in a separate machine room and controlled remotely, but some operators will find it more convenient to have the machine close at hand for easy tape loading and to retain hands-on control of jog/shuttle transport functions. If multiple video capture stations will be using the same video deck, a nine-pin switcher may be used for switching control over the deck between the various stations.

The main consideration for audio stations is to provide an acoustical environment in which it is possible to hear program material accurately. For facilities with surround-sound encoding capability, a surround playback system must be properly set up to allow quality control of the encoded audio signal.

Ultimately, DVD title design is a highly creative and iterative process. It requires forethought, careful planning, and the tight integration of project planning, asset capture and authoring tools. Being successful in DVD requires understanding the format and the production process, building a production environment tailored to the type and volume of work that will be done, and creating interesting, valuable content that delivers on the promise of DVD.

APPENDIX A: RESOURCES

DVD FORMAT RESOURCES

Book A and B of the DVD 1.0 specification can be obtained from Toshiba Corporation through the address and phone numbers below. Cost is US $5,000 for the first copy and US $500 for each additional copy. A non-disclosure agreement must be signed.

Toshiba Corporation
DVD Products Division
1-1, Shibaura 1-Chrome, Minato-Ku
Tokyo 105-01, Japan
Tel: +81 3 5444 9580
Fax: +81 3 5444 9430

ON THE WEB

Sonic Solutions
➢ www.sonic.com

Industry and market information
➢ www.dvd.net

Motion Picture Experts Group (MPEG information)
➢ www.mpeg.org

Optical Video Disc Association
➢ www.ovda.org

DVD FAQs
➢ www.cd-info.com/CDIC/Technology/DVD/dvd-faq.html

General DVD Information
➢ http://janus.unik.no/~Erobert/hifi/dvd/

DVD Video Group
➢ www.dvdvideogroup.com