Understanding DVD-Audio

A Sonic White Paper

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Introduction

The DVD-Audio specification has been designed to replace CD-Audio as the primary carrier of prerecorded music for the record industry. While the home video and record industries are similar in many respects, each business has its own unique requirements for distribution media. Like DVD-Video, DVD-Audio is built on the foundation of DVD-ROM. So a DVD-Audio disc is actually a DVD-ROM disc that includes a zone of material supported by the DVD-Audio specification (and may optionally contain a zone of DVD-Video material as well). These zones are essentially directories or folders within the UDF file system.

The DVD-Audio specification incorporates many of the same DVD-Video navigational and architectural features, but it also includes several new interactive and playback features, such as still graphics slide shows. And it supports even higher audio fidelity and more flexible multi-channel playback options than DVD-Video. Thus, while the two formats are closely related, DVD-Audio extends DVD-Video to create a truly distinct product tailored for audio-centric applications. For those intending to create DVD-Audio titles, this paper will clarify the functional and technical similarities and differences between the new DVD-Audio format and it's established DVD-Video cousin.

DVD-Audio Design Objectives

In developing the DVD-Audio format, the DVD Forum's Working Group 4 (WG-4) and the ISC began with a set of objectives. The most important of these were:

- High Quality Audio — the new format should support the very highest quality audio possible

- Multi-Channel Audio — the new format should permit extensive multi-channel capabilities, and should recognize the fact that multi-channel programs might be played back in venues where only stereo monitoring was available.

- Additional data — text data, still images and video should be accommodated within the format.

- Navigation — with DVD-Video now established, various interactivity features should be supported.

- Simple Interface — the new format should accommodate a simple CD player-like interface for playback settings where elaborate controls and visual displays are impractical.

- DVD-Video Compatibility — the new format should be broadly compatible with DVD-Video and permit utilization of DVD-Video features, where appropriate.

- Copyright — the format should support effective anti-copying and anti-piracy measures.

The list is varied, and in some cases the objectives might seem potentially at cross-purposes. The challenge confronting WG-4 was to create a flexible format that would serve multiple purposes in a variety of settings.
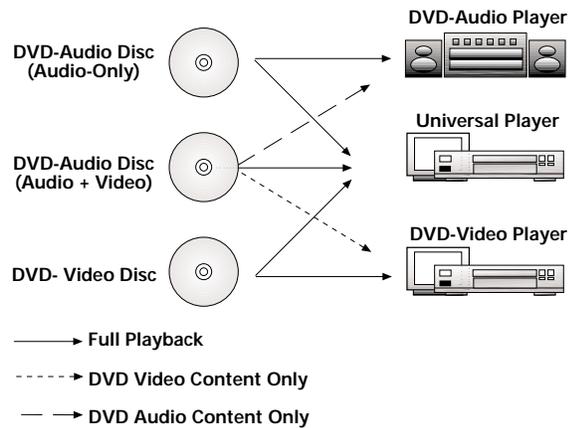
DVD-Audio Players

To ensure DVD-Audio's flexibility across a wide range of applications, WG-4 decided not to attempt to define one single set of features that would be mandated for all DVD-Audio players. Instead, a DVD-Audio disc may contain a variety of different content types, each of which will play back on one or more of several different player types designed for different playback settings.

While this approach sounds complicated, much of the distinction between the different envisioned playback settings boils down to the question of whether or not video display is available. With DVD-Video, it was reasonable to expect that video display would always be available at playback. With an audio format, it is crucial to support playback without a video display, particularly such situations as a "Walkman" style portable, a "boom box," or a car. Even for home listening, requiring video support in all players would increase manufacturing costs, making it harder to reach the less-expensive end of the audio player market.

Though the need for video-less playback was clear, DVD-Audio's developers also needed to support all the visual extras that consumers would expect from a next-generation entertainment format: graphics, text and motion video. To cover all bases, WG-4 envisioned five roughly-defined player types that might possibly be used to play back content from a disc in DVD-Audio format. These include:

- A "simple" Audio-only player that has no video output, and navigates the disc linearly using a list of tracks that is analogous to the Table of Contents (TOC) on a CD

- A "smart" Audio-only player (still no video output) that gives the user more choice of how to navigate the material on the disc, and may include an LCD display to show song titles and other text information such as lyrics

- An "Audio-with-Video" player that supports navigational choice and includes video outputs to support multimedia, including visual menus, album artwork, "slide show" graphics and motion video (such as music videos)

- A "Universal" player that offers the same audio and multimedia support as the Audio-with-Video DVD-Audio player, but also plays DVD-Video discs

- A DVD-Video player, which might be used to play optional video content that has been included on a DVD-Audio disc (though the DVD-Audio content on a DVD-Audio disc will not play on a DVD-Video player).

DVD-Audio disc and player types.

While the different player types above may be inferred from the DVD-Audio specification, it is considered unlikely that all of them will actually reach the market. In particular, it is unclear what demand there might be for the Audio-with-Video player that is not a Universal player. Similarly, many observers believe that there will be little justification for a distinct Video-only player once the Universal player is available. Eventually, then, new consumer DVD players may well be sold in just two main categories: Audio-only and Universal.

One way to easily visualize the difference between the two main categories of DVD-Audio players (Audio-only and Universal) is to compare the prototypical remote control implied for each type in the specification. The Universal player's remote control looks very much like that of a DVD-Video player, whereas in contrast, the minimal set of functions required to control the Audio-only player makes for a very simple remote indeed:
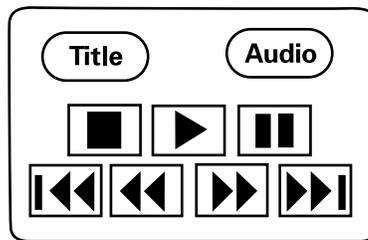
Example remote control for an Audio-only DVD-Audio player.

DVD-Audio Content

While the availability of different player types allows DVD-Audio discs to be played in a variety of settings, it also means that it is possible for a DVD-Audio disc to include some types of content that will not be available for playback in some situations. By choosing which types of content are put on a given DVD-Audio title, it is the producer who decides what the end-user's experience will be in various playback settings.

The base-case DVD-Audio disc is one that contains no graphics, text or motion video information. This "Pure Audio" disc supports higher fidelity, greater capacity and more

channels than a CD, but it functions in much the same way, with similar track-based navigation. Pure Audio discs play on both Audio-only and Universal DVD-Audio players, but they do not play on DVD-Video players.

Somewhat more sophisticated DVD-Audio titles may be created by adding text that accompanies the music (lyrics, for example), or using the format's logical structure to offer listeners different navigational options, such as multiple paths (playlists) through the audio material. These discs will still play on the simple Audio-only players, but their more sophisticated features will come to life when they are played on smart Audio-only players, or on video-enabled players such as Universal players. They do not play on DVD-Video players.

More complex DVD-Audio titles will take greater advantage of the format's multimedia capabilities, using visual menus for navigation, slide shows with audio, and motion video. Once again, these titles will play audio on Audio-only players, but without all the extras that will be viewable on video-enabled players such as Universal players. If such a disc includes motion video content, that content (only) will typically be playable on DVD-Video players.

The following table provides an overview of some common combinations of disc contents and player types:

		Disc/Contents		
		DVD-Audio disc without Video	DVD-Audio disc with Video	DVD-Video disc
Player Type	Audio-only DVD-Audio Player	• Audio • Text information	• Audio elements of DVD-Audio and DVD-Video titles	Not playable
	Universal DVD-Audio Player	• Audio • Still pictures • Text information	• Visual menus • All audio, text, graphic and video content	• All DVD-Video content supported
	DVD-Video Player	Not playable	• Video content only	• All DVD-Video content supported

Disc contents and player types.

Audio Formats

The core content type of the DVD-Audio format is, obviously, audio. While the DVD-Video specification gives equal weight to both linear PCM (pulse code modulation) and compressed audio formats such as Dolby Digital (AC-3), the DVD-Audio specification puts the priority on delivering the highest possible audio fidelity, and thus focuses primarily on PCM.

PCM data may be stored in either of two forms: linear (LPCM) or "packed" using Meridian Lossless Packing (MLP). Players are required to support both LPCM and MLP audio in either stereo or multi-channel configurations. Players may also—at the

manufacturer's discretion—support optional audio formats such as Dolby Digital, DTS, or others not yet defined.

A DVD-Audio disc may offer up to two audio streams in any given program. The first stream is required to be PCM (stereo or multi-channel), the optional second stream may be an optional audio type.

Audio Resolution

Within the PCM approach (LPCM or MLP), DVD-Audio offers content developers a wide array of choices regarding resolution. In PCM, the resolution of a given audio stream depends on two factors: the word-length and the sample-rate. The sample-rate is the number of times per second that the amplitude of the source analog waveform is sampled for conversion into a digitally stored value. The word-length is the number of bits available to store the value of each sample.

When digitizing an analog signal, better resolution (higher fidelity) may be achieved by increasing the sample-rate (number of samples per unit of time), the word-length (number of bits per sample), or both.

DVD-Audio's PCM support covers two "families" of sample-rates. One family is based on the 44.1 kHz rate of the audio CD, and also includes the multiples 88.2 and 176.4 kHz. The other family starts with the 48 kHz rate commonly used in video formats, and adds 96 and 192 kHz.

DVD-Audio also includes support for several word-lengths, including not only the 16-bit samples used in CD-Audio, but also 20- and 24-bit samples as well. A longer word-length translates into finer resolution and a wider dynamic range.

Multi-Channel Sound

Of all of DVD-Audio's features, the one that consumers are generally expected to find most appealing is the format's ability to deliver multi-channel sound. In each sample-rate family, the highest sample-rate (176.4 or 192.0 kHz) is supported only for mono or two-channel playback. The rest of the rates (44.1, 48, 88.2, and 96 kHz) are supported for mono up through six channels.

|	44.1 kHz Family			48 kHz Family		
Sample-rate	44.1 kHz	88.2 kHz	176.4 kHz	48 kHz	96 kHz	192 kHz
Maximum Channels	6	6	2	6	6	2

Sample-rate families in DVD-Audio

DVD-Audio's maximum data-rate allocable to audio—9.6 Megabits per second—places limits on the total data bandwidth available to spread among the channels. Six channels of 20-bit audio at either 88.2 or 96 kHz, for instance, would substantially exceed the format's data-rate. The specification offers two complementary strategies for dealing with this limitation. One is MLP (explained below), the other is mixed resolutions.

Mixed resolutions allow the producer to prioritize the allocation of bits among the channels in a given audio track. Each channel is assigned to one of two "Channel Groups," with the resolution of Group 1 always equal to or better than that of Group 2. Within a given track, the sample-rates used for all the channels in both groups must be from the same family.

Assignment of channels to groups, and selection of attributes within each group, may be changed on a track-by-track basis. To regularize the use of mixed resolutions among channels, most—but not all—of the reasonably foreseeable possibilities for varying the resolution of up to six channels are defined in the format's 21 supported channel configurations.

To illustrate the range of channel groupings permitted by the specification, here are a couple of examples shown with possible attribute assignments:
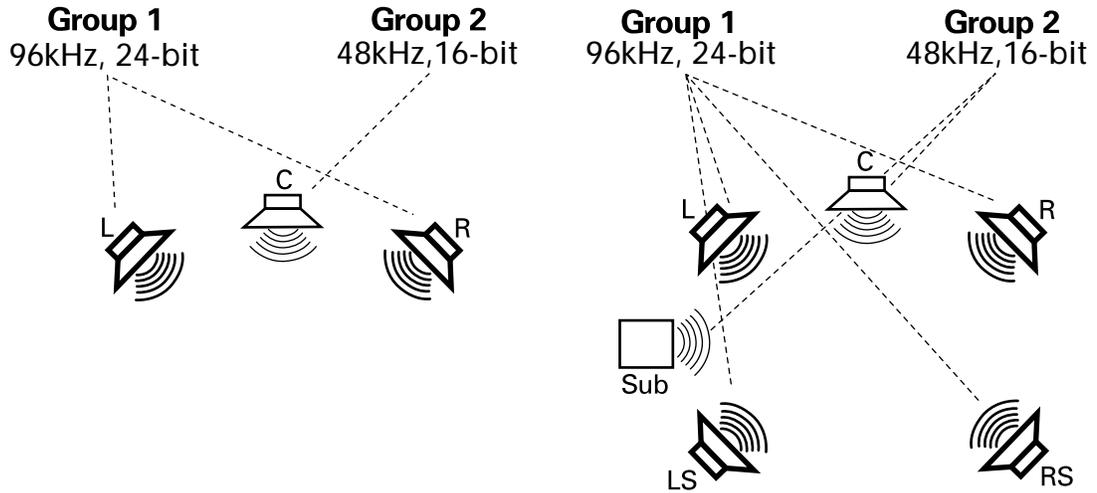
Examples of supported channel assignments. Assignment 8 uses three channels, with priority to left and right. Assignment 21 uses six channels, with priority to the four corners (left and right front, left and right surround).

Playing Time and Lossless Packing

Because DVD-Audio supports so many different variations of sample-rates, word-lengths and channel configurations, the capacity in minutes of the format may vary widely. The ability to vary these attributes on a track-by-track basis simply adds to the complexity of stating the maximum playing time. But it is clear that the use of more channels, more samples, or more bits per sample will all result in shorter playback capacity.

Quantization (bits)	Sample-Rate (kHz)	Channels	Data-Rate (Mbps)	Time (minutes)
16	44.1	2	1.41	422
16	48	2	1.54	388
20	96	4	7.68	78
24	192	2	9.22	65

Note: Single-layer, single-sided disc with no lossless compression; assumes 5% overhead for navigation and formatting data.

Example playing times for different audio variations.

As shown in the table, at the same resolution as CD-Audio (stereo 16-bit/44.1 kHz), DVD-Audio is capable of far greater playing time than CD-Audio's 74 minutes. But even with DVD-Audio's greater data rate and data capacity, full support for high-fidelity surround sound (six channels of 24-bit/96 kHz audio, for instance) would exceed the format's maximum bit-rate and quickly use up the available storage. To address this issue, WG-4 adopted the Meridian Lossless Packing (MLP) compression system developed by Meridian Audio and licensed through Dolby Laboratories. Because it is a

completely lossless system, a decoded MLP datastream is bit-for-bit identical to the pre-encoded PCM source stream.

MLP permits substantial reduction in the bandwidth required to store high-quality multi-channel PCM audio. The efficiency of the algorithm varies with the program content, particularly for material at sample-rates of 44.1 or 48 kHz. For higher sample-rates (88.2, 96, 176.4 and 192 kHz), however, MLP has been demonstrated to reliably achieve a 45% reduction in bandwidth requirements. This allows a DVD-5 disc to be used for presentation of up to 74 minutes of program using six channels of 24-bit/96 kHz audio. DVD-Audio discs are not required to use MLP, but decoding capability for MLP is mandated for all DVD-Audio players.

SMART Content and Downmixing

One of the problems confronted by WG-4 in defining DVD-Audio stems from the fact that, aside from home theater systems, most playback situations (stereo receivers, headphones, and boom-boxes, for instance) are currently configured for stereo. To ensure that a DVD-Audio disc will always play, regardless of the available monitoring configuration, WG-4 had to define how a player should present multi-channel programs in situations where only stereo playback is available. The difficulty is that a program mixed for surround presentation may not sound correctly balanced in stereo, particularly if the player simply ignores the surround channels.

DVD-Audio will allow both stereo and multichannel mixes of the same music to be delivered on one disc. So one solution would have been to require that every disc that includes a multi-channel program must also include a two-channel version of the same program. But that would have imposed significant limitations on the playing time of discs with multi-channel programs.

Instead, WG-4 mandated that players support an approach championed by Warner Bros. Records called "SMART Content" (System Managed Audio Resource Technique). SMART allows the producer to determine in advance a set of "coefficients" defining the relative level, panning and phase that will be applied to each channel of a multichannel mix if it is combined into stereo. A SMART "downmix" will only be played if a discrete 2-channel mix of a given program has not been included on the disc.

SMART coefficients are specified as 8-bit numbers in a six-by-two matrix, along with a phase bit for each channel. A set of 16 tables of these coefficients may be defined for each Audio Object Set (more on these below). The table for each individual track of a title may be selected from among these 16. This allows producers a workable means to control the sound of their music in cases where their multichannel mix is downmixed by the player.

Value-Added Content

While audio playback is at the heart of DVD-Audio, the format is also intended to offer a workable platform for the kinds of value-added multimedia features that have proven difficult to deliver to the mass market on formats such as CD-ROM and Enhanced CD. These features include graphical accompaniment for the music, text information about the music and the artist, and motion video such as music videos or interviews.

Still Pictures

The DVD-Audio specification fully supports the display of still pictures during audio playback, and offers the producer a wide range of options as to when and how the pictures are shown.

Still-graphics in DVD-Audio are MPEG-2 encoded images. The basic graphical unit is an ASV (Audio Still Video), composed of an MPEG still, a subpicture overlay (SPU), and highlight information (HLI). The subpicture and highlight layers are optional.

Button Highlight + Subpicture Overlay + Main Picture = DVD Image

Lyrics Artist Bio
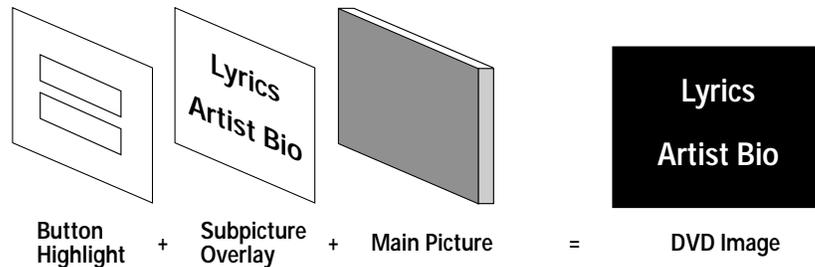
Components of an Audio Still Video (ASV)

ASVs are grouped into sets of graphics referred to as ASVUs (Audio Still Video Units), each of which may contain up to 99 ASVs (individual images). While the data size of an individual ASV may vary greatly, typical ASVs may be expected to average about 100 KB.

The total size of an ASVU may not exceed 2 Megabytes, which is the size of the buffer that player manufacturers are required to provide to allow ASVUs to be preloaded into player memory. This preloading process ensures that players will not interrupt audio playback in order to read graphical data from the disc. For instance, a listener can browse a series of still graphics without affecting the currently playing song.

The portion of audio over which the images from a given ASVU are intended to display is referred to as the ***ASVU range***. An ASVU range may be either a single track or a set of tracks. From an authoring point of view, it is crucial to realize that audio output is muted during preloading of ASVUs. Depending on player design, the duration of this muting is likely to be at least two seconds, possibly more. Thus each ASVU range is separated by a silence of at least two seconds. This limitation will require careful planning of graphics usage in situations such as live albums, where audio program may continue for long periods without the opportunity to load a new ASVU.

For each ASVU, the producer defines a playback mode that determines the order and duration of graphical display. "Browseable" graphics have a defined minimum and maximum on-screen duration, but allow the user to skip forward through the set of images by using the remote control. "Slideshow" graphics, on the other hand, are displayed for a predetermined amount of time.

Within each of these modes, the order in which the images is displayed may be defined as "sequential" (order predetermined by the producer), "random," or "shuffle" (random, but no image repeated until every image has been shown). The format supports a variety of start and end effects (wipes and dissolves) as transitions between images.

The specification also allows the highlights within a given ASV to change over time. This is useful for content such as song lists, lyrics or libretto. Links allowing listeners to navigate to different parts of a song by clicking on lyrics are expected to be a common feature of DVD-Audio titles.
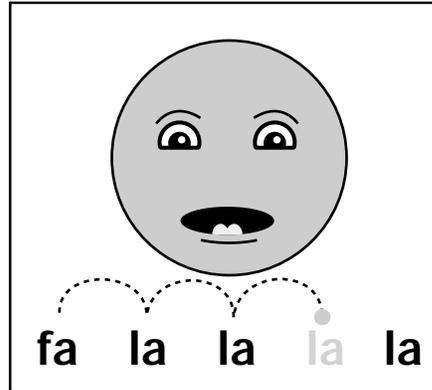
Changing highlights within an ASV can be used to indicate the current line or word of lyrics.

Text Information

The DVD-Audio specification provides for storage of text information on disc, though inclusion of text is not mandatory. Text support is provided for multiple "language units," with up to eight languages available on any given disc. Two character types are supported. For languages such as English that use single-byte characters (ISO8859-1), text is structured for presentation as "pages" of four lines of up to 30 characters each. Japanese and other languages using double-byte characters (JIS Kanji) are organized into pages of two lines of up to 15 characters each.

The manner in which any given player uses this text information (if at all) is left to the discretion of the player manufacturer. A player with video output, for instance, may display the text on screen. But the size of the pages defined by the specification suggests that the primary application is envisioned as an LCD screen on "smart" Audio-only players, Audio-with-Video players, and/or Universal players.

The specification defines two distinct types of text. Audio Text Data is intended for display of static information that is not synchronized to the audio program. If Audio Text Data is used at all, it must include the Album title, "Group" name (more about Groups later) and Track name. It may also include optional information such as the name(s) of the artist and composer. Up to 64 KB of data may be included for each language unit.

Real Time Text is stored on disc as part of the audio stream, and may be synchronized to audio playback. Ideal for lyrics and libretto, Real Time Text may also be used for context-dependent commentary such as running liner notes. Once again, the extent to which a given player supports Real Time Text or Audio Text Data is up to the hardware manufacturer.

Video on DVD-Audio

DVD-Audio's support for motion video is substantially similar to that of DVD-Video, using Video Objects (VOBs) comprised of MPEG-2 video plus audio and optional subtitles. However, some advanced features that are supported in DVD-Video VOBs—such as parental control and complex interactivity—are not supported in all DVD-Audio settings. To fully understand these limitations, it is necessary to first understand the overall organization of the DVD-Audio format.

The Structure of DVD-Audio

As noted above, a DVD-Audio disc is a DVD-ROM disc that includes a special zone (the Audio_TS folder or directory) for DVD-Audio material. A DVD-Audio disc may also include a Video_TS folder for an optional DVD-Video zone, as well as a DVD-Others zone for applications and data (e.g. a browser for Web connectivity) that may be accessed from a computer-hosted DVD-ROM drive.

The overall volume structure of the DVD-Audio Disc requires the DVD-Audio area to appear first, followed by the DVD-Video area and any other non-Audio/Video files and directories. As with DVD-Video, the final playback experience of a given DVD-Audio title involves two interrelated aspects of DVD playback: the program data itself (audio, still pictures, text and motion video) and the logic determining the order and conditions of playback. But because DVD-Audio discs are intended for playback on a number of different player types, the way in which the information on disc is utilized and experienced also depends on the type of player.

Multiple Content Managers

In the world of DVD, the first place a player goes to find out what content is present on a given disc is a directory referred to as a "Manager." In our discussion above about the structure of DVD-Video, we learned about the Video Manager (VMG) in the DVD-Video zone. A DVD-Audio disc that includes an optional DVD-Video zone will naturally include a VMG as well, but this VMG is only used if the disc is played in a DVD-Video player. For playback in a DVD-Audio player, the specification requires inclusion in the Audio zone of several different content directories, each used to accommodate a different playback situation (player).

The most basic form of Manager in DVD-Audio is the SAMG (Simple Audio Manager). Containing a list of up to 314 tracks, it serves the same function as the TOC (table of contents) on a CD-Audio disc. Simple Audio-only players look at SAMG to find the information they need for linear, track-based navigation of the disc.

As mentioned earlier, "smart" Audio-only players, Audio-with-Video players and Universal players all support more sophisticated navigation than do simple Audio-only players. The directory information these players need is found in the AMG (Audio Manager). Smart Audio-only players use a section of AMG designated as AOTT, while Audio-with-Video players and Universal players use the AVTT section. Simple Audio-only players, meanwhile, ignore AMG completely.

Data Structure: Audio Object Sets and Audio Objects

Like the DVD-Video specification, the DVD-Audio specification describes two parallel organizational constructs: the data structure and the logical structure. When we

discussed the organization of the DVD-Video zone on a DVD-Video disc, we learned that conceptually the zone is made up of navigational structures called domains, including a Video Manager (VMG) and one or more Video Title Sets (VTS). The presentation data referenced from within these domains is found in containers called Video Object Sets (VOBS) which contain Video Objects (VOBs).

Similarly, the DVD-Audio zone includes two domains: AMG (the audio manager described above) and Audio Title (ATT). The presentation data referenced from AMG (visual menus, if any) is contained in a VOBS. The presentation data referenced from ATT, meanwhile, is contained in one or more Audio Object Sets (AOBS).

Each AOBS is comprised of some number of Audio Objects (AOBs). Analogous to VOBs, AOBs are made up of one or more tracks (songs or compositions) of audio, optionally accompanied by the still images and/or Real Time Text discussed earlier. Tracks, in turn, are made up of one or more cells.

Logical Structure: Albums, Groups and Tracks

DVD-Audio players that read AMG (all except simple Audio-only players) are able to take advantage of DVD-Audio's capacity to organize material hierarchically rather than simply linearly. This logical hierarchy exists in parallel to the format's data structure. It is based on five different levels: album, group, title, track and index.

Each side of a DVD-Audio disc contains one album. Each album may contain up to nine groups, each of which is essentially a playlist specifying the playback order of a number of titles. While any title may contain up to 99 tracks, there may be no more than 99 tracks total within a single group.

As on a CD, a track may be thought of as a single audio program (i.e. a song). Audio attributes such as channel configuration, sample-rate, and word-length may be changed on track boundaries (players may mute during such attribute changes). An index is a reference point to a portion of an audio track (cell), and there may be up to 99 indices within a single track.
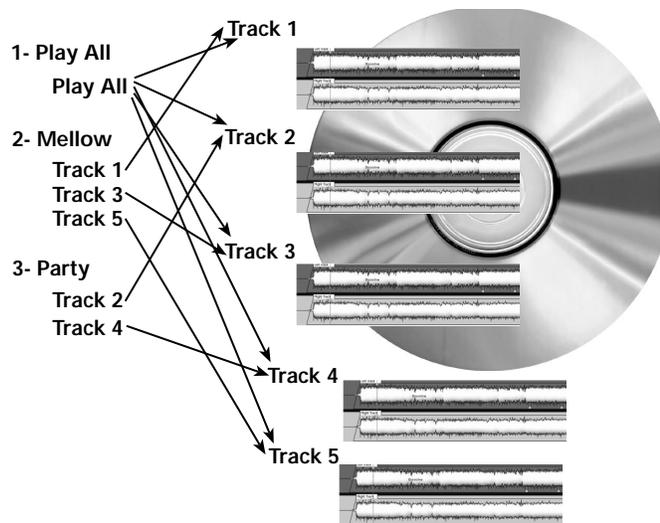
DVD-Audio Zone Structure

While this hierarchy has many levels, in practice the end-user is never aware of the existence of titles. On a smart Audio-only player, for instance, a user would normally be able to play any track using the remote by simply entering a group number and then the number of a track within that group.

Because a group is simply a playlist, a given track may be referenced by more than one group. On an album with twenty audio tracks, for instance, one group might be a sequence of all the songs, another could be a "mellow" playlist of just acoustic numbers, and a third might be a "party" playlist of just dance tracks. Groups thus allow producers to create up to nine different listening experiences drawn from one underlying set of material.
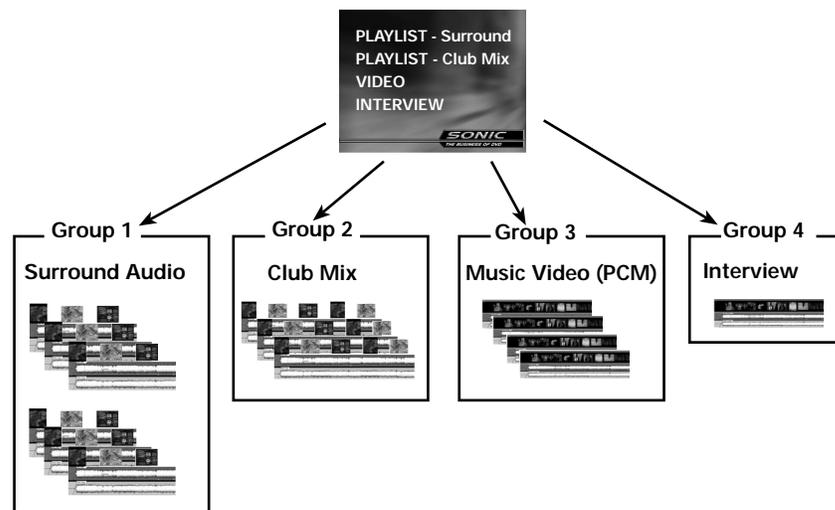
Logical Hierarchy of Example Title with Several Groups

Navigation and Program Chains

As noted above, DVD-Audio discs are required to include three different content directories to facilitate navigation on different types of players: SAMG is used by simple Audio-only players, AMG/AOTT is used by smart Audio-only players, and AMG/AVTT is used by players that have video output (Audio-with-Video players and Universal players).

In players that use AVTT, navigation is supported via a visual menu like those used in DVD-Video (the AMGM in DVD-Audio is analogous to the VMGM in DVD-Video). AOTT machines can't use visual menus (they have no video output), but the underlying method of enabling navigation is the same. As with DVD-Video players, navigation of the content referenced in both AVTT and AOTT is based on program chains (PGCs), which are instructions that tell the player what to play and when to play it.

Just as video PGCs point to VOBs, audio PGCs direct the player to AOBs. If a given AOB is to be accompanied by still images, the audio PGC will also point to the appropriate ASVU (collection of stills).

On many DVD-Audio discs, all the audio in a given group will utilize the same channel configuration and audio attributes, and in this case that group would normally be comprised of a single PGC. There may be groups, however, where one or more song is available in different mixes: one for playback in stereo settings and the other in a

multi-channel environment. Two different PGCs would be created, one for stereo and one for multi-channel. During playback the player would choose which PGC to play depending on the playback environment.

The DVD-Audio specification includes a set of Navigation Commands for use in audio PGCs, as well as General and System parameters that are stored in player memory. As with DVD-Video, the commands are broken into various categories (Link, Jump, GoTo, SetSystem, Set and Compare), but the navigation commands supported in DVD-Audio are a subset of the DVD-Video set. Presumably that's because the group is intended to be DVD-Audio's primary mechanism for defining a specific path through all the available content on the disc. The availability of nine groups allows navigation that is far more varied than that of CD-Audio, but the possibilities are more limited than in DVD-Video.

Among the most important navigational constraints in DVD-Audio are those relating to movement within a group. A user may enter a group at any point by selecting a specific track. But once playback has started within a given group, that group will continue playing in order through to the end, unless the user exits playback by using the Menu or Group button on the remote to go to the album's main menu. The specification makes no provision for linking directly from a given group to content outside that group.

Using Video in DVD-Audio

One important aspect of DVD-Audio groups is that they may include not only audio tracks drawn from Audio Object Sets (AOBS), but also Video Title Sets (VTS) from a disc's optional Video zone. A VTS on a DVD-Audio disc is similar to a VTS on a DVD-Video disc, but there are a number of important distinctions in the video capabilities of the two formats. For one thing, the video title sets on a DVD-Audio disc do not each include an individual menu (VTSM); the only menu in the Video zone on a DVD-Audio disc is the VMGM.

Another distinction is in the audio format required for video soundtracks. As noted above, the DVD-Audio specification requires that every audio program (AOBS audio) include a PCM stream (this is the only audio type for which player support is mandated). This rule may or may not apply to the soundtracks of any video on the disc, depending on the player types for which the video's soundtrack is intended.

During the DVD-Audio production process, the producer decides whether or not the soundtrack of any VTS on the disc will play back on Audio-only players. If so (an AOTT/AVTT VTS), the VTS must follow the same audio requirements as an audio program (one mandatory PCM stream plus one optional additional stream). If the VTS soundtrack is not intended for playback on Audio-only players (an AVTT-only VTS), a PCM stream is not required (either PCM or Dolby Digital may be used).

	AOTT/AVTT VTS	AVTT-ONLY VTS
Playable on Audio-only player?	Yes	No
Required audio format	Linear PCM	Dolby Digital or LPCM
Optional audio format	Dolby Digital	Dolby Digital or LPCM
LPCM parameters	max. channels @ 48kHz: 8 max. channels @ 96kHz: 2 bits: 16, 20 or 24 max. bit-rate: 6.1444 Mbps	same as AOTT/AVTT
Dolby Digital parameters	max. channel s: 5.1 max. bit-rate: 448 kbps	same as AOTT/AVTT

Audio format requirements for video soundtracks in DVD-Audio vary depending on whether the type of Video Title Set used allows playback on an Audio-only player.

The DVD-Audio specification also requires that if a given type of player is able to play some of the content in a group, it must be able to play all of the content in that group. This means that a group which includes a VTS that is not enabled for playback on Audio-only players may not also contain AOBS audio (which plays on Audio-only players). In effect, videos that are not enabled for (audio) playback on Audio-only players must be segregated into their own group(s).

Video Capabilities

Another distinction between video on a DVD-Video disc and video on DVD-Audio is found in the capabilities of video PGCs (which are used to control which VOBs should be played under which conditions). The features available to control VOBs in DVD-Audio are a subset of those available on a DVD-Video disc. The degree to which the video feature set is different depends on the context in which the video is used.

We learned earlier that conceptually a Video zone on a DVD-Video disc is made up of distinct domains: a Video Manager (VMG) and a series of Video Title Sets, each comprised of a Video Title Set Menu (VTSM) and one or more Video Titles (VTT). While the main video content of a DVD-Video disc is normally stored in the title sets, the VMG contains the VMG menu (VMGM), which may use either still images or motion video (VOBs) for their backgrounds. Thus, VOBs may be used in both the menu and title domains of the Video zone.

If a Video zone is present on a DVD-Audio disc, motion video may once again be used in either the zone's menu or title domains. But the menu domain of the Video zone is never seen during playback of the disc on any type of DVD-Audio player (including Universal); it is present only to allow the disc's Video Title Sets to be viewed on a DVD-Video player. On DVD-Audio players, the viewer sees instead the visual menus in the AMG domain of the Audio zone.

Like VMG menus, AMG menus may use motion video backgrounds. The only domain on a DVD-Audio disc from which motion video is never referenced is Audio Title (ATT). In short, then, on a DVD-Audio disc video may be used in the AMG menu (AMGM), the

VMG menu, or a Video Title. (Video Title Set Menus, as noted earlier, do not exist in DVD-Audio.)

The domain in which the DVD-Audio specification is most restrictive with video (compared to DVD-Video) is VTS. Parental control and seamless branching are not supported. Also, VTS PGCs in DVD-Audio do not include pre-commands or post-commands, and the use of dummy PGCs is not supported. Thus video title sets on DVD-Audio discs are less capable of complex interactivity than those on DVD-Video discs. It is possible to create complex interactivity in the AMGM, where features such as pre- and post-commands are supported. However, this is not the intended purpose of the AMG domain.

Two additional notes about video on DVD-Audio discs: A DVD-Audio disc may contain DVD-Video content in its menus that is not accessible during playback on a DVD-Audio player. That's because the contents of the VMG menu—including any motion video therein—is never seen by an audio player. If desired, then, the AMG menu and VMG menu might each have a completely different look and feel, including the use of different motion video (if any).

It is also possible to create a DVD-Audio disc that plays the same content on either a DVD-Video player or a DVD-Audio player (Audio-with-Video or Universal). In other words, the presence of AOBS audio is not required. In this case, all the content (other than menus) would be video title sets with PCM audio. This content would be accessed through AMGM on an audio player and VMGM on a video player. How much of this material would also play on an Audio-only player would depend on whether or not Audio-only playback is enabled for the video title sets.

An Example DVD-Audio Title

To see how all these audio and video options might work in practice, let's consider how a typical CD release with a dozen songs might be organized if it were released as a DVD-Audio title.

- Group 1 on the DVD might be the same material in the same sequence as the CD release, but in multi-channel surround. Each song could be accompanied by a browseable slide show allowing the listener to navigate to different index points in the song by clicking on lyrics.

- Group 2 could be a dance version of the album, with ballads dropped and longer "club" mixes substituted for several of the other songs.

- Group 3 might be a collection of three or four music videos produced for the album, each enabled for playback on audio-only players.

- Group 4 might be a mini-documentary including interviews with the band (with playback on audio-only players disabled.)

Taking advantage of the disc's DVD-Others zone, meanwhile, would open up even more creative, promotional and commercial opportunities when the title is placed in a DVD-ROM drive. The disc might contain a custom browser programmed to take the user to the artist's section of the label's Web site. There the user might hear song samples from the band's other albums, order albums and other merchandise online, check a tour schedule and order tickets, or send fan e-mail to the band. Combining the flexibility of the DVD-Audio format with the underlying capabilities of DVD-ROM, the possibilities for DVD-Audio discs become nearly unlimited.