DVD-ROM Format & Applications

July 2003

by Graham Sharpless

Contents

1. Introduction

DVD technology was developed to provide an optical disc format with a much larger capacity than the CD, for a wide range of applications. Pre-recorded DVD discs provide capacities from 4.7 GB to 9.4 GB with 17.1 GB having limited availability. They are capable of supporting a wide range of applications, including DVD-Video, for full-length movies, and DVD-Audio, the very high quality multi-channel audio format.

The term DVD-ROM is used in two ways.

1. DVD-ROM defines the physical and logical format of pre-recorded DVD discs and is used to differentiate these from recordable or write-once discs. Using this definition both DVD-Video and DVD-Audio formats are also DVD-ROM discs.

2. DVD-ROM is also used to refer to the computer multimedia applications of DVD. DVD-ROM discs, as opposed to DVD-Video or DVD-Audio discs, are being used for games, encyclopaedias and other applications where the large size is needed. In addition DVD-Video and DVD-Audio discs often include a DVD-ROM section with data that runs on a PC, giving additional features such as Internet access.

This document concerns the second use of the term DVD-ROM and describes the requirements defined by the computer industry, the differences between it and CD-ROM, plus applications, compatibility issues and hardware.

1.1 DVD-ROM Requirements

The **Technical Working Group**, representing the computer industry, listed the following requirements for a DVD-ROM specification for multimedia, games and other computer applications.

- Single format for computer and TV-based applications
- Backward read compatibility with existing CD-ROMs
- Forward compatibility with future R/W and WORM discs
- A single file system for all content and disc media types
- Low cost drives and discs
- No mandatory container
- Reliable data storage and retrieval
- High on-line capacity
- High performance for sequential and non-sequential data

DVD-ROM drives and PCs with DVD capability are now widespread in the USA, Europe and Japan. Generally these also include MPEG-2 decoders either in hardware or software. They are then capable of playing DVD-Video discs as well as DVD-ROM applications.

2. DVD-ROM Specification

DVD-ROMs are like large CD-ROMs, capable of holding more data for a wide range of applications.   Some applications include MPEG-2 video, as used on DVD-Video discs, to give added realism to games and richer content for multimedia applications.

The DVD-ROM specification is actually the physical specification for all DVD read-only discs together with the UDF file system. Like CD-ROM the DVD-ROM specification does not define how the user data is to be formatted and used. That is left to the application. In contrast the DVD-Video and DVD-Audio specifications define precisely how the data is formatted.

A DVD-ROM disc can be any of the physical DVD formats DVD-5, DVD-9, DVD-10 etc.

2.1 DVD-ROM vs CD-ROM

CD-ROM discs are specified in the *Yellow Book* and are based on the original *Red Book* Audio CD. A DVD-ROM provides at least 7 times the capacity so can store much more data for complex multimedia applications and games.

Table 1 gives a comparison of the major differences between a CD-ROM disc and DVD. Note that 1 GB = 1 billion bytes.

Table 1 DVD-ROM vs CD-ROM Capacities

	DVD-5	**DVD-9**	**CD-ROM**
Capacity (GB)	4.7	8.5	0.7
File Structure used	UDF & ISO 9660		ISO 9660

Unlike CDs, all DVD discs not only have identical physical formats but also use the same logical format and file system. All application data on the disc, whether video, audio, text, graphics or program data, are contained in files.

2.2 DVD-ROM Disc Layout

Dual layer (DVD-9) DVD-ROM discs will normally be organised as Parallel Track Path discs (see below), with the file system located on layer 0. The two layers therefore represent a single volume (see Figure 1). For both single and dual layer discs the data will start at the inner diameter.

Single layer disc

Lead In	→	Data Area	→	Lead Out

Dual layer disc – parallel track path

Lead In	→	Data Area (Layer 1)	→	Lead Out
Lead In	→	Data Area (Layer 0)	→	Lead Out

Figure 1 Disc Layout for Single and Dual Layer Discs

For DVD-10 discs the two sides represent two separate volumes.

2.3 Directory & File Structure

The following diagram shows the directory and file structure for a typical DVD disc with specified directories (VIDEO_TS and AUDIO_TS) for DVD-Video and DVD-Audio files (if present) and other directories (whose names are not specified in the DVD specifications) containing files for use on computers or games consoles.
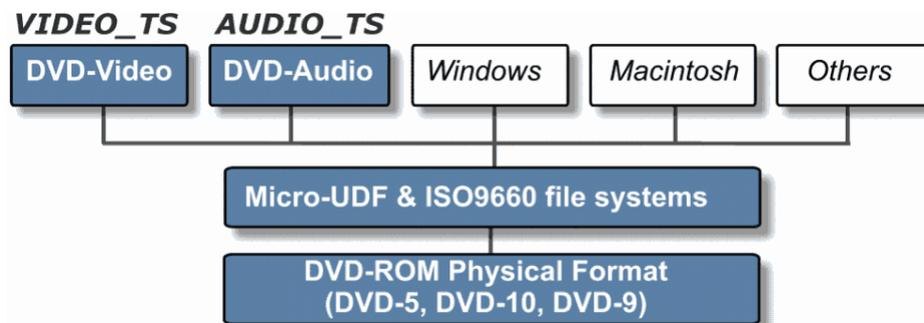
Figure 2 Directory & File Structure

- The Universal Disc Format (UDF) file system was developed to support re-writable as well as read-only media. It is the file system chosen for all DVD formats.

- ISO 9660 is included to provide backward compatibility with Windows 95, although Windows 98 supports UDF. MacOS 8.1 and above on DVD-enabled Macintosh computers also supports UDF.

DVD-Video and DVD-Audio players only read UDF, not ISO 9660.

Hybrid titles, with data for more than one application (eg DVD-Video plus a PC game) will include data in two or more of these directories.

3. DVD-ROM Applications

DVD-ROM applications can take advantage of the increased capacity of DVD discs and, optionally, make use of DVD-Video's high quality MPEG-2 video and multi-channel audio encoding. There is a wide range of applications for DVD-ROM including:

- Bigger and better games allowing current multi-disc CD-ROM games to be distributed on one DVD-ROM disc. DVD allows the content of six or more CD-ROM discs to be stored on a single disc.
- More extensive multimedia applications, such as encyclopaedias, with additional content including higher quality MPEG-2 video and surround sound audio.
- Very large databases and clip-art libraries.
- Hybrid DVD/online titles where the bulk of the data needed (such as video) is stored on the disc and updates are downloaded from the Internet. The Internet can also be used to pay for and unlock software contained on a DVD-ROM disc.
- Interactive DVD-Video titles, which will play on DVD-Video players with limited interactivity and on computers for full interactivity. These include movies with an associated game or multimedia content or web access, which can only be played on a PC or Macintosh.

Application specifications are available for DVD-Video and DVD-Audio only. Other applications must include suitable application software for PC and/or Macintosh to allow the content to be read and processed.

4. DVD-ROM Hardware

DVD-ROM titles are designed to play on a specific platform eg PC or Macintosh. These platforms, with appropriate hardware/software, will also play DVD-Video and DVD-Audio discs.

- Most recent PCs can be upgraded by adding a DVD-ROM drive and hardware or, for faster processors, software MPEG-2 decoder in order to play DVD discs.
- The latest Apple Macintosh computers can provide DVD playback or can be upgraded with the external Apple DVD-Video kit.
- New Games consoles such as Sony's Playstation2 and Microsoft's X-box, which incorporate DVD drives and are capable of playing DVD-Video discs.
- Enhanced DVD-Video players can provide more interactive possibilities such as Internet access.

4.1 DVD-ROM Drives

DVD-ROM drives, like CD-ROM drives, are being developed with ever-increasing speeds. Early drives offered 2x speeds, while the latest drives now offer 16x speeds. These faster drives are not necessary for DVD-Video titles (which read data at 1x), but allow faster data transfer for multimedia and games applications.

Single speed DVD-ROM drives have a data transfer rate of 11.08 Mb/s, which is equivalent to a 9x CD-ROM drive. Table 2 below gives the main specification parameters for a typical 16x drive.

Table 2 Specification for a Typical DVD-ROM Drive

	DVD-5	DVD-9	CD-ROM
Capacity (GB)	4.7	8.5	0.7
Drive speed (typical)	16x		48x
Max Data transfer rate (Mb/s)	177		57.6
Linear velocity (m/s)	up to 55.8	up to 61.4	up to 62

The linear velocity is lower for a DVD than for a CD at the same data rate. The highest speed DVD-ROM and CD-ROM drives are not CLV (constant linear velocity) but CAV (constant angular velocity) where the data rate increases from the inside to the outside. Such drives achieve their maximum speed only at the outside diameter.

DVD-ROM drives include a cache of typically 256 or 512 kB, which will store 128 or 256 sectors respectively. The bigger the cache the faster it can supply data to the computer.

4.2 MPEG-2 Decoders

An MPEG-2 decoder is needed to play DVD-Video titles plus any MPEG video contained on a DVD-ROM disc. Both hardware and software decoders are available.

- **Hardware** decoders allow a slow processor to be used. Many decoders include a video output, which allows your favourite movies to be watched on a TV instead of the computer monitor
- **Software** decoders require a faster processor (which all new PCs have) and a suitable graphics card, but offer a lower cost solution for new PCs.

DVD add-on kits usually comprise a DVD-ROM drive and MPEG-2 decoder board. Software to play DVD-Video discs is also included in the package. Normally this includes an on-screen controller to simulate the remote control of a DVD-Video player.

4.3 Microsoft Windows & DirectShow

Microsoft has included DVD capability in Windows 98/ME/2000/XP including the following features:

- Reading data sectors from DVD-ROM drives and providing support for the DVD-ROM command set
- UDF file system support
- Support for streaming data such as MPEG-2 video and Dolby Digital audio
- **DirectShow** (formerly ActiveMovie), which improves compatibility by replacing the old MCI (Media Control Interface) with a new standard interface to play Video Object (VOB) files. VOB files contain the audio, video, subpictures, menus and navigation commands defined in the DVD-Video specification. DirectShow allows applications to control the playback of VOB files (including interpreting program instructions and user interactivity) and supports interlaced video and multi-channel audio
- **DirectDraw**, which supports the transfer of decoded video streams from an MPEG-2 decoder to the display card via dedicated buses
- Copy protection and region coding support for both software and hardware decoders to enable authentication between the decoder and the DVD-ROM drive for playing DVD-Video discs.

4.4 QuickTime

QuickTime 4 (and later versions) on both Macintosh and Windows platforms is capable of playing back MPEG-2 video including VOB files, using an existing MPEG-2 decoder.

4.5 Copy Protection

Copy protection has not been available for DVD-ROM discs, but a number of new technologies are due to be released soon, based on existing CD-ROM copy protection methods. These are intended to prevent the content of discs being copied, pirated or transferred to hard disk for use without the disc itself.

DVD-ROM drives must comply with the CSS specification and region coding for DVD-Video.

5. Compatibility Issues

DVD-ROM titles are, as yet, few in number compared with DVD-Video titles. The reason is partly that while a DVD-Video player is purchased primarily or only to play DVD-Video discs, a DVD-ROM drive in a PC can be used to play DVD-Video and CD-ROM discs as well as DVD-ROMs.

5.1 Reading CD-R Discs

All DVD-ROM drives will read all DVD pre-recorded discs (from 4.7 to 17.1 GB capacities), plus CD audio discs and CD-ROM discs. Some early DVD-ROM drives were not able to read CD-R discs, but most now do so.

The dye used for the recording layer in CD-R discs is designed for lasers with wavelengths 775 nm to 795 nm (ie for CD lasers) but offer insufficient reflectivity at 650 nm, the laser wavelength used for DVDs. The only solution is to use a dual laser pickup with both 650 and 780 nm lasers. Such pickup devices are now available from several companies and most DVD-ROM drives now include them.

5.2 MultiRead

The Optical Storage Technology Association (OSTA) has defined MultiRead, which is a specification defining drives that are capable of reading CD-DA, CD-ROM, CD-R and CD-RW.

MultiRead2 is an extension of MultiRead for drives capable of reading CD-DA, CD-ROM, CD-R, CD-RW, DVD-Video, DVD-Audio, DVD-ROM, and DVD-RAM (but only the original 2.6GB version).

Future versions may include reading of other recordable and re-writable DVD formats.

5.3 DVD-Multi

The DVD Forum has announced DVD Multi, which "will set hardware specifications to enable disc compatibility for virtually all formats officially created by the DVD Forum, both for consumer electronics and personal computers."

DVD Multi specifications will ensure compatibility of the following products.

- For computers **DVD-ROM** drives will read DVD-Video and DVD-Audio discs (if they have the relevant decoders) plus DVD-ROM, DVD-RAM, DVD-RW and DVD-R discs.
- **DVD Recorders** attached to PCs will read all the above discs and write to DVD-RAM, DVD-RW and DVD-R discs.
- **DVD Multi Players** will be able to read DVD-RAM, DVD-RW and DVD-R discs. However this does not mean that the content can be read and decoded.

The DVD-Multi specification does not extend to DVD+R or DVD+RW formats which are not supported by the DVD Forum.

6. Producing DVD-ROM Titles

The production process comprises authoring, pre-mastering and manufacture. Multimedia titles for DVD-ROM can be created using similar tools to those used for CD-ROM titles such as Macromedia Director, Visual Basic or Visual C++. Where MPEG-2 video files are to be incorporated, DVD-Video authoring tools will also be required to encode the audio and video, add navigation and create the VOB files.

6.1 Premastering and Testing

The resulting files are then premastered using software that is designed to format the data using the UDF Bridge file system and according to the DVD specification. Where relevant, the DVD-Video, DVD-Audio and/or other files must be contained in the appropriate directories (as described above).

The pre-mastering process will result in a disc image, which can either be written to DLT with the appropriate DDP file, for glass mastering, or be used to write a DVD-R for testing purposes. However, DVD-9 format titles cannot be fully tested until a pressed disc is made.

Several CD-ROM premastering tools now also support DVD and will write data to DVD-R discs as well as CD-R. However there are few that will write to DLT and support DVD-9. One that will is Sonic Solutions' ROM Formatter, a low cost tool for formatting DVD-ROM content and writing to DLT. Features of this software include:

- Formats data for DVD-9 as well as DVD-5 and DVD-10 formats.   This includes creating a single volume split between the two layers.
- Position of data on the disc can be specified by the user. This includes controlling the positioning of the layer break on a DVD-9 disc.
- Writes to DVD-R and DLT or can be used to create a DDP Disc image to hard disk for efficient network transfer for replication.
- Macintosh-compatible pure DVD-ROMs can be premastered.

6.2 Manufacturing DVD-ROM Discs

The manufacturing process is identical to that of a DVD-Video or DVD-Audio disc. The disc can be a DVD-5, DVD-10 or DVD-9 depending on the data size and whether a double-sided disc is acceptable. DVD-9 and DVD-10 discs will require two DLTs, one for each side/layer. Alternatively, for DVD-5 and DVD-10 formats, the title can be mastered from DVD-R disc(s). DVD-9 titles cannot be mastered from DVD-R.

DVD-RAM and DVD-RW discs are generally not suitable for mastering because, unless the data on the disc has been fully erased, or it is a new disc, the files may not be contiguous.