DVD Optical Storage

Information Brief

Worth remembering

- DVD can store up to 17GB[1] of data in a robust optical format
- The first DVD drives were read-only devices, or DVD-ROM
- The DVD format should spark innovative multimedia applications for business featuring full-screen, full-motion MPEG-2 digital video and Dolby Digital™ surround sound
- Planned DVD enhancements include write-once (DVD-R) and rewritable versions (DVD-RAM) available in 1997 or 1998

Overview

There's no doubt about it—DVD is poised to revolutionize both the home electronics and computer industries. DVD has the look and feel of today's familiar audio CDs and CD-ROM discs (4.75-inch/120mm) that store music and computer software. For the computer industry, DVD delivers up to 17GB of storage, 25 times the current data capacity of CD-ROM. (A 3" variant of the format has also been proposed with 2.6GB of storage per side.) DVD drives are backward-compatible with audio CD, CD-ROM, CD-i and PhotoCD. DVD-R (write once recordable) technology should be introduced by late-summer 1997, followed by DVD-RAM (write many) in 1998. For digital video storage, DVD uses the MPEG-2 compression scheme to accommodate the huge storage demands of high-quality feature length movies.

Inside DVD technology

Originally named "Digital Video Disk," then "Digital Versatile Disk," the format is now simply and officially "DVD" with no three-word-equivalent. DVD has become an industry standard thanks to the efforts of Sony, Toshiba, Phillips, IBM and other companies. IBM chaired the computer industry technical working group that was responsible for defining the requirements of DVD for the computer industry. IBM helped bridge the gap between two opposing factions who had proposed incompatible formats. The brokered agreement sets forth a universal standard, avoiding a replay of the VCR marketing war between proponents of the VHS and Beta formats.

Like CD-ROM, the DVD format is read by an infrared laser focused through a protective plastic layer onto the disc's reflective layer. (The transparent layer is 1.2mm thick on a CD-ROM, but only .6mm on a DVD-ROM.) The beam reflects off pits burned into the reflective layer by the recording laser and is passed through optics to the pickup. The laser beam utilized on a CD-ROM player has a wavelength of 780 nanometers (.78 millionth of a meter). DVD players employ a

laser with a wavelength of 635 and 650 nanometers, designed to read through the thinner .6mm transparent layer. This makes it possible to focus on smaller pits of digital data, about half the physical size of pits on a CD-ROM —effectively doubling the density of pits on a DVD-ROM. More data is squeezed onto the disc by recording tracks closer together and closer to the center hole, as well as improving the error-correcting decoding algorithms. The result is a single-sided DVD that holds seven times as much data as a CD-ROM. The transfer rate is >2000KB per second, or roughly equivalent to a 14X-speed CD-ROM. This improved capacity and performance make it ideal for video-intensive multimedia applications. But that's just the most basic configuration . . .

DVD discs come in capacities of 4.7, 8.5, 9.4 and 17GB. Most of the early discs will be single-sided, but the specification includes dual-layered and double-side versions that define the four levels of storage capacity. DVD data is read by a variable-focus laser; on dual-layered discs, a lens shifts the beam's focus from the pits on the outer layer to the pits on the inner layer.

Capacity	Layers	Sides
4.7 GB	1	1
8.5 GB	2	1
9.4 GB	1	2
17 GB	2	2

Movies provide an illuminating example of the huge capacity of DVD (1 DVD disc can hold the equivalent of 3264 high-density floppy disks) that makes it a natural as *the* universal storage format. A typical feature-length movie (133 minutes) will fit compressed on a single-sided disc. *Gone with the Wind*, which runs 220 minutes, will require two single-sided discs or a double-sided disc. Notice that a dual-layer disc doesn't have twice the storage capacity as a single layer disc; sandwiching two data layers (the top layer is semi-transparent) on the same side results in a degree of loss in reflectivity, critical to the optical pickup process. As a result, single and double-sided discs should be more common than the dual-layered variety. *Eraser* and *Twister* are among the first movie releases on double-sided discs, with a standard viewing ratio of 4:3 on one side, and the 16:9 letterboxed version on the flip side.

Meet the DVD Family

DVD-ROM (Read only memory)

IBM is among the first to offer DVD-ROM drives, initially on the Aptiva C3D computer. Current industry trends indicate that on desktop models, MPEG-2 decoding will be implemented first on a PCI card, eventually migrating to the motherboard. Watching movies on your computer is just one application of DVD technology. Consider having a phone directory of virtually every business in the US at your fingertips, all on one DVD-ROM. That much data would fill *six* CD-ROMs. Multimedia titles are already available on DVD with 16-bit color instead of 8-bit, enhanced by full-screen MPEG-1 movies instead of quarter-frame QuickTime windows.

DVD technology appeared first in the consumer market, with models that play (decompress) DVD movie titles using an advanced MPEG-2 video board (see "Compressing Digital Video," below). Several manufacturers introduced DVD players in March, 1997, opening the floodgate of competition that is already driving prices down from the $1,000 level of current top-of-the-line

models. Great picture quality—720 horizontal pixels/line of resolution *vs*. 240 pixels for the VHS format— is enhanced by Dolby Digital sound (also known as AC-3™) delivering 5.1 audio, that is, 5 surround channels plus one sub-woofer channel. Other advantages allowed by DVD include:

- random access
- parental control of programs
- multiple aspect ratios (4:3, 16:9, pan-and-scan)
- 8 separate audio tracks for multiple language versions on the same disc
- 32 subtitle channels on the same disc

In addition to alternate versions, such as the "director's cut," future viewers can enjoy alternate camera angles, and user-controlled branching for interactive story lines. As of this writing, more than 100 DVD movie titles are available, with about 600 expected by the end of 1997—everything from *Ace Ventura: Pet Detective*, to *Doctor Zhivago*. To whet your appetite, point your Web browser to www.dvdexpress.com for a complete listing.

DVD-R (read/write-once)

The next phase of the DVD technology rollout is expected to complement current CD-R technology. Write-once is currently used primarily by content providers and application developers and is considered to be a "special purpose" device. DVD-R will fill this niche and is expected to be introduced by late summer 1997.

DVD-RAM (read/write many times)

The third phase should be eventually priced as a consumer item and is intended to replace VCRs. DVD-RAM technology probably won't arrive until 1998, but has the potential to have a significant impact on the computer industry due to the high storage capacity of its discs, as well the ability to write to them many times.

DVD-Audio

As of this writing, standards have not been set for audio-only DVD. The disagreement centers mainly on sampling rates and the number of channels supported. Audiophiles want a higher sampling rate of 96KHz, compared to the current standard of 44.1KHz of audio CDs.

Compressing Digital Video for DVD

Even with the enormous storage capacity of DVD, digital video must be compressed to fit within the 4.7GB capacity of a single-side disc. Because DVD has standardized on MPEG compression of digital video, a summary of the technology follows. (For more details, see the Digital Video Information Brief.)

The MPEG standards

The MPEG standards are named after an International Standards Organization (ISO) subcommittee that developed them, the Moving Picture Experts Group. The standards provide a common world language for high-quality digital video. The MPEG compression process is asymmetrical (taking more time to compress than decompress), and requires serious computational power to reduce the file size. But the results are impressive.

MPEG encoding is a *lossy* process, that is, some information is purposely sacrificed (lost) to reduce the file size. The discarded data is selected by a sophisticated algorithm based on human perception, eliminating only the visual information that our eyes usually ignore. The details of

lines and edges are preserved, resulting in high image quality. In simple terms, higher compression ratios can be applied to sequences depicting little or no change from frame to frame. Action sequences require more gentle compression. MPEG compresses each frame of video uniquely. Some frames—known as **I frames**, or *intra-coded* frames—are processed without regard to surrounding frames, and are compressed the least because they serve as a reference point. I frames define the first in a **group of pictures** (GOP) usually numbering 12-15 consecutive frames. Next in the GOP is the **B frame**, or *bi-directional* interpolated frame. B frames refer to neighboring frames in the group preceding and following the B frame, detecting a maximum amount of redundant information to be discarded. In a typical GOP of 13 frames, B frames comprise more than half the total. This reduces the data stream very efficiently. **P frames**—*predicted* frames—refer backwards to the preceding I or B frame for a comparison of redundant information, which is discarded. Compression of P frames is not as aggressive as that of B frames.

MPEG-1 provides 352 x 240 resolution at 30 frames per second, with quality equivalent to VHS videotape, when proper compression techniques are used. The 352 x 240 resolution is typically scaled and interpolated. (Scaling causes a blocky appearance when one pixel—scaled up—becomes four pixels of the same color value. Interpolation blends adjacent pixels by interposing pixels with "best-guess" color values.) Most graphics chips can scale the picture for full-screen playback, however software-only half-screen playback is a useful trade-off. MPEG-1 enables more than 70 minutes of good-quality video and audio to be stored on a single CD-ROM disc. Prior to the introduction of Pentium® processor-based computers, MPEG-1 required dedicated hardware support. Today, Microsoft Windows 95 supports the MPEG-1 format through the ActiveMovie API, and Pentium processors with MMX™ technology are ideal for smooth software playback of MPEG-1 video.

MPEG-2 has a resolution of 704 x 480 at 30 frames/60 fields per second, four times greater than MPEG-1. It is optimized for the higher demands of broadcast and entertainment applications such as DSS satellite broadcasts and DVD players for home theater. At the time of this writing, there are no personal computers available that are powerful enough to play back MPEG-2 without dedicated hardware. Several IBM ThinkPad models include a Media Processor for hardware-assisted MPEG-2 video playback at Half Horizontal Resolution (HHR). HHR provides excellent video playback scaled to full-screen XGA (1024 x 768) resolution without the storage demands of full MPEG-2. In addition, IBM anticipates that the ThinkPad 770 will include a DVD drive capable of playing MPEG-2 encoded movies at full screen resolution.

The MPEG-2 standard is backward-compatible with the MPEG-1 standard, thus any system equipped for MPEG-2 playback will also be able to handle MPEG-1 video.

DVD means business

The DVD specification is as versatile as its storage is vast. The features that are so appealing to consumers for entertainment purposes are equally useful in a myriad of business applications, from archiving huge databases, to multimedia presentations, to interactive training. Even before the advent of DVD, digital video had proven a uniquely effective medium in conveying complex information. Although widely acknowledged as the tool of choice for many applications, the storage demands of digital video limited its use to short clips on CD-ROM, usually at quarter-frame resolution. Those constraints are now behind us. With MPEG-1 and MPEG-2 encoding, digital video on DVD should become as universal as the VHS tape cassette.

Beyond its huge storage capacity, DVD has other advantages that will most likely benefit business users even more than consumers of home videos. The following feature/benefit scenarios, although seemingly obvious, are merely speculative. It remains to be seen which features will

become indispensable to business users. (A case in point: when home VCRs were first marketed, it was thought most people would use them to time-shift, that is, to record a program for later viewing. Although people do use VCRs that way, the most popular use has become viewing rented movies at home.)
What is certain: DVD is the most advanced, convenient, and versatile storage medium yet to be offered to a world drowning in terabytes of business data. A few of the business-centric features of this new industry standard:

- **Random access** Interactive training relies on responsive feedback to user input. DVD has the attributes of the latest generation of CD-ROM players—quick access to any part of the program, and fast throughput— plus the storage capacity for full-motion, full-screen digital video for interactive simulations.

- **Parental control** This feature can be used to "authorize" various audiences to view one of several programs on the same disc. For example, a company's customers could view a promotional program tailored expressly for them, while being "locked out" of the version containing sensitive information, such as references to wholesale prices intended for sales representatives.

- **8 separate audio tracks** Authoring eight separate CD-ROMs for eight countries is expensive. With DVD you can store a single MPEG-2 presentation with a choice of voice-over—in up to eight languages. Users select the appropriate language track through an on-screen menu.

- **32 subtitle channels** As in the above example, it's much more economical to produce one program for worldwide distribution. Foreign-language voice-overs are just one way to keep costs in line. Subtitles are even easier—and cheaper—to implement. The DVD specification includes user-selectable codes for subtitle languages ranging from Esperanto, Greenlandic, Kinyarwanda, Urdu, to Zulu. Even Latin is included for viewers in Vatican City!

- **Interactive branching** A natural for interactive training. Depending on user input, simulations can branch to multiple endings. For example, a simulation of a salesperson handling an irate customer could play out to: 1) a satisfied customer exchanging their merchandise for a more expensive product; 2) a dissatisfied customer leaving the store in a huff; 3) a punch in the nose.

- **Multiple angles** Just like instant replay in sporting events, situations can now be analyzed from various points of view. Catalogs can display merchandise from any angle—over, under, sideways— user-selected by on-screen menus or by a handheld remote control.

- **Regionalized discs** To discourage movie piracy, the entertainment industry insisted on DVD players that read regional codes on the disc, corresponding to six geographies around the world. Thus, a DVD movie disc encoded for North America cannot be played on a DVD player sold in Europe. These codes could be exploited for other commercial purposes. Including the regional code in the data stream of a business DVD is a simple but effective form of geographical customization. For example, a company might publish a DVD catalog of goods only available in Europe, and another catalog disc for Asia. Because owners of Asian- authorized DVD players can only view the Asian-encoded version of the disc, the company won't have to deal with Asian inquiries for products available only in Europe.

Summary

It’s been a long time coming, but DVD is finally here. With so many of the major manufacturers on board—Sony, Philips, Hitachi, IBM, JVC, Matsushita, Mitsubishi, Pioneer, Thomson (RCA), Toshiba—no other storage format has been so widely supported at launch. Industry analysts expect that by 1998 half of all computer drives will be DVD drives. For computer users, the features are compelling: huge storage capacity, convenient size, long shelf-life, and many user-definable features. DVD should become the universal storage medium for the next decade.

For more information

For information via the World Wide Web	www.pc.ibm.com www.interactive.ibm.com
For product and dealer location information	1 800 426-2968
To access the IBM PC Company Bulletin Board	1 919 517-0001
For product information sent directly to your fax machine	1 800 IBM-3395 (1 800 426-3395)
ThinkPad Catalog	Doc #1004
PC Desktop Catalog	Doc #1005
For digital video compression	1 770 835-7750

[1]MB equals one million bytes and GB equals one billion bytes when referring to hard drive capacity. Accessible capacity may vary.

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