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6 DVD Technology

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6.1 INTRODUCTION

This chapter reviews DVD, which is perhaps the most significant new communication technology since the videocassette recorder (VCR). DVD originally meant *digital video disc*, but advocates found this label too limiting and changed it to digital *versatile* disc. Some prefer restricting the name to DVD (just as we no longer refer to IBM as International Business Machines). DVD is a digital storage device that physically resembles a CD. DVD discs look like CDs and DVD players look like high end CD players. DVD-ROM devices are compatible with existing CD discs and are already well on their way to replacing CD-ROM drives on high-end personal computer systems. This technology substitution (Klopfenstein, 1989b) has begun despite the lack of DVD-ROM specific software. Many believe the CD's days are numbered, with DVD its likely, if not inevitable, successor. A DVD's visual similarity

to CDs bodes very well for its rapid adoption by users (Rogers, 1995), and because DVD players are backward compatible with CDs of varied formats, the stage is set for rapid DVD technology substitution.

As is the case with broadcasting technologies, video recording and transmission technologies are in a transitional stage from the past's analog technologies to the very near future's digital technologies. DVD is actually not the last stop in the transition to a completely digital video world. All-digital television systems are still a few years away. Cable television and telephone companies eventually may encroach into the video delivery business, but telephone companies in particular have been slow to do that (O'Shea, 1998). In the short-term, recorded video retains many advantages over digital transmission systems. Video storage technology has an established history of market success (VCR), market failure (RCA CED videodisc and Sony Betamax), and limited adoption (laserdisc) (Klopfenstein, 1989a). For a complete review of all current home video technologies, see Klopfenstein (1998).

6.2 DVD BACKGROUND

Those unfamiliar with history are doomed to repeat it. There are a number of historical parallels between DVD and its predecessors that allow for easier understanding of where DVD technologies are headed today. Home video recording dates back to the earliest days of magnetic recording technology, (see Schoenherr, 1996), while VCRs can trace their heritage to the professional Sony U-Matic, the first videotape cassette recorder (Klopfenstein, 1985). The first consumer Betamax was introduced in 1975 at a list price of $2295.

While DVD proponents today will note how DVD diffusion is much faster than that of the VCR, the DVD has been introduced at prices dramatically lower than that of the first VCRs. A continuing theme in the history of home video has been format standards battles. The most famous is the Sony Beta versus JVC VHS battle of the 1970s that was won rather handedly by VHS. Since then, there has been a camcorder battle where the tide was turned: Sony's 8mm camcorders have been displacing VHS and VHS-C camcorders. In 1998, the new digital disc format, DVD, was facing incompatible recording and limited play (Divx) versions of the standard read-only system as well as some competing standards in rewritable DVD technologies.

The growth of the VCR in the late 1980s was impressive. Indeed, it equaled and then exceeded comparable sales for color television sets in the 1960s. Many believe for good reason that DVD will diffuse more rapidly than either VCR or color television. Table 6.1 shows this intriguing growth.

In the early 1980s, the VCR was an expensive item that seemed destined for elite households (Klopfenstein, 1989b). A less expensive alternative that could exceed the video quality (but could not record) was the videodisc player (VDP). One VDP was developed by RCA, which needed a new product to follow the success of color TV in the market (Graham, 1986). Another was developed by MCA (in partnership with Philips) as an outlet for its movie inventory. Their Laservision videodisc could hold up to 54,000 separate video images, or up to one hour of

TABLE 6.1
VCR Versus Color Television Set Sales

Total VCR Sales		Color TV Sales	
1975	30,000	1959	90,000
1976	55,000	1960	120,000
1977	160,000	1961	147,000
1978	402,000	1962	438,000
1979	475,000	1963	747,000
1980	805,000	1964	1,404,000
1981	1,361,000	1965	2,694,000
1982	2,035,000	1966	5,012,000
1983	4,091,000	1967	5,563,000
1984	7,616,000	1968	6,215,000
1985	11,853,000	1969	6,191,000
1986	12,500,000	1970	5,320,000

Source: Klopfenstein (1998)

Note: VCR was introduced in 1975. Color TV was introduced in 1954.

moving pictures, on a side. When Philips' Magnavox $695 *Magnavision* was marketed in late 1978, only two hundred disc titles were available, mostly old movies. As it turned out, the limited number of titles available early in the history of the laserdisc was critical to its lack of adoption (Klopfenstein, 1985). There are direct parallels between the situation of videodisc players and today's DVD; literally hundreds of times more titles are available on VHS cassettes than on DVD.

Never having reached mass market status, the laserdisc now clearly appears to be well on its way to the same fate as LP audio records. RCA's heavily promoted, non-optical Selectavision VDP lost the company $580 million in its three years on the market in the early 1980s (Klopfenstein, 1985). Today's Divx version of DVD is backed by a $200 million promotional program as well as partnerships with many consumer electronics manufacturers. Students of consumer electronics history will see that such strong promotion does not guarantee market success.

Many lament the lack of standards in video recording and storage technologies because of the belief that lack of standards slows market adoption. Indeed, lack of a technical standard prevented the adoption and diffusion of AM stereo (Klopfenstein and Sedman, 1990). On the other hand, the standards battle between Beta and VHS led both sides to technological innovations, such as longer recording times, high fidelity sound, and lower prices, that probably accelerated VCR adoptions (Klopfenstein, 1985). The same drive to innovation is evidenced in the battle between the quasi-compatible Netscape and Microsoft WWW browsers. The introduction of Divx by a segment of the consumer electronics industry may have contributed and detracted from DVD, diffusion as will be discussed later.

Another issue associated with video recording technologies is copyright (see the pro-electronics manufacturers' "Home Recording Rights Coalition" web site for a history of events in recording rights: http://www.hrrc.org). The relevance of this concern is dramatized by the plight of the digital audio tape (DAT) format. Challenges by recorded music copyright holders slowed the diffusion of this audio technology and may have effectively killed it as a consumer audio format (Cohen, 1991). The Motion Picture Association of America (MPAA) and the Consumer Electronics Manufacturers Association (CEMA) have worked together in an attempt to avoid this happening again with new digital video recorders (Pietrucha, 1996). Look to these organizations to see their latest stances on recording and antipiracy technologies, topics of direct relevance to DVD.

6.2.1 Recent Home Video Developments

DVD is expected to eventually challenge the VCR as the movie playback device of choice in many homes. Rather than fight the new DVD technology, video stores are likely to embrace it. The stores can rent and sell DVD discs just as they do now with VHS tapes. Several chains are experimenting with renting both discs and DVD players. This move is significant because it addresses one of the variables trialability research has shown to be directly correlated with adoption of new technology (Rogers, 1995). Trialability involves removing barriers from potential adopters so they may experience a new technology without fully committing to it. This disc-with-player rental does precisely that.

Early studies showed that the primary use of VCRs was to record broadcast programs for later viewing, a practice known as *time shifting*. However, the VCR really made its presence felt in the U.S. film industry. Video rentals in 1995 reached about $8 billion with cassette sales climbing over $7 billion ("Rental stores," 1995). Home video revenues appear to have reached a high plateau (King, 1996), and the enormous number of tapes now available would seem to assure the VCR some life despite the encroachment of the DVD.

Ironically, the home video industry is in position to embrace the new DVD format. The home video market did not grow much in 1997. A widely documented downturn in the rental business sent video retail stocks plummeting and played a role in retailers' aggressive lobbying for longer windows of video exclusivity before titles are released to pay-per-view (retailers want 60 days rather than the current average of 38 days). Despite differing views among researchers, a wide cross section of Hollywood studio executives and retailers believe that consumer video rental activity declined significantly in 1997 (Klopfenstein, 1998). The most often cited explanation for the decline was a shortage of box-office blockbusters. Prominent Wall Street investment analyst Tom Wolzien believes as many as 5 million rentals a month evaporated from the market because more households are watching movies on cable pay-per-view and digital satellite systems. Hollywood studios and video retailers reacted by working together to offer consumers more in-store copies of new releases ("A year long battle," 1998).

Two other studies confirm significant sales declines for 1997 as well as the first quarter of 1998. Alexander & Associates' Video Flash, a weekly phone survey of

1000 consumers, reports consumer video spending at $9.3 billion in 1997, down about 10% from $10.38 billion in 1996. It estimates that for the first 12 weeks of 1998, consumers spent $2.2 billion buying videos, down 3.1% from 1997. Similarly, VideoScan, which tracks point-of-sale data from 16,000 nationwide retail stores that account for about 70% of all video sales, says purchases for the first quarter of 1998 were down 5% from 1997. Annual sales for 1997 fell by a similar percentage from 1996 figures (Arnold, 1998). According to VideoScan, the top seller in 1997 was *Bambi* with *Ransom* taking the top spot in 1997 rentals ("A Year Long Battle," 1998).

According to a number of sources, video stores supply approximately 54% of movie studios' revenues by paying more than $60 per video. The store sees a profit after renting the tape 25 times which usually happens because demand remains high for up to six weeks after a hit is released. About 8% of store revenue comes from fees charged for late tapes. In 1995, Media Group Research estimated total video revenue would grow about 8% a year the next few years with rentals rising about 3% a year and cassette sales leaping 15% a year ("Rental stores," 1995). That prediction looked foolish in 1997.

While viewing movies at home has become a way of life, the movie theater still has some advantages over home tape viewing: 1) going to the movies is a social occasion, 2) movies appear in theaters before they appear on cassette, and 3) theaters offer the large, wide screen. As noted at the conclusion of this chapter, home theater technology threatens to erode the nonsocial reasons for going to the movie theater.

6.2.2 Digital VCRs

A digital VCR standards group representing about 50 companies announced it had agreed on technical specifications for recording transmission signals from the U.S. high-definition TV (HDTV) system. The U. S. HDTV system will operate at 19.4 megabits/s. JVC jumped ahead of digital VCR competitors by rolling out its own digital VHS (D-VHS) format in 1994. D-VHS players will initially work with Thomson Consumer Electronics' Digital Satellite System (DSS) set-top boxes, which are deployed as part of Hughes' DirecTV digital broadcasting satellite (DBS) system. VCR manufacturers believe the VCR is on track to survive its 25th anniversary and life beyond millennium, if only due to the lack of consensus on a rewritable DVD format as a replacement for analog tape. The prospects for advanced digital VCR formats such as D-VHS or W-VHS are negligible in 1998, but they may be introduced along with a new M-DVD magnetoresistive format ("VCRs proliferate," 1998). JVC demonstrated a prototype D-VHS deck operating in HD (high definition) mode needed for terrestrial DTV (digital television) in January 1998. Digital VHS recorders were available for under $500 by spring 1999 (Hara, 1999). At the same exhibition, Hitachi touted the merits of its current D-VHS model, codeveloped with Thomson, for recording HD-DSS signal ("Novel VCRs," 1998).

Smart VCRs were available by 1999 (Hall, 1999). These VCRs will automate many aspects of installation including setting the clock, locating the available channels, and will even accept voice commands (an interface likely to begin showing up almost as an afterthought on many home appliances in the next few years). Not only are there VCRs that skip commercials in recording and/or playing back, Thomson

markets one that also fast forwards over the prerecorded promotional material at the beginning of most feature films on cassette (Cole, 1998). Sanyo's VCR has a feature called Speed Watch that allows users to watch a tape at twice the normal tape speed while the audio remains at normal levels. It seems likely that only the huge installed base of videotapes will assure some future for the VHS VCR, but its fate is tied to the success of recordable disc technology ("VCR near end," 1998).

6.2.3 Personal Computing and DVD

Continued advances in processing speed and personal mass storage bode well for computer applications in media including video. At the start of 1998, about 45% of U.S. households had computers ("PCs in Over 45 Percent," 1998; Lanctot, 1998), and various manufacturers offer combination TV/PCs intended for the home's current television viewing room. In terms of new technology, the trend of the Internet and WWW is clearly toward multimedia applications (audio, video, and animation). The day is rapidly approaching when we may be able to access hundreds then thousands of video titles through video servers made available from Hollywood studios, telephone companies, and cable television companies (Klopfenstein, 1997; 1998).

CD-ROM drives have become standard equipment on personal computers, but the substitution of DVD-ROM drives for CD-ROM drives is well under way. The sales push is coming from high-end personal computer manufacturers offering DVD-ROM drives for a small price increase over CD-ROMs. While CD-ROM drives cost PC manufacturers $25-$35, DVD-ROM drives cost about $100. This cost is more of a problem at the low-end computers. Software titles available only on DVD-ROM are appearing slowly, but DVD movies are being produced more rapidly. Unfortunately, incompatibility among DVD drives from different manufacturers is inhibiting the growth of DVD-ROM. A title might work on one drive, but not another. PC OEMs and drive manufacturers must resolve compatibility issues before consumers rush to embrace the products. Moreover, computer and video game manufacturers are taking a wait-and-see attitude ("DVD-ROM Watershed," 1998).

Despite a lack of DVD-ROM disc titles, sales for DVD-ROM devices in 1997 and 1998 were surprisingly strong. According to industry observers, worldwide market demand for DVD-ROM was expected to quadruple in 1999 to more than 20 million units, and increase to over 40 million in the year 2000 (Digital Video Systems, 1998). CEMA reported that 34, 000 DVD players were sold in January 1998, and more than double that (81,000 units) were sold in August. Pre-Christmas sales of DVD players for 1998 were about 500,000 units, according to CEMA (Koenig, 1998). Various research reports predicted that by 1999 DVD-ROM drives would outsell CD-ROM drives in the U.S. (Kovar, 1998b).

6.2.4 DVD

In 1995, consumer electronics manufacturers, including old VCR rivals Sony and Matsushita, bombarded the media with descriptions of their next-generation recording medium, DVD. They touted DVD and DVD players as digital replacements for VCRs and VHS tapes, laser discs, video game cartridges, and compact

discs (CDs) — both audio CDs and computer CD-ROMs — are to be subsumed as well. As vendors did with videocassette tapes, DVD vendors proposed different standards: Sony's Multimedia Compact Disc (MMCD) versus Matsushita's DVD, called Super Density DVD (SD-DVD) (D'Amico, 1995). A format war was avoided when the industry players agreed to support a format that combined a Toshiba design with a Sony/Philips (the original CD partners) encoding scheme (Braham, 1996).

The DVD is a variation on the now-ubiquitous CD. DVD, introduced in March 1997, can store complete feature films, music, video games, and multimedia computer applications. This new disc is identical in shape and size to CDs and CD-ROMs, but it has a much more storage capacity. The 1998 DVD discs hold 133 minutes or 4.7 gigabytes of video per side; double-layered DVDs capable of holding 241 minutes or 8.5GB of video became available soon thereafter. These higher-capacity discs are most likely to be used in computers. For example, if stereo music is the stored information, a single DVD can hold the contents of more than a dozen CDs. The movie studios consider the DVD disc a major opportunity because it will allow them to resell many of their existing inventory of films, just as music companies have done with the audio CD.

DVD specifications compared with the standard CD, are shown in Table 6.2

TABLE 6.2
DVD and CD Specifications

	CD	DVD
Disc Diameter	120 mm	120 mm
Disc Thickness	1.2 mm	1.2 mm
Disc Structure	Single Substrate	Two bonded 0.6 mm substrates
Laser Wavelength	780 nm	650 and 635 nm
Numerical Aperture	0.45	0.60
Track Pitch	1.6 um	0.74 um
Shortest pit/land length	0.83 um	0.4 um
Reference Speed	1.2 m/sec, CLV	4.0 m/sec, CLV
Data Layers	1	1 or 2
Data Capacity	680 megabytes	Single layer: 4.7 gigabytes Double layer: 8.5 gigabytes

Source: Sony (n.d., 1996).

Basic DVDs have one or two layers per side and are one- or two-sided. Each variation is given a code matching the rough capacity: DVD-5, 4.7GB (1 side, 1 layer); DVD-9, 8.5GB (1 side, 2 layers); DVD-10, 9.4GB (2 sides, 1 layer); and DVD-18, 17GB (2 sides, 2 layers). The first iteration of a write-once disc is called DVD-R, with 3.9GB per side (one layer only), and the first iteration of read-write DVD is called DVD-RAM, with 2.6GB per side, one layer only (Dvorak, 1998).

6.3 DVD FORMATS

Various DVD formats are defined by function rather than storage capacity as shown in Table 6.3 (based on "State of the DVD Union" (1998) and other sources.).

6.3.1 DVD-VIDEO

The DVD Forum's DVD-Video standard, the basis for today's DVD movie discs, is being challenged by the controversial new Divx format, supported by retailer Circuit City and several leading movie studios. Promoted as a new way to rent movies, and as a possible future mechanism for music and software distribution, Divx DVDs will cost about $5 and allow unlimited playback for 48 hours. Viewers would then discard the disc or use a modem-equipped Divx player to buy more time. Today's DVD-ROM drives and set-top players won't play Divx media.

6.3.2 DVD-ROM

Second-generation DVD-ROM drives have little trouble reading the various CD formats, as well as DVD-Video discs and interactive DVD-ROM titles created exclusively for playback on a PC. Format compatibility, however, has been an issue.

6.3.3 DVD-RECORDABLE (DVD-R)

The DVD Forum's first DVD-R specification defines a write-once format storing 3.95GB of data per side, but two rival proposals define 4.7GB capacities. Recently accepted for consideration by the DVD Forum's Working Group 6, DVD-RW is the rewritable version of DVD-R, the "other" rewritable format endorsed by the DVD Forum. The next generation of 4.7GB DVD-R drives was expected to reach the market in 1999 at a price between $3000 and $5000 with the 4.7GB DVD-RW coming along as well. Philips, Sony, and Hewlett-Packard have all revealed plans to deliver drives by mid-1999. The expectation was that the drives and media will be compatible with DVD-RAM. (Parker 1999). Original DVD-R drives cost well over $10,000, making them of interest only to DVD content creators.

6.3.4 DVD-RAM

Rewritable DVD suffers from a format war between the DVD Forum's announced 2.6GB-per-side DVD-RAM spec and at least three competing proposed formats, including a 3GB-per-side version, DVD+RW, backed by Sony and Philips. With no clear resolution, the forum was working to upgrade to its existing spec. Initial DVD-ROM drives probably will not be able to read at least a few of the proposed formats. A number of DVD-RAM units are shipping, but shifting standards might give these early models short lifespans.

6.3.5 DVD-AUDIO

The DVD Forum recently announced a draft DVD-Audio specification defining discs that can hold up to 30 hours of six-channel sound. A final draft is expected later

this year, but it could be derailed by a competing Sony/Philips proposal called Direct Stream Digital. Today's DVD-ROM equipment might lack the copy-protection circuitry needed to play DVD-audio discs, but the demand for DVD-audio may be limited by marketing rather than technological concerns. Marketers commonly sell 2-disc sets of CD-audio when one CD is capable of holding all the audio. It's not clear where the demand for 30 hours of audio will come from.

TABLE 6.3
DVD Versions as of 1998

Type	Sides or layers used	Capacity
DVD-ROM	Read-only 1 side, 1 layer	4.7GB
DVD-ROM	Read-only 1 side, 2 layers	8.5GB
DVD-ROM	Read-only 2 sides, 1 layer	9.4GB
DVD-ROM	Read-only 2 sides, 2 layers	17.0GB
DVD-R	Write-once 1 side	3.9GB
DVD-R	Write-once 2 sides	7.8GB
DVD-RAM	Rewritable 1 side	2.6GB
DVD-RAM	Rewritable 2 sides	5.2GB
DVD+RW	Rewritable 1 side	3.0GB
DVD+RW	Rewritable 2 sides	6.0GB
DVD-R/W	Rewritable 1 side	4.0GB
MMVF	Rewritable 1 side	5.2GB
MMVF	Rewritable 2 sides	10.4GB

Source: DVD (1998).

Sonic Solutions announced in 1998 that its technology was being used to produce the first individual DVD disc that combines DVD video, DVD audio, and DVD-ROM. Fans of Travis Tritt, a country music singer, will be able to use the same disc to view a concert from multiple camera angles on their home DVD-video system, interact with him on their home computer's DVD-ROM drive, or listen to the full, uncompressed high-density audio program in surround-sound on their DVD-audio player. The company's unique DVD-video and new DVD-audio production technology make it possible for single, hybrid discs containing both formats, plus computer data, to be formatted on the same DVD disc (Sonic DVD Technology, 1998). This product may be a gimmick, but it does show the multimedia possibilities for DVD.

6.4 FORECASTING DVD ADOPTION

As of August 1998, an estimated 800,000 DVD home video players had been sold (Patrizio, 1998). DVD-ROM drives are expected to outship CD-ROM drives by 2001 (Kovar, 1998b). DVD player sales through the first quarter of 1999 were 300% higher than in the same period in 1998 (DVD Player, 1999). (Online: http://www.twice.com/html/statistics.html. [May 6, 1999]. The total installed base

of DVD players was at about the one million unit mark at the beginning of 1999 (Scally, 1999).

InfoTech predicted that worldwide DVD-ROM title revenues would increase from $3.5 million in 1997 to $567 million in 1998, largely because of 7 million PCs equipped with DVD-ROM by year-end. DVD-ROM is expected to become a mainstream PC component. By 2003, worldwide DVD-ROM title revenue across both PC desktop and TV set-top platforms is forecast to exceed $70 billion, as DVD-ROM replaces CD-ROM as the principal format for packaged interactive media, including applications software, business information, games, education and computer-based training.

A key to the early success of DVD will be the perceived difference in the sharpness of the user's television picture. The CD was clearly an improvement over easily scratched LP records. DVD carries images with smaller and more varied pixels (720 pixels per horizontal line versus the standard 240) than a CD, which means greater clarity and detail than today's best VCRs can produce. If viewers can easily see the difference, it will bode well for DVD (Vizard, 1997). Given the steady increase in television picture resolution, these differences will become more visible. An easily overlooked problem, however, could be the durability of DVD discs and how well they can stand up to the rigors of video and DVD-ROM rentals. On the other hand, DVD discs may allow longer archiving than is possible with videotape.

The following summary of DVD's key advantages is based on Johnson (1995) but remains valid as of this writing:

- better video and audio quality
- backwardly compatible with existing CDs
- movie discs more convenient and durable, and potentially less expensive than cassettes
- able to cut directly to particular scenes, with no need to rewind
- more storage capacity (the same is true for DVD audio)
- negligible cost differential between a DVD player and high-end VCR

DVD offers other advantages including new flexibility in home video use. During playback of movies, DVD discs can provide a choice of viewing options. For example, there's standard 4:3 pan-and-scan viewing, the way most movies are displayed from broadcast and tape sources. By pressing a button on the player's remote control, users can switch to letterboxed viewing or high resolution pictures on advanced widescreen (16:9) sets. DVD movie discs also have the capability to present soundtracks in eight different languages and up to 32 distinct subtitles. A feature announced by Toshiba is a built-in parental control system that allows selection of the rating level to be viewed: PG, PG-13, R or NC-17; the player automatically shows a version of the movie edited to that rating level by the producers of the film.

DVD liabilities include the following:

- limited software available, and it will take years to approach the number of titles available on VHS
- disc players do not record; this fact combined with the previous makes software availability a limiting factor in the adoption of DVD players as was the case with the laserdisc around 1980
- durability: CDs and CD-ROMs are only marginally durable enough to withstand the abuses of public library and commercial rentals
- current CD-ROM drives will not play DVD discs
- DVD systems will eventually be challenged by delivery of movies-on-demand over cable or phone lines

The potential of DVD includes a broad range of multimedia and computer applications. Because DVD consists of a suite of disc types, each with increasingly higher storage capacities, the format holds tremendous growth potential for data-intensive home and business applications. DVD players also come in a variety of models. The first in the DVD family of drives were read-only, a one-time recordable DVD-R, and a rewritable DVD-RAM. Philips correctly believed the computer DVD-ROM would be more important to early sales than the consumer video DVD player (Oosterveld, 1996), a position supported by evidence form the marketplace to date.

Introduced in 1997 at prices around $1500, by mid-1998 DVD player prices were under $400. Both the rate of decline and the price in real dollars are dramatic in historical terms. DVD is simply far less expensive than were its VCR, laserdisc, and CD predecessors. This relative coast strongly suggests the potential for accelerated diffusion patterns. Retail discount chains began selling DVD players in 1998 (Scally, 1998) with all Wal-Mart stores expected to have them by the end of that year (Koenig, 1998). This is a very significant development because it would seem to already portend the DVD's movment from videophile status to that of a mass market product.

In 1998, all major Hollywood film studios announced support for the DVD format. Initially, some (especially Dreamworks SKG) were reticent to support this digital version of their product. One problem that remained was the deliberate pace at which most studios were releasing titles as well as a tendency to release older films rather than new releases on DVD.

Somerfield (1996) predicted a number of obstacles for DVD to overcome. The short-term success or failure of the DVD rests on the availability of movie discs, until the time comes when inexpensive recordable discs are available. The movie studios that control the production and sale of movies on video have their own agendas. First, movies released on video in this country may not yet have been distributed to theaters on other continents. The studios are concerned that a DVD released in the U.S. could be sold abroad and hurt foreign theatrical sales. To prevent this, the studios want the discs encoded to prevent playback in certain regions of the world. This regional coding system has become the norm.

The studios also want copyright legislation in place similar to the Audio Home Recording Act that delayed the launch of the DAT format several years ago. That legislation took 18 months, from proposal to passage, to get through Congress. No new DVD legislation has apparently been introduced. To compound the issue, the MPEG-2 encoding that must be implemented to compress the movies to DVD is quite

complex and can be done by only three facilities: Warner, Sony, and MCA. The number of titles that can be made ready for disc in the few months before late 1996 fall launch was quite limited. Paucity of discs was one major factor in the quick demise of RCA's videodisc player in the early 1980s (Klopfenstein, 1985; 1989).

6.5 DIGITAL TRANSMISSION CONTENT PROTECTION (DTCP)

According to DVD Frequently Asked Questions (Taylor, 1998), in order to provide for digital connections between DVD components without allowing perfect digital copies, a digital copy protection system has been developed. The 5CP draft proposal (for "five-company proposal") was made by Intel, Sony, Hitachi, Matsushita, and Toshiba in February 1998. Content is marked with standard CGMS flags of *copy never* or *copy once*. Devices that are digitally connected, such as a DVD player and a digital TV, will exchange keys and authentication certificates to establish a channel. The DVD player will encrypt the encoded video signal as it sends it to the receiving device, which must decrypt it.

Digital display devices will be able to receive and display all data. Digital recording devices will be able to receive only data that is not marked *copy never*, and they must change the CGMS flags to zero copies if the source is marked for one copy. Digital CPS is designed for the next generation of digital TVs and digital video recorders. It will require new DVD players with digital connectors (such as those provided on DV cameras and decks). These new products probably won't appear before the middle of 1999. Since the encryption is done by the player, no changes are needed to the existing disc format. Movie studios and consumer electronics companies want to make it illegal to defeat DVD copy protection, and are pursuing legislation in the U.S. and other countries.

CSS is allowed for DVD-video content only. Because a DVD-ROM can hold any form of computer data, any desired encryption scheme can be implemented.

Watermarking, which will be added to DVD at some point, permanently marks each digital video frame with noise that is supposedly visually undetectable. Watermark signatures can be recognized by video playback and recording equipment to prevent copying. New players and other equipment will be required to support watermarking. It is possible to make new watermarked discs compatible with existing players, but movie studios will probably not allow it. There are reports that the watermarking technique used by Divx causes visible raindrop or gunshot patterns (Taylor, 1998).

6.6 RECENT DEVELOPMENTS IN DVD-ROM

Two factors will pull DVD in different directions. First, if Disney and other studios continue to limit their releases on DVD, its value as a home video technology will be greatly diminished. On the other hand, as computer manufacturers begin to substitute DVD-ROM drives for CD-ROM drives, the cost of DVD player manufacturing will go down. It is not unreasonable to believe that in the next 5 years, although

VCRs will remain the home video technology of choice, a significant number of homes will add a DVD player to their home entertainment system.

DVD movie players and titles have been available in the U.S. since March 1997, and PCs equipped with DVD-ROM drives began shipping during the third quarter. The DVD-ROM market will enhance economies-of-scale in manufacturing and should lead to lower DVD player prices. The initial signs for the DVD player in 1997 were mixed. While DVD player sales in its first year compared very well to those for CD players, the meaningfulness of that comparison is limited severely by the lack of affordability of CD players in that technology's first year.

A survey from the Yankee Group research firm found consumer awareness of the new format (the first stage of adoption) surprisingly low despite significant publicity surrounding the launch of DVD hardware and software. Only 28% of the more than 1900 U.S. households surveyed by the Yankee Group were familiar with DVD. Among consumers who had heard about DVD, only 13% said they were very or somewhat likely to purchase a DVD player within the next 12 months.

TABLE 6.4
Consumer Awareness and Purchase Intentions for DVD

	% of Total Households	% of Total Households Aware of DVD
Have you ever heard of DVD?	28.3	
How likely are you to buy a DVD player?		
Very likely	0.5	1.8
Somewhat likely	3.1	11.1
Total	3.6	12.9

Source: Yankee Group Study (1997).

Perhaps more interesting from this survey of potential adopters is that approximately equal numbers of respondents indicated an interest in purchasing a DVD video or a DVD-ROM device ("Study indicates," 1998). One might easily argue that 50% awareness of the DVD product within a year of its launch is not all that low.

According to *GameWeek* (McGowan, 1998), DVD finished 1997 with an estimated U.S. household population estimated to be somewhere between 100,000 and 200,000. There were 350,000 DVD players shipped (not consumer purchases) to retailers in 1997, according to the Consumer Electronics Manufacturers Association. In terms of software, there were 1.5-2 million DVDs sold in the U.S. in 1997 at stores tracked by VideoScan. Warner Home Video claimed that Warner alone shipped more than 3 million DVDs (worth $50.6 million at wholesale) to retailers in 1997 including 92,000 copies of *Batman and Robin*. More than 500 DVD-Video releases were available at the end of last year and

the DVD Video Group predicted that total would rise to 1500 at the close of 1998. The DVD system price point to reach mass consumer market acceptance is said to be $299 (Bismuth, 1998).

Cable and DBS are becoming far more serious competitors to home video than ever before. Much to the chagrin of the Video Software Dealers Association (VSDA), Hollywood has been allowing shorter windows between the time a movie comes out on video and the time it's available on pay television. Hollywood stands to benefit if the CD audio library rebuilding phenomenon is repeated in DVD. Just as CD adopters bought new copies of music they already owned in 33 1/3 rpm record albums, so might VHS tape owners choose to buy better quality DVD copies of movies they already have on tape.

6.7 FACTORS TO WATCH

Although sales of DVD players in 1998 will pale compared to those for VCRs, we are likely to see the beginning of a product substitution of DVD for VCRs. The random access capability of a disc cannot be matched by a tape cassette, and most home video movie buffs will not miss having to rewind a tape. If the CD market is any indication, software manufacturers will keep DVD prices higher than those for prerecorded videocassettes. This may well be based on psychological rather than economic considerations.

On the other hand, observers should not be fooled by inappropriate comparisons between 1997-1998 sales of DVD players and those of VCRs in the mid-70s or CD players in the early 80s ("DVD Posts Impressive Gains," 1998). The DVD player costs in real terms significantly less than 10% of what VCRs and CD players cost in their first year of introduction, so the perceived risk in adoption is dramatically less than what it was for its two predecessors. After videophiles purchase their player, the next set of adopters will look at how many disc titles are available. With only a few hundred select titles available at any one store in 1998 and many blockbuster movies still available only on VHS, growth of the DVD player will remain restrained.

As noted earlier in this chapter, Divx technology was created to allow limited viewing of digital movies on disc. This was attractive to studios who feared the notion of selling their movies in a format that allows for ready duplication. This author expected the marketplace to reject Divx. Indeed, web sites were produced that decried the introduction of Divx. Divx probably served one of two purposes: 1) it may have confused the marketplace, or 2) it may have simply increased overall awareness of the DVD format.

In spring 1998, Circuit City delayed the rollout of Divx until September 1998. Divx players were priced about $100 more than DVD players for what many certainly would view as a less functional system (e.g., a Divx disc cannot be played on a regular DVD player). The company expected to lose money on the format for two years (the consumer electronics retailing business operates on very thin profit margins, so this sounds very risky). History has shown that announcements of participation by other market players (Hollywood studios, in this case) do not portend market success (Klopfenstein, 1985), and Divx's prospects were further limited because Circuit City did not find other retail competitors to carry its product. Finally, in June 1999, Circuit City announced that Divx would be discontinued.

DVD players will continue to add features, perfect the technology, and lower the player price. Recordable DVD machines are in development although exact predictions of market introduction are all but impossible. A good rule of thumb is to ignore bold predictions about recordable DVD introduction dates and instead watch for the date when they are actually available. Creative Labs introduced the only DVD-RAM available in fall 1998 for a list price of $499.

In addition, there may be technical obstacles to reliable DVD recording if recordable CDs are any indication. One study found that only 41% of the CD-R discs evaluated from 13 major manufacturers passed a quality test, while almost 32% were marginal and 27% failed (Williams, 1998). Until one standard DVD recording technology is established, DVD recorders will not be an important factor. Indeed, if incompatible standards are sought, the life of the VHS VCR will be extended. The day is coming, however, when we will be transferring our home movies from analog tape to digital disc. DVD-RAM camcorders were available by late 1998.

The future of DVD was complicated by the discovery that certain DVD drives in computers could not read certain CD-recordable discs. More recently, the market has been confused by the approach of digital HDTV. DVD will not support the digital HDTV format, which has minimally five times the resolution of DVD. Promoters of DVD say HDTV will not make DVD obsolete, but one could argue that DVD will survive during the transition to HDTV and eventually die a slow death (Dvorak, 1998). Perhaps a more likely scenario is that future DVD technology will be adapted to meet the needs of HDTV.

6.8 DVD-RAM

DVD-RAM is the latest generation of high-capacity rewritable 5.2GB double-sided DVD-RAM discs that provide much greater storage capacity than existing CD-R systems. One of the advantages that DVD-RAM offered when introduced was its functionality as a 2X DVD-ROM drive capable of reading DVD-Video, DVD-ROM, DVD-R, CD-ROM, CD-R/RW, Video CD, and CD Audio. DVD-RAM also provides PD read/write and playback capability. Future developments of this type of storage technology will include the ability to read a removable 2.6GB DVD-RAM disc using DVD-ROM, thereby making DVD-RAM an even more flexible storage solution (Kwong, 1998).

Four camps were promoting different rewritable DVD standards in late 1997: DVD-RAM, which is championed by Matsushita's Panasonic and approved by the industry's DVD Forum; DVD+RW, which is endorsed by Sony and Philips; the DVD-R/W format proposed by Pioneer; and the DVD MultiMedia Video File Format (MMVFF) proposed by NEC. A major concern of three of the four competing camps was maintaining compatibility with some existing specific CD or DVD format, at least in the first generation of rewritable DVD systems. The DVD-RAM format by Panasonic will play CD-PD and most other CD format discs. Sony and Philips said they see DVD+RW as a natural extension of the CD-RW format, and in Pioneer's DVD-RW system, compatibility with DVD-R is considered critical to its niche of potential customers. The first DVD+RW drives were scheduled for sample shipments in mid-

1998, with retail shipments planned for the third quarter; the specifications call for a 3GB per side disc that does not require a caddy. It will play most CD formats, including DVD-Movie, DVD-ROM, DVD-R, CD-ROM, CD-R, CD-RW, and CD Audio.

One of the first DVD-RAM drives was available in fall 1998. The Creative Labs' drive, manufactured by Matsushita, reads DVD-ROM and DVD movie discs, reads all CD formats, and records over 5 GB of information on a $30 cartridge. The drive works exactly like a hard disc. Windows users could use the Universal Disc Format (UDF) to format the entire 2.6GB per side of the double-sided media as a single partition. According to *PC Magazine*, the drive was fast by optical disc standards when reading discs, but had fairly slow access times, about one-third the observed sustained read rate. To use DVD movie discs, an extra card is needed (Poor, 1998).

The DVD-RAM format that is supported by Panasonic, Hitachi, and Toshiba and also has the backing of eight of the 10 original DVD Forum members, features single and dual-sided discs which require a caddy and 2.6GB per side. The format's strength is said to be its random access characteristics and backward compatibility with discs using most of today's CD and DVD formats. Panasonic, Toshiba, and Hitachi planned to deliver drives in 1998 at a street price of about $799. Blank DVD-RAM media is sold in single-sided ($24.95) and dual-sided ($39.95) configurations. Both will require a caddy, although caddies for the single-sided discs are removable, allowing the bare disc to be played in future versions of DVD-ROM and DVD Video players. DVD-RAM promoters see their format as a data storage device first, but Panasonic has also made it clear that the specifications will serve as a platform for audio and video recording systems coming in the next five years, when greater storage capacities can be realized from new technologies such as blue laser, and when MPEG-2 encoded chips are more economically manufactured (Tarr, 1997).

Pioneer released DVD-R drives in October 1997 for $17,000; this price could drop within a few years to less than $5000. The initial price for blank DVD-Rs is $50. DVD-RAM drives will be introduced for less than $1000, with blank discs at about $30 for single-sided and $45 for double-sided. Disc prices for both DVD-R and DVD-RAM will drop quickly, but DVD-R discs will probably be cheaper in the long run. Toshiba, Pioneer, and Hitachi expected DVD-RAM to be available in 1998 (see "DVD FAQ," 1998).

While DVD-R may compete eventually with speedy and convenient removable magnetic discs like Iomega's Jaz drive, benefits must be weighed against the comparatively low cost of CD-R media and the huge installed base of CD-ROM drives. Optical formats such as CD-R and CD-RW are readable in the great installed base of CD-ROM drives worldwide. Indicating a widespread demand for a standard rewritable data-exchange format, CD-RW drives were outselling CD-R by two to three times in 1998. DVD-RAM already may be a viable alternative to CD-RW. Based on Matsushita's phase-change technology, first used in the 650 MB Panasonic Phase Change Dual (PD) rewritable drive, a device that debuted in 1995 and could read and write PD media as well as read CD-ROM, DVD-RAM is a two-sided, 5.2 GB disc. DVD-RAM drives can read DVD-RAMs, DVD-ROMs, DVD-Videos, DVD-Rs and PDs. They also can write to DVD-RAM and PD media. But DVD-RAMs can not be read in current, second-generation DVD-ROM drives.

Manufacturers developing these DVD-ROM drives say that they are fixing the problem (Gustavson, 1998).

Like DVD-ROM, DVD-RAM is based on the Universal Disc Format (UDF) and supports the MultiRead specification, which makes it backward-compatible with CD, CD-ROM, CD-R and CD-RW. Just as CD-RW drives now outsell CD-R drives, it is likely that DVD-RAM could become a preferred SCSI replacement for generic IDE DVD-ROM drives in high-end PCs. Creative Labs' $500 PC-DVD-RAM drive had a write speed nine times faster than that of CD-R (Gustavson, 1998).

6.9 DVD-AUDIO

Finally, another standards battle to watch is that which is going on with DVD audio. This format would seem to elicit less interest than DVD video because music copyright holders have little to gain with DVD. Copy protection is a key concern, and few audio applications require the hours of recording capacity that DVD audio will allow.

6.10 SUMMARY AND CONCLUSIONS

The outlook for DVD technology in the next 5 years appears to be very bright if not guaranteed. The diffusion of innovations is one way to understand how new communication technologies spread through or are rejected by the marketplace. The five attributes of innovations are relative advantage, compatibility, trialability, complexity, and observability (Rogers, 1995). The only way to know how an innovation rates on each of these attributes is to conduct research about the innovation among potential adopters. Speculation about DVD is possible based upon these attributes.

Relative Advantage (Is it better than previous ideas?)

DVD has clear advantages over CD. It has dramatically superior storage capabilities, faster read/write times, and the ability to display feature films in various formats on one disc. However, until titles become available, CD-ROM and VHS tapes will continue a substantial relative advantage to users.

Compatibility (Does it fit with how adopters use the technology?)

Once again, because there already is so much familiarity with CD technology, DVD would seem to score highly on the compatibility variable.

Complexity (Can I understand it?)

To the extent that an innovation is perceived to be complex, the less likely it is to be adopted. DVD may come down on both sides of this attribute. Once again, the widespread existence of CD technology should make DVD seem less complex. On the other hand, the availability of various DVD formats adds to complexity. Squabbles over standards within the DVD variations (DVD-audio, DVD-RAM, etc.) will increase.

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