

Evaluating DRM: Building a Marketplace for the Convergent World

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As digital rights management technologies are increasingly integrated into media products, devices, and platforms, it is important for the public to understand the tradeoffs and choices associated with different DRM systems. With sufficient information, competition between different DRM offerings can help promote a marketplace for digital media products that is diverse and responsive to reasonable consumer expectations. This paper seeks to contribute to the public discussion and understanding of DRM in the media marketplace by systematically reviewing the types of factors that product reviewers, consumer advocates, and members of the public may want to consider when evaluating products incorporating DRM.

Introduction

The explosive growth of the Internet and digital media has created both tremendous opportunities and new threats for content creators. Advances in digital technology offer new ways of marketing, disseminating, interacting with, and monetizing creative works, giving rise to expanding new markets that did not exist just a few years ago. These technologies also promise to democratize the production of creative content by putting the creation and wide distribution of creative works within the reach of private individuals. At the same time, however, the technologies have created major challenges for copyright holders seeking to exercise control over the distribution of their works and protect against piracy.

Digital rights management (DRM) represents a response to these issues.¹ DRM is designed to help content creators protect their content from widespread

¹ We use the term DRM very broadly throughout this paper to mean all measures used to protect content in digital media devices and services. We include in this category limitations that content owners impose on device manufacturers through licensing agreements, such as requirements that devices exclude certain outputs or protocols. This broad focus reflects what is ultimately important to consumers. The technical means by which content protections are enforced—whether by flagging, by encryption, by eliminating physical ports, or by other means—and the legal basis on which the

uncontrolled distribution. Its proponents maintain that DRM can facilitate the secure distribution of digital content in new markets and help fuel new business models that exploit the power of digital media and the Internet, giving consumers many more choices. Critics, meanwhile, contend that DRM will do little to stop piracy, and that its main effect may be to frustrate consumers' ability to take advantage of the full power of digital media.

Congress, the courts, and federal regulatory agencies continue to consider and debate a variety of legal and policy issues related to the impact of new technologies on copyright and copyright holders. DRM – including, at times, the idea of government-mandated DRM – is a significant component of that discussion. But even as the policy debates continue, private sector companies are developing and releasing DRM-equipped products that have an actual impact in the current consumer marketplace. For now, and for the foreseeable future, it is the market rather than the government that is likely to play the primary role in shaping DRM.²

As DRM increasingly becomes integrated into media that consumers purchase, it will be important for the public and product reviewers to understand how to evaluate the impact of DRM on the media user's experience. Different DRM systems will provide different capabilities for users. An informed base of consumers capable of comparing products and expressing and acting on their preferences is essential to ensuring that the marketplace for digital media products and services is diverse, competitive, and responsive to reasonable consumer expectations.³ But the extent of the public's current understanding of DRM is at best unclear. A 2005 survey of European digital music users, for example, found that 71 percent did not know whether the music they purchased was subject to usage restrictions.⁴

This paper represents an initial attempt to give consumers, product reviewers, and consumer advocates concrete guidance for evaluating DRM in the media marketplace. In the first section below, we describe some ways in which DRM is

limitations are imposed on manufacturers will be irrelevant to the consumer experience. The question that ultimately matters to consumers is, can the products and services I buy be used in the ways that I want and expect to use them?

² It is important to note, however, that government provides significant legal backing to DRM that market participants choose to employ. Under the Digital Millennium Copyright Act (DMCA), circumventing DRM measures is generally illegal. 17 U.S.C. § 1201. So while government may not directly dictate the form that DRM takes, it does help to strengthen DRM's impact by prohibiting circumvention.

³ As a recent report by a U.K. Parliamentary group observed, "it is crucial to note that the market cannot function efficiently when consumers are unaware of the presence of [Technological Protection Measures], fail to understand what acts will be forbidden, or when they have no real choice because particular content is only available with TPM restrictions." All Party Parliamentary Internet Group, *Digital Rights Management* 15 (June 2006) at <http://www.apig.org.uk/current-activities/apig-inquiry-into-digital-rights-management/DRMreport.pdf>.

⁴ Nicole Dufft et al., *Digital Music Usage and DRM: Results from an European Consumer Survey*, 39 (May 24, 2005) at http://www.indicare.org/tiki-download_file.php?fileId=110. The survey also found that 63 percent of digital music users had never heard of Digital Rights Management, and another 23 percent had heard of it but did not know exactly what it is. *Id.* at 37.

already having a major impact on how the public accesses and interacts with digital content. In the second section, we suggest specific questions that consumers and reviewers should be asking about media devices and services incorporating DRM. These “metrics” for DRM include:

- **Transparency** – Is there clear disclosure to users of the effects of DRM? Are users provided sufficient information about any significant impact the DRM may have on, for example, the potential uses of a work or the interoperability of devices?
- **Effect on Use** – What are the specific parameters and limitations for the use of a work? For example, to what extent does the DRM permit such personal uses as time shifting, place shifting, or limited sharing; allow users to enjoy the work on their choice of platforms or devices; facilitate end-user creativity by allowing users to interact with the work; or create a risk of losing access due to an event such as a company going out of business?
- **Collateral Impact** – Does a DRM technology have any other potential impact on a user, apart from its effects on the user’s use of the particular work? For example, does it entail any risks with respect to the user’s privacy, or with respect to the security or functionality of the user’s computer or other device?
- **Purpose and Consumer Benefit** – Does it appear that DRM is being used to innovate and facilitate new business models that fill previously unaddressed demand and give consumers new choices? Or is DRM being used to lock consumers into old business models or to limit consumers’ choices in services and devices?

Finally, in the third section we argue briefly that, in evaluating how DRM-equipped products perform against the various metrics criteria we have identified, reviewers and others should compare those products not only to analog predecessors or current marketplace competitors, but also to what is technically and legally possible using general-purpose, networked computer architecture.

Our intent is to provoke greater discussion and public understanding of DRM. We seek to engage both consumer organizations and technology developers to educate consumers and to encourage the development of diverse and innovative DRM solutions. Whether DRM serves principally as an enabler of new business models that exploit the potential of digital media, or whether it also functions as a tool used to frustrate innovators and lock in consumers, will largely be determined by the extent to which informed consumers create competitive

pressure in the marketplace. A sufficiently informed and engaged consumer base can drive competition between different DRM offerings, which in turn can push content providers and technologists to develop innovative approaches to media distribution and DRM and to abandon approaches that offer little value from the consumer perspective.

▣ I. Consumer Encounters with DRM

DRM is already here. Digitally protected DVDs have become the de facto standard for home video. Music and video download services, employing a variety of rights protection technologies, are proliferating. Some record labels have begun mass-market distribution of copy-protected CDs. Consumer electronics manufacturers are rolling out networkable digital home entertainment devices designed to accommodate content protection considerations. Computer hardware and software vendors, aiming at the same market, are deploying media center editions incorporating DRM software.

We briefly examine four digital media products below, focusing both on the ways in which DRM limits certain consumer uses of digital media, and on the ways in which it facilitates new channels for the distribution of content.

DVDs

DVDs, which use digital technology to raise dramatically the quality of home theater, have become the widely adopted standard for digital home video. They were among the first digital media products incorporating DRM to be adopted on a mass market scale.⁵

In contrast to unprotected audio CDs, DVDs used for the distribution of commercial video content use DRM to bind the content to the physical disc on which it is recorded. This means that the “Rip, Mix, Burn” environment of digital music does not translate to DVDs.⁶ For example, the DRM on DVDs does not permit a user:

- to “rip” the digital video from a DVD onto a hard drive. Several companies offer hard-disk-based portable video players, including

⁵ Movies on analog VHS videocassettes, however, had widely incorporated copy prevention technology from Macrovision since at least the end of the 1980s. The 1998 Digital Millennium Copyright Act made it mandatory for analog VCRs to respond to this technology. See 17 U.S.C. § 1201(k).

⁶ “Rip, Mix, Burn” was the slogan of an Apple Computer advertising campaign launched in 2001 to promote the digital music capabilities of computers equipped with CD burners and iTunes software.

Apple's video iPod. But under the current DVD DRM, there is no simple legal way to move the content from DVDs onto such devices, or onto the hard drives of personal computers.⁷

- to make a backup copy of a DVD. If the disc breaks or is scratched, the user must buy a new one.
- to excerpt or mix video from a DVD in the same way as with digital music files. A student cannot excerpt a clip from a documentary for use in a school report. A user cannot create a compilation of "best movie kisses" or "biggest explosions" in the same way the user can make a mix CD. And users cannot easily take scenes from their favorite movies to use as the background on their desktop computers.
- to view the DVD content on a playback device that has not been approved by the DVD Copy Control Association ("DVD CCA"), such as DVD players for the Linux operating system.

The DVD CCA in theory could change the licensing terms of the DVD encryption standards, known as the Content Scrambling System or CSS, to allow technology developers to implement some of these capabilities. But film studios generally express strong concern that such capabilities would facilitate infringing uses, not just legitimate ones. To date, DVD CCA has been extremely restrictive in its licensing terms, only allowing playback and forbidding other uses. Recently, however, DVD CCA announced its intention to allow use of CSS with downloaded movies, enabling users eventually to burn movies purchased at store kiosks or online to blank DVDs. It does not appear that these licensing changes will immediately affect prerecorded movie DVDs.⁸

DVDs also include other limitations. Some DVDs have made it impossible to skip past the previews at the beginning of the disc. Almost all DVDs employ "region coding," which prevents a DVD purchased in Europe or Asia from being played in a player purchased in the United States. (Region coding facilitates the ability of movie studios to pursue different distribution schedules and strategies in different regions, a common part of the studios' existing business models.)

⁷ A determined user could use a high quality video camera to record the playback of a DVD from his television, but few would go to such trouble. Software that circumvents DVD encryption in order to copy DVDs is available on the Internet, but using it would be illegal under the DMCA, and finding and downloading it likely would be too much trouble for many mainstream users in any event.

⁸ See DVD Copy Control Association, *DVD CCA to Enable Retailers and Later, Consumers to Create Protected DVDs Compatible with Existing DVD Players* (Aug. 3, 2006) at <http://www.dvdc.ca.org/data/css/DVDCCAreordrIsFINAL.pdf>; May Wong, *Movie transfers to DVDs to become easier*, USA Today (Aug. 9, 2006) at http://www.usatoday.com/tech/news/2006-08-09-dvd-downloads-easier_x.htm.

DVDs have been a tremendous commercial success, but this has been primarily due to their higher quality as compared to VHS tapes. DVDs do not take advantage of the capabilities of digital media to provide many new features to consumers. In fact, DVDs use DRM to block many of those possibilities. In some respects, such as region coding, DVDs are less flexible than analog media.⁹

Digital Video Recorders (DVRs)

While DVDs are limited in the new features they offer, digital video recorders (DVRs) take advantage of unique features of digital technology to transform the way that people watch television. DVRs are not just VCRs with improved picture quality. They are radically different devices that offer users a variety of tools for customizing their TV-viewing experiences.

Thanks to abundant internal storage, DVRs allow users to record and play back hours of television programming without having to deal with tapes or discs. DVRs also can automatically retrieve program schedule information from the Internet, which allows users to select the recording of a favorite show whenever it is broadcast – a much easier recording option than manually checking schedules and programming specific recording times on a VCR. Other features include instant replay and the ability to pause live TV.

DVRs incorporate several types of DRM. First, as DVRs evolve in the direction of greater networkability – permitting users to transfer recorded programs to multiple televisions, home computers, or mobile devices¹⁰ – they may use DRM to alleviate content owner fears that unrestricted transfers could fuel infringement. For example, the TiVoToGo service uses a DRM-protected format for many file transfers, so that a user can transfer recorded programs only to devices the user has registered as part of his or her “secure viewing group.” Each device can be in only one such group. TiVoToGo also reportedly embeds a digital watermark, designed to enable TiVo to trace the origin of any TiVoToGo program that finds its way onto the open Internet.¹¹

DVRs also may use DRM to enable television program distributors to restrict recording of pay-per-view or video-on-demand programming. The DRM allows

⁹ Major consumer electronics companies are in the process of developing two competing high definition video disc successor formats, Blu Ray and HD-DVD, with the cooperation of film studios. Both will employ a new DRM system called the Advanced Access Content System or AACSLA, which will give content owners a greater range of options for what level of control to assert than does CSS. The official website of the AACSLA Licensing Administrator is at <http://www.aacsla.com>.

¹⁰ In addition, supplementary devices may offer options for expanding remote, networked access to DVR-recorded content. One example is Slingbox, a system that allows a user to stream video accessible from his home television – including programs recorded on his DVR – to Internet-connected PCs or other devices. See <http://www.slingmedia.com/slingbox/> (visited May 18, 2006).

¹¹ May Wong, *TiVo expands to iPods, PSPs for TV playback*, USA Today (Nov. 21, 2005) at http://www.usatoday.com/tech/products/services/2005-11-21-tivotogo-expansion_x.htm.

a program distributor to signal that a particular program may not be recorded at all, or that recordings of the program should expire after a specific duration of time. DVRs that incorporate the DRM are designed to recognize these signals and respond accordingly.¹² Some observers have expressed concern that these capabilities could one day be used to restrict DVR recording not only of pay-per-view or video-on-demand programming, but of regular television as well.¹³

Copy-Protected CDs

Compact discs were launched in the 1980s and became a mainstream medium for distribution of popular music long before widespread consumer use of the Internet. CDs did not originally include any content protection mechanisms.

With the proliferation of illegal online file sharing and the inclusion of CD burners in PCs, however, record labels began to explore copy-protected CD technology as a safeguard against large-scale unauthorized copying. Early protection mechanisms sought to make CDs unusable in any device suitable for copying, especially CD-ROM drives in personal computers. Consumers' experiences with these early copy-protection schemes varied widely – some CD-ROM drives were in fact still capable of playing the protected CDs, whereas some CD car stereos, portable CD players, and players with special data handling features suffered problems with audio playback. A substantial backlash in the marketplace caused the recording industry to limit the technology's deployment.

More recently, two major record labels adopted and began widespread distribution of new CD copy-protection measures designed to avoid some of the earlier problems and accommodate greater flexibility in consumer uses of music. The new copy-protected CDs permit users to:

- play the CDs in almost any CD player, including CD-ROM drives in computers;
- burn copies of their CDs (although the burned CDs, unlike the original, cannot usually be copied and/or played in a CD-ROM drive);
- copy individual tracks onto their computers in a copy-protected file format;

¹² See TiVo Support, *Questions About Macrovision Copy Protection*, at <http://customersupport.tivo.com/knowledge/root/public/tv2186.htm> (visited May 19, 2006).

¹³ See Greg Sandoval, *TiVo Users Fear Recording Restrictions*, USA Today (Sept. 22, 2005) at http://www.usatoday.com/tech/products/services/2005-09-22-tivo-recordings_x.htm?csp=34; Lucas Graves, *Has TiVo Forsaken Us?*, Wired Magazine (Nov. 2004) at <http://www.wired.com/wired/archive/12.11/view.html?pg=3>.

- share individual tracks with friends and family for a limited time or for a limited number of plays; and
- copy music onto compatible portable music players.

Despite these advantages over early CD copy-protection schemes, protected CDs are still subject to a number of limitations that do not apply to ordinary CDs. Music can be copied from the protected CDs in a limited number of file formats. As a result, the music may not play on certain portable music players or with certain player software. In particular, Apple's popular iPod is not among the compatible portable devices, for reasons relating to Apple's licensing policy. In addition, excerpting and sampling of copied tracks is not possible.

Copy-protected CDs also often require a user to install special software onto a computer in order to play or copy the CD on that computer. Such software installation can raise a number of issues. In the fall of 2005, technologies used by Sony BMG to protect millions of CDs became the focus of intense controversy when it was discovered that software they installed suffered from a number of defects. The software hid itself on users' computers using "rootkit" techniques common to spyware; opened security vulnerabilities on users' computers; failed to obtain user consent prior to installation; could not readily be uninstalled; and more.¹⁴ Several class action lawsuits were launched against Sony BMG as a result, and Sony agreed in a settlement to stop using the specific technologies in question and to provide unprotected copies of the music to customers who had purchased the flawed CDs.¹⁵

Online Digital Music Services

Online digital music services were among the first large-scale attempts at direct commercial distribution of digital media files over the Internet. There are two principal models employed by these services: sale and subscription.

Sale services roughly replicate the basic business model of offline brick-and-mortar stores. Users purchase songs over the Internet. They receive a digital copy of each song, usually incorporating DRM that allows fairly expansive use of the music while attempting to deter large scale redistribution online. Users generally are able to do a variety of things with these digital files, such as:

¹⁴ For detailed information on how the Sony software worked, see Mark Russinovich, *Sony, Rootkits and Digital Rights Management Gone Too Far*, Sysinternals (Oct. 31, 2005) at <http://www.sysinternals.com/blog/2005/10/sony-rootkits-and-digital-rights.html>; J. Alex Halderman and Edward W. Felten, *Lessons from the Sony CD DRM Episode* (Feb. 14, 2006) at <http://itpolicy.princeton.edu/pub/sonydrm-ext.pdf>.

¹⁵ For detailed information on the Sony lawsuits, see Sony BMG Music Entertainment, *Welcome to the Information Web Site for the Sony BMG CD Technologies Settlement* (Apr. 7, 2006) at <http://www.sonybmgcdtechsettlement.com>; Electronic Frontier Foundation, *Sony BMG Litigation Info*, at <http://www.eff.org/IP/DRM/Sony-BMG/> (visited April 14, 2006);

- make backup copies of the music in case a particular device or copy is damaged.
- create custom playlists of songs and burn mix CDs a limited number of times.
- transfer songs to multiple portable devices.
- include the music in their personal multimedia productions, including home movies and slide presentations.

At the same time, the DRM on the files places limitations on their use that are not present in traditional physical media. For example:

- The digital files are only compatible with certain music-playing software and portable music players. For example, songs from Apple's iTunes Music Store cannot be played on portable devices other than Apple's iPod without significant extra effort.
- Users generally can play the digital files on a limited number of computers. If a user already has authorized the full number of allowed computers, the user must deauthorize one of them before authorizing a new computer to play the files.
- Users generally cannot lend a digital music file to a friend. (However, a user could burn digital music files to a CD and then lend that CD to a friend. Alternatively, a user could temporarily authorize, and later deauthorize, a friend's computer as one of the limited number of computers the user has registered for the service, though this might be too cumbersome for most people.)
- Users cannot resell the songs if they get tired of them in the same way they can resell a used CD or DVD.

Subscription services represent a different approach. These services offer on-demand streaming of a vast library of music for a single monthly access fee. As long as users are subscribed to the service and connected to the Internet, they have instant access to any file in the service's library at any time. Subscribers are paying not for ownership, but for access. (As noted below, however, many subscription services also offer the option of paying for permanent ownership of individual songs or albums.)

The subscription model has several unique features:

- A user has on-demand access to a much larger library of music than any individual would be likely to acquire for himself.
- Unlimited access to the service's music library is conditional on being signed up and connected to the Internet, and on using compatible music player software. The music generally is streamed (i.e., not copied) to the user's computer. In cases where the content may be downloaded without an actual purchase, the downloaded songs cannot be copied again and the user loses access to them upon cancellation of membership.
- In some cases, a user's account cannot be used to access the service from more than a small number of authorized PCs.
- Most services allow a user to transfer an unlimited amount of music to compatible portable devices at an extra monthly cost. Portable devices need to be connected to an Internet-connected computer on a periodic basis to confirm that the user's subscription is still valid.
- A user may purchase music for an additional fee per song or album. Purchased music usually comes with DRM features comparable to those of the sale-based services.
- If the service ever goes out of business, a user retains only the songs and albums that were purchased individually. The same is true if the user's subscription lapses.

The online music subscription business is striking because it is not closely analogous to any common business model for delivering physical media to consumers. It is an altogether new approach enabled by digital networking and DRM.

It is important to note that, for music distributed by smaller, independent, or niche record labels, there are a variety of online services that differ substantially from the two models described above. Most of these services require users to pay fees, but the digital music files they receive in return are in audio formats that do not include DRM protection. These services, of which eMusic is a leading example, provide alternative sources of digital music for consumers who are looking for non-major label content or who are weary of the restrictions posed by any kind of DRM.

Digital music sales are growing rapidly – in 2005, global revenues from music purchased over the Internet and mobile phones nearly tripled from their 2004

level.¹⁶ We fully expect that as the digital marketplace develops, new music services will appear and existing ones will continue to evolve, offering consumers attractive new ways to take advantage of the capabilities of digital files and the Internet.

▣ II. Metrics

The examples above illustrate that DRM can operate in a variety of ways, with a variety of consequences for consumer choices and the media marketplace. We believe it may be useful, therefore, to set out the different dimensions against which DRM products may be measured and compared. The ability of consumers to compare DRM products will be essential to driving competition between different DRM offerings.

Below we propose a list of consumer metrics for DRM-equipped digital devices and services. This list is not necessarily exhaustive; other issues that matter to consumers may emerge as technologies and media markets evolve. But the metrics identify some specific questions that product testers and reviewers should be asking as they evaluate media products, services, and devices incorporating DRM. We hope that this list will help both to guide reviewers and to spark further discussion and elaboration on what issues will be of importance to consumers.

1. Transparency

To what extent are the effects of DRM clearly disclosed to users? In particular:

- *Are users given fair notice of product characteristics that may be relevant to them?*
- *Is notice provided in a manner that is sufficiently prominent and understandable? Is important information buried in long license agreements or similar fine print?*
- *Is notice provided at appropriate times? For example, is notice provided both up front, and as part of ongoing interactions with the product or service?*

Unless limitations associated with a product are clearly disclosed, users are likely to be surprised and angered when they encounter them. This is also true for collateral impacts of the type discussed later in this section.

¹⁶ International Federation of the Phonographic Industry, *Digital formats continue to drive the global music market – World Sales 2005* (Mar. 31, 2006) at <http://www.ifpi.org/site-content/press/20060331a.html>.

Relevant Information for Disclosure: Disclosure is certainly warranted when DRM will cause a product's function to deviate significantly from mainstream consumer expectations for the particular type of media in question. But expectations also evolve, and consumers likely will become increasingly accustomed to the flexibility with which they use digital files on their general purpose, Internet-connected computers and other devices. In evaluating what should be disclosed, product reviewers should think carefully about the full range of technical tradeoffs DRM entails.

Disclosure is particularly important where DRM-equipped products will not work with certain devices or in certain configurations. There is no shortage of examples: DVDs purchased on a trip abroad may not work in the purchaser's home DVD player due to region coding; songs downloaded from iTunes cannot easily be transferred to non-Apple portable music players; copy-protected CDs, unlike CDs without such protection, will not easily transfer onto the purchaser's iPod. Incompatibilities like these should be conspicuously labeled. Consumers should not learn about them only upon taking the products home, plugging them in, and receiving an error message.

Manner of Disclosure: Where some form of disclosure is provided, product reviewers should consider whether it is sufficiently prominent and understandable. What constitutes an appropriate manner of disclosure will depend in part on the likely importance of the information to consumers. It will also depend significantly on the nature of the product. Some come in physical packaging that can feature labels; others come as downloadable files and may have to find other means of providing notice. In some cases, it may be appropriate to disclose less significant details of DRM in licensing agreements. Because consumers rarely read through long license agreements, however, disclosure in the license accompanying a product will not always be sufficient. Reviewers should read license agreements carefully to determine if they contain key information that should be disclosed in a more prominent fashion.

Timing of Disclosure: An additional factor in evaluating disclosures is timing. Certainly information that is reasonably likely to affect a consumer's purchasing decision should be disclosed prior to purchase. But in general, notices should not be provided only once, when a possibly hurried user is signing up for a service or picking out a product in a store. Depending on the nature of the DRM, disclosure at other times may be warranted as well, as part of a user's ongoing interaction with a product or service.

For example, for songs purchased online that are limited in the number of times they can be burned to a CD, users should be notified appropriately as they approach the limit. If the first reminder of the limit is a message denying a user's effort to burn a CD after the limit has been reached, the user may well feel

unfairly surprised. Likewise, a CD that installs special DRM software when inserted into a computer should alert users of that fact immediately prior to installation. One of the complaints raised against Sony BMG was that some of its CDs installed software automatically, before providing any notice, or even when the user declined to consent to the installation.

Post-purchase disclosure also can be relevant in the case of upgrades. DRM systems inevitably get cracked, which can prompt their distributors to try to plug holes. Software upgrades, distributed online or otherwise, may update and fix vulnerabilities in DRM, but also could cause compatibility problems with older products now deemed insecure by the DRM devices.¹⁷ In addition, updates could change usage rules governing a user's already-purchased content; the major online music services reserve the right to do this in their terms of service.¹⁸ When upgrades have negative side effects, distributors may be tempted not to disclose them, because they do not want to discourage users from upgrading. Reviewers and consumer advocates should be watchful for such omissions.

2. *Effect on Use*

What specific parameters does DRM establish for the use of a work? What limitations does it entail? In particular:

- *To what extent do DRM measures facilitate or permit personal uses and copying of content, for purposes such as time shifting, place shifting, and limited sharing?*
- *Do DRM protections allow consumers to use media they buy on a wide variety of platforms and devices, or with a wide range of services – or is interoperability narrowly limited?*
- *To what extent do DRM measures facilitate end-user creativity, by allowing users to interact with and create content rather than just passively receiving it?*

¹⁷ An example of this type of backwards-compatibility issue was demonstrated when Apple released its iTunes 4.0.1 software upgrade. An upgraded version of iTunes on one computer could no longer be used to listen to music streamed over the Internet from a non-upgraded version on a separate computer. See *Apple iTunes update irritates fans*, BBC News (May 29, 2003) at <http://news.bbc.co.uk/1/hi/technology/2946180.stm>.

¹⁸ See, e.g., iTunes Music Store Terms of Service, § 9(b-d) at <http://www.apple.com/support/itunes/legal/terms.html> (visited May 19, 2006); Rhapsody Service Terms & Conditions, § 7 at https://rhapapp.real.com/rhapsody_pages/policy.jsp?policy=terms (visited May 19, 2006). One prominent example of a music service changing its terms and affecting previously-purchased content occurred when Apple released iTunes 4.5, reducing the number of times a user could burn a playlist of purchased music from 10 to 7. See *iTunes Celebrates Its First Anniversary; Over 70 Million Songs Purchased* (Apr 28, 2004) at <http://www.apple.com/pr/library/2004/apr/28itunes.html>.

- *Does a DRM scheme create risks that users could unexpectedly lose access to their content?*

Any evaluation of a DRM technology must include a careful look at the impact on the ways a creative work can be used.

Personal Use and Copying of Works: Consumers have developed a number of expectations concerning the use and copying of familiar types of content. Widespread use of the Internet and digital technologies is likely to foster additional expectations concerning personal use, as consumers grow accustomed to the flexibility that computer platforms provide. Of course, expectations may vary depending on the medium and the delivery method. But they may include (and are not necessarily limited to) the following:

- Flexible personal use – the ability to read, listen to, play, or watch a lawfully acquired copy of a work in a manner or sequence of the consumer’s choosing;
- Time shifting – the ability to record or store a work to enable use at a later time;
- Place shifting – the ability to use a work on different devices and at different locations within a personal, family, or work environment (for example, recording a program in one room to watch in another);
- Archiving – the ability to copy a work for purely archival purposes;
- Lending or reselling – the ability to lend, give, or resell a lawfully acquired copy of a work; and
- Limited copying for noncommercial purposes – the ability to engage in limited copying, such as that contemplated by the Audio Home Recording Act or the fair use doctrine.

Some traditional personal uses may not translate easily into the digital world. For example, it is easy and common to lend physical items, such as books. In contrast, it is somewhat less natural to “lend” a digital file, since people tend to copy files rather than physically moving or transferring them. Online music stores generally lack a simple mechanism for true lending – although users may be able to burn playlists onto physical CDs, which they could then lend. In addition, at least one major service permits subscribers to share music by sending a playlist to up to twenty friends, who may listen up to three times.¹⁹

¹⁹ See Musicmatch Terms of Use at <http://www.musicmatch.com/info/terms/index.htm> (visited May 19, 2006).

This may serve some of the same purposes as lending from the consumer perspective.

To the extent that consumers value the personal uses provided by traditional physical media, product developers should make every effort to implement comparable capabilities in digital products. Doing so without opening the door to widespread infringement may pose significant technical and business challenges, but consumers and product reviewers may reasonably press product and platform developers to take on these challenges. In addition, where DRM-equipped products will not allow personal uses that have been commonplace for that type of media, that fact should be disclosed to consumers.

Choice and Interoperability: Many consumers have already encountered compatibility limitations in the online music market. Songs purchased on iTunes will not work on portable music players other than Apple's own iPods, and Apple's iPods will not work with songs purchased from other online stores in Windows Media format. The confusing tangles of DRM incompatibility can be frustrating to users accustomed to buying CDs under the assumption that that they will play in any device in which they fit.²⁰

To some extent, compatibility limitations stem from the basic purposes of DRM. One major aim of DRM is to limit a user's technical ability to use or distribute digital content in ways the copyright holder has not authorized. To do that, DRM needs to make the content incompatible with devices or platforms that would enable (or fail to prevent) such unauthorized uses. For example, if Apple's iTunes song files were freely playable on any platform, then anyone could build a device or write software that played the songs but ignored or stripped the DRM.²¹ Thus, compatibility arguably needs to be limited to devices that are deemed trusted or secure.

Of course, DRM can also be used for purposes such as segregating markets or creating and enforcing different distribution windows. These uses of DRM can result in compatibility issues as well – as in the example of DVD region coding, which makes U.S. DVDs incompatible with players sold outside North America.

²⁰ The impact of compatibility limitations can be especially serious for users with special needs. For example, visually impaired users may not be able to access digital content effectively if DRM renders the content incompatible with specialized text-to-speech devices or software. See All Party Parliamentary Internet Group, *supra* note 3, at 13-14 (noting that DRM can "prevent the disabled from accessing digital content . . . because the specialist hardware and software that is used to convert the content into speech, Braille, or large type, fails to interwork with the protected material.").

²¹ Of course, compatibility limitations cannot prevent determined hackers from building or writing such devices or software anyway. See Tony Smith, *DVD Jon: buy DRM-less tracks from Apple iTunes*, The Register (Mar. 18, 2005) at http://www.theregister.co.uk/2005/03/18/itunes_pymusique/. But so long as such efforts require circumventing DRM, they create potential legal jeopardy under anticircumvention laws, which makes widespread commercial deployment unlikely.

Given the purposes of DRM and the likelihood of multiple distribution platforms, it is not realistic to expect every digital distribution service and every DRM-equipped file to be compatible with every other platform or playback device. Nonetheless, DRM that is compatible with a range of platforms and devices – and thus permits competition and consumer choice – generally should be favored over DRM that locks users in to a narrow set of complementary technologies. Media products and technologies that can be expanded and deployed in ways not anticipated by the original developers are likely to have significant long-term advantages over those with more closed architectures.

One route to greater interoperability is for different products, services, and devices to adopt the same DRM platform. For example, if a vendor of DRM solutions licenses its DRM widely, a variety of companies can incorporate that DRM into a variety of competing downstream products.²² Alternatively, a group of companies may come together to develop a joint DRM standard they would all use.²³ There is also an effort to develop an open, royalty-free DRM system, which in theory would eliminate licensing concerns as a potential barrier to widespread adoption.²⁴ In any event, reviewers should recognize that the licensing policy for a DRM system may help determine not only the range of existing devices with which a product using that DRM will interoperate, but its compatibility with future innovations as well.

A different way of achieving interoperability would be to develop standard interfaces and protocols to enable users to shift their content back and forth between separate DRM platforms, so that content acquired in one DRM format nonetheless can be accessed and used with devices employing different DRM systems. The idea is that information relating to the user's identity and the rights the user has acquired for particular content would be recorded in a standard format that is not specific to any one DRM platform. Based on that information, the content could be translated into, or exchanged for, alternative DRM formats as needed to make the content work with different devices – but only to the extent the user's rights so permit, and without jeopardizing protections against unauthorized use. The viability of such a scheme remains to be seen, however.²⁵

²² Perhaps the leading example of this approach is the Microsoft Windows Media DRM system, under the logo "PlaysForSure." A significant number of digital music stores and portable device vendors use the Microsoft system. See <http://www.microsoft.com/windows/windowsmedia/playsforsure/default.aspx> (visited Jul. 10, 2006).

²³ Members of the consumer electronics industry have formed a consortium called the Marlin Developer Group, which aims to develop a common DRM standard. See <http://www.marlin-community.com> (visited Jul. 10, 2006).

²⁴ See <http://www.openmediacommons.org/about.html>; Open Media Commons Releases Specifications and Source Code for Open, Royalty-Free Digital Rights Management (Mar. 21, 2006) at http://openmediacommons.org/news/03212006-omcworkshop_press_release.html.

²⁵ Sun's Project DReaM aims to develop this kind of standard interface between DRM systems, as does the electronics industry's Coral Consortium. See Gerard Fernando et al., *Project DReaM, An Architectural Overview* (Sept. 2005) at

In short, reviewers evaluating DRM-equipped products or services should probe the extent to which the DRM locks users into a particular family of products in complementary markets. Examining licensing agreements, policies for granting future licenses, and compatibility with any standard protocols that have been developed will be important parts of that inquiry.

As discussed above, where DRM does entail limitations on choice and interoperability, transparency is essential. Consumers would not have expected a tape deck to be capable of playing vinyl records, but in the world of digital media, compatibility-related complications may be less obvious for consumers to discern. Vendors should clearly and conspicuously label products in a way that makes it clear to users what compatibility problems they may face.

Facilitating End-User Creativity: Digital technologies and open computer architectures can empower individual consumers to be much more than passive consumers of media. The digital revolution has made mass publishing available to anyone with a computer. It provides cheap, easy access to the kind of music and video production tools previously available only to corporations and professionals. In a world in which people increasingly express themselves through rich media, they will want the ability to quote, comment, and editorialize on and through all kinds of media in the same way they have historically been able to do with text.²⁶ Naturally, copyright law establishes some boundaries for such activity, but the fair use doctrine provides a certain amount of leeway, especially for noncommercial uses that have little impact on the market for a copyrighted work.²⁷

As much as possible, DRM solutions should seek to allow users to interact with, excerpt, and expand on existing works in ways that are consistent with copyright law. They should allow reuse of content for noncommercial creative purposes – such as using purchased music as background in home videos. And they should take advantage of the metadata capabilities of digital media to make it easy to purchase licenses to expand upon and redistribute content as part of users’ own creations.

DRM is currently not well adapted to the task of facilitating end user creation. Nor is it a simple task to develop DRM solutions that, in accommodating a

<http://www.openmediacommons.org/collateral/DReaM-Overview.pdf>; <http://www.coral-interop.org> (visited Jul. 26, 2006); Coral Consortium Call to Action at <http://www.coral-interop.org/main/calltoaction.html> (visited Jul. 26, 2006). Neither has yet been implemented on a substantial scale in the marketplace.

²⁶ See, e.g., Tom Zeller Jr., *The Lives of Teenagers Now: Open Blogs, Not Locked Diaries*, New York Times (Nov. 3, 2005) (“Most teenagers online take their role as content creators as a given. Twenty-two percent report keeping their own personal Web page, and about one in five say they remix content they find online into their own artistic creations, whether as composite photos, edited video productions or, most commonly, remixed song files.”).

²⁷ See 17 U.S.C. § 107.

broad range of creative uses, do not also open the door to uses that infringe copyright. But reviewers should recognize that the potential for interactivity and user creativity is one of the great advantages of digital media. In the long run, DRM should work towards allowing users of computers and consumer electronics devices to interact with and transform content, not just to consume it passively.

Permanence / Risk of Unexpected Loss of Access: In some cases, DRM may create risks that a user's access to content unexpectedly could be interrupted or lost. In particular, DRM that involves some kind of ongoing, post-sale linkage to or dependence on the individual provider of the content could make content permanently inaccessible if the provider goes out of business. Access likewise could be impaired if the provider ceases to support a particular product line, format, or functionality.²⁸ Similarly, when DRM requires some kind of Internet-based "handshake" or verification on an ongoing basis, a user's access to purchased content could be interrupted if the user loses his Internet connection.

Of course, under some business models, users may acquire content with full understanding that their rights to access the content are not necessarily permanent. Access to rented content may expire after a certain period of time, and access to subscription-based content may expire if the user allows the subscription to lapse. But unless such limits are an explicit part of the bargain at the time of purchase, users generally expect that content they purchase will remain accessible and usable.

Whether risks of future loss of access exist is unlikely to be immediately apparent from direct tests of DRM equipped products or their associated platforms, or from the disclosures provided by the makers of those products or platforms. In general, assessing such risks will require a sound understanding of how a DRM scheme works and an effort to think through how it could be affected by various future contingencies. Product reviewers should conduct such an analysis, so they can inform consumers about any risk of purchased content becoming stranded and unusable.

²⁸ For example, Divx movie discs (a one-time competitor to DVDs, with no relation to the current video codec DivX) ceased to be playable after Circuit City discontinued support for the Divx system in mid-2001. For a description of Divx, see DVD Journal, *What Was Divx?* at <http://www.dvdjournal.com/extra/divx.html> (visited May 18, 2006). Note that industry-wide format changes, such as from 8-track tapes to audio cassettes to compact discs, can also leave a user with stranded media. But because the formats are open, continued access is not dependent on one company; so long as *any* vendor builds devices or supports or repairs old ones, the user has options. See All Party Parliamentary Internet Group, *supra* note 3, at 16 (noting that "there are rather more aspects to discontinuation when TPM [Technological Protection Measures] is involved" because "some schemes bind copies to particular machines" and moving a copy to a new machine "may involve access to the manufacturer's website, which may no longer be active.").

3. *Collateral Impact*

Does the DRM have any other potential impact on a user, aside from its direct impact on the ways the user can use or distribute the protected content?

- *Are users' privacy and anonymity preserved? What data is "phoned home" to a central server of the content distributor or other party?*
- *Does the DRM carry any risk of impairing the security of users' computers or other devices?*
- *Are there other ways in which the DRM could impair the functionality of users' computers or other devices?*

In some cases, DRM may affect more than just the use of the specific DRM-protected content. Secondary or collateral effects may relate to such matters as user privacy, computer or network security, or other potential impairment to the functionality of user devices.

Privacy and Anonymity: Analog media generally affords the ability to read, view, or otherwise access content anonymously. Some DRM systems, however, may associate a specific identity with each use of or access to content, and communicate that information back to the content distributor using the Internet.²⁹ This kind of system may benefit users by enabling them to access their content from multiple devices or remote locations, based on their identities. On the other hand, usage under such a system is not anonymous in the same way it is when one reads a book or watches a videotape.

Making usage less anonymous can raise significant privacy questions. Information about what individuals read, watch, and listen to can be quite personal and sensitive. Moreover, such information could be linked to purchase histories or other data that a content provider may possess, creating detailed profiles of individual users.

Evaluations of DRM should include an analysis of whether the DRM collects and communicates information about individual users. If so, it will be important to explore such questions as what information is collected; to whom the information is communicated; how the information will be used; with what other entities the information may be shared; and how long the information will be retained. In general, information collection, use, and retention should be narrowly limited to what is necessary to achieve the core functions of the DRM

²⁹ For example, the Google Video service embeds encrypted user account information in purchased videos, and relays that information back to Google each time a user plays a video. See *Google Video Player Privacy Notice* (Jan. 6, 2006) at <http://video.google.com/support/bin/answer.py?answer=32170>.

system, except where individuals have freely chosen to authorize broader use of the information. In addition, users have a right to expect that any privacy implications of DRM will be clearly disclosed.

Security: When DRM involves the installation or alteration of software on a user's computer or other device, there is a possibility that sloppy or overly aggressive programming could impair the general security of the device. The controversy over Sony BMG's copy protected CDs was partly due to reports that the software they installed created security vulnerabilities which could be exploited by virus writers seeking to access users' computers. Product reviewers, consumer advocates, and computer security experts should be alert for DRM behaviors that pose security risks. Examples of such behaviors include:

- disabling or changing users' firewall, anti-virus, or anti-spyware settings;
- gaining high-level operating system privileges;
- giving third parties remote access to users' devices;
- using techniques such as cloaking, which are most often associated with malicious software;
- executing even when a computer is starting in "safe mode;" and
- using techniques deliberately designed to make software difficult to uninstall.

Device Functionality: There may be other ways, not directly related to security, in which DRM could impair the overall functionality of a user's device. DRM may drain battery or processing power. It has been reported that playing music files with certain DRM can cut the battery life of MP3 players by 25 percent.³⁰ Some DRM software appears to run, and thus use processing power, even when the user is not accessing protected content – which could slow the performance of the device, particularly if multiple DRM systems operate this way and have a cumulative effect.³¹ DRM systems also could interfere with a device's general purpose copying hardware or software; there have been reports of certain DRM modifying the operation of the device drivers for DVD burners.³²

³⁰ James Kim, *The truth about battery life*, CNET (Mar. 13, 2006) at http://reviews.cnet.com/4520-6450_7-6467771-1.html.

³¹ Sony BMG's CD protection software reportedly continued to run and consume processing power even when the associated media player was not running. *See supra* note 14.

³² Jane Pinckard, *StarForce's \$1000 Break-Your-PC "Contest,"* 1up.com (Dec. 15, 2005) at <http://cgw1up.com/do/newsStory?cId=3146416&did=1>.

4. *Purpose and Consumer Benefit*

Does it appear that DRM is being used to innovate and facilitate new business models that fill previously unaddressed demand and give consumers new choices? Or is DRM being used to lock consumers into old business models or to limit consumers' choices in services and devices?

Individual consumers evaluating DRM in connection with specific purchasing decisions may focus mainly on the details of what the DRM's practical impact is and how that impact is disclosed. But product reviewers and consumer advocates should also step back and look at the big picture. Proponents of DRM often say it facilitates the development of new business models and delivery channels, which ultimately benefits not just content providers but consumers as well. Reviewers and advocates should try to evaluate whether particular DRM schemes appear in fact to be playing such a positive role in the marketplace – or whether they seem mainly to serve some other purpose, such as locking in users to a particular company's technology platform.

This inquiry may be more subjective than, for example, determining the particular usage parameters established by a DRM scheme. But in many cases, the purpose and role of DRM may not be terribly difficult to perceive.

For example, suppose an online video rental service uses DRM to cause downloaded video files to expire at the end of the agreed upon rental term. It is easy to understand why this online rental business, or the content companies licensing videos to it, would not be comfortable distributing so called “rentals” that in fact take the form of permanent files on customers' computers. Furthermore, there is clearly consumer demand for video rentals (at appropriate price points relative to those of outright purchases), and some renters may find it more convenient to obtain the videos online rather than from the local video store or through the mail from Netflix. So it seems reasonable to conclude that the DRM causing the video files to expire is facilitating a business model for which there is real consumer demand.³³

Another example may be DRM schemes that focus primarily on tracking and accounting for usage – rather than just restricting it -- to permit appropriate payment. A service named Weed offers a technology platform to enable users to share media files (songs or video) with one another on a temporary basis, and to earn commissions when those referrals lead to sales.³⁴ A person downloading a

³³ Several major movie studios have already experimented with this kind of delivery model. See Tim Gnatik, *An Online Supplier for Your Desktop Cineplex*, New York Times (Aug. 12, 2004) at <http://tech2.nytimes.com/mem/technology/techreview.html?res=9C00E0DF163FF931A2575BC0A9629C8B63>.

³⁴ See <http://www.weedshare.com/>.

Weed file – whether from a friend’s website, an email, or a peer-to-peer service – can play the file three times for free. If the person then decides to buy the file, portions of the purchase price go to whomever that person received the file from, and to whomever were the previous two sources of the file before that. This is an innovative business model that taps into consumers’ interest in using peer referral systems to promote and identify media they particularly like. It seems clear that, for the system to work, it needs to have a means for tracking referred files through the distribution chain, as well as for limiting each user to three free plays prior to purchase.

While DRM may help foster new choices for consumers, DRM with narrower competitive aims may limit such choices by making it harder for consumers to switch brands. We do not mean to suggest that it is or should be impermissible for companies to employ DRM for such a purpose. Companies are likely to seek to use DRM for competitive advantage where they see an opportunity to do so. However, we believe it is fair for reviewers and consumer advocates to point out when DRM is being used in ways that offer no significant consumer benefit, and to be appropriately critical.

▣ III. Applying the Metrics – Frames of Reference

In assessing how a particular DRM performs with respect to the criteria identified above, product reviewers and others may at times find it useful to compare DRM-equipped digital media products to their traditional analog predecessors. Comparisons to analog capabilities can be informative for consumers who are accustomed to analog media. Comparisons to competing digital products already in the marketplace can be informative as well. Such frames of reference could be helpful, for example, in evaluating how the specific use parameters and limitations associated with a DRM scheme are likely to relate to existing consumer expectations, or in thinking about what effects of DRM should be disclosed to achieve transparency.

At the same time, frames of reference based narrowly on existing products or services will tend to put the focus more on familiar features than innovative ones, and will cease to be useful over time. For example, several years ago, few were predicting that home users would easily be able to create, edit, and remix digital video. Now it is reasonable for product reviewers, in considering the uses DRM allows, to probe the extent to which users are able to interact with or excerpt digital video they purchase or capture.

CDT believes that, in applying metrics for DRM, it is important to consider a forward-looking frame of reference as well: specifically, what an honest and law-abiding consumer could do with networked, general purpose computers and

open-format media. In such an open-media environment, devices are freely interoperable. Content can be readily moved across home and personal networks, converted to different formats, and accessed on several devices. Consumers are able to easily transfer and access their content from diverse locations over the Internet. Wide personal and transformative uses of content are possible, limited only by the imagination of technologists in devising new ways to manipulate digital data.

Content owners will object that it is not reasonable to expect protected digital media to live up to such a standard. After all, completely unprotected media of the kind envisioned in the open media environment is easily susceptible to massive piracy. This is a fair observation. Our point is not that everything that is possible with unprotected content on general purpose computers should be immediately possible for DRM-protected media, nor that every deviation from the open media environment is somehow harmful or unfair.

Rather, using the open media environment as a frame of reference helps illustrate the technical choices and tradeoffs associated with DRM. In a world of technological convergence and digital media, there is no *technical* reason why content cannot be distributed with the flexibility that networked, general purpose computer architecture can provide. There may be economic, business model, or legal reasons for taking a different approach. But consumers and product reviewers seeking to evaluate DRM should have a clear picture of the tradeoffs that have been made in each of the areas described in the metrics.

Awareness of those tradeoffs may prompt product reviewers and other critics and commentators to press manufacturers and content owners to develop secure ways of implementing the missing capabilities. Over time, in other words, an open media environment can serve as an aspirational goal that helps shape the evolution of the DRM and media marketplace. Keeping the open media environment in mind, product reviewers, consumer advocates, and highly engaged consumers will be able to ask themselves whether makers of products and platforms are keeping up with advances in digital media technology – and apply marketplace pressure for them to do so.

▣ Conclusion

As valuable creative content continues to move online and creators migrate to digital media, DRM is likely to continue to play a major role in the media marketplace. Consumer education about DRM technology, which to date has been lacking, therefore will be critically important. The voice of consumers has been largely absent from many of the debates surrounding DRM. But it is

consumers who will ultimately have the final say in whether various approaches to content protection succeed or fail.

Product reviewers are uniquely situated to help ensure that consumers are informed in making these choices. Reviewers should push manufacturers to take full advantage of the revolutionary potentials offered by digital media and networking technologies. They should lay out the limitations and consequences associated with different DRM schemes. And they should distinguish between cases in which DRM enables new markets or fulfills previously unmet demands, and those in which product manufacturers or content owners are using DRM mainly to stifle innovation or hinder competition. Only through tough, honest, and educated reviewing will a robust and consumer-friendly marketplace in DRM and digital media emerge.



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DRM Metrics

Transparency

To what extent are the effects of DRM clearly disclosed to users?

Relevant Information for Disclosure -- Are users given fair notice of product characteristics that may be relevant to them?

Manner of Disclosure -- Is notice provided in a manner that is sufficiently prominent and understandable? Is important information buried in long license agreements or similar fine print?

Timing of Disclosure -- Is notice provided at appropriate times? For example, is notice provided both up front, and as part of ongoing interactions with the product or service?

Effect on Use

What specific parameters does DRM establish for the use of a work?

What limitations does it entail?

Personal Use and Copying of Works -- To what extent do DRM measures facilitate or permit personal uses and copying of content, for purposes such as time shifting, place shifting, and limited sharing?

Choice and Interoperability -- Do DRM protections allow consumers to use media they buy on a wide variety of platforms and devices, or with a wide range of services -- or is interoperability narrowly limited?

Facilitating End-User Creativity -- To what extent do DRM measures facilitate end-user creativity, by allowing users to interact with and create content rather than just passively receiving it?

Permanence / Risk of Unexpected Loss of Access -- Does a DRM scheme create risks that users could unexpectedly lose access to their content?

Collateral Impact

Does the DRM have any other potential impact on a user, aside from its direct impact on the ways the user can use or distribute the protected content?

Privacy and Anonymity -- Are users' privacy and anonymity preserved? What data is "phoned home" to a central server of the content distributor or other party?

Security -- Does the DRM carry any risk of impairing the security of users' computers or other devices?

Device Functionality -- Are there other ways in which the DRM could impair the functionality of users' computers or other devices?

Purpose and Consumer Benefit

Does it appear that DRM is being used to innovate and facilitate new business models that fill previously unaddressed demand and give consumers new choices?

Or is DRM being used to lock consumers into old business models or to limit consumers' choices in services and devices?