The Role of Architecture in DRM Vendor Economics

Pramod A. Jamkhedkar† Gregory L. Heileman‡
†Department of Computer Science
‡Department of Electrical & Computer Engineering
University of New Mexico, Albuquerque, NM

Abstract

The advent of digital rights management (DRM) has lead to the creation of two generations of DRM technologies. First generation technologies largely focused on copy protection, and because of this, many erroneously equate copy protection and DRM. Second generation technologies, however, have begun to address a much broader scope of possibilities associated with the myriad of business opportunities that can be built around the more general idea of managing rights. Nevertheless, to date, DRM vendors have experienced very little success in the marketplace. This in spite of the fact that respected analysts had predicted the growth of a multi-billion dollar DRM market by the year 2004. Experts have postulated a number of reasons for the failure of this market to appear, some related to the business models, others to the technologies themselves, and still others related to the lack of standards in this area. In this paper we consider the role that the definition of a well-defined DRM architecture will have in addressing these problems. In particular, we consider how the specification of a minimal architectural framework can help to guide the development of technologies in DRM, as well as help to identify the role that standards should play and where in the architecture they should be defined. It is important to note that a similar architectural framework was instrumental in the development of Internet technologies and standards. Furthermore, the issues faced by the telecommunications industry in the early eighties are quite similar to those currently faced by the DRM industry. Various networking technologies were available, and what was needed was a technological framework that could integrate them and still allow different kinds of services to the applications that involve communication. It was the layered architecture of the OSI model and the hourglass shape of the TCP/IP protocol suite that provided the necessary framework. It is also important to recognize that in general layered architectures act as a buffer against rapidly changing technologies. The hourglass-shaped structure of TCP/IP has helped to make the Internet universal. Subsequently, the integration of the Internet into the telecommunications industry was supported by a standardization process. Furthermore, the development of standards promoted the integration of independently developed solutions. This paper makes use of the Internet analogy in order to consider how a layered architectural framework can also promote and guide the development of the DRM industry.

1 Introduction

The digital rights management (DRM) industry is relatively young, emerging over the past fifteen years. In its initial stages, the DRM industry modeled itself along the lines of the prevalent rights management business models in the non-digital world. However, the emergence of digital technology made it possible to create perfect copies of on-line content. Later, the development of the Internet facilitated the dissemination of this content. Hence most of the DRM technologies developed during the late eighties and early nineties concentrated on copy protection. These are referred to as first generation DRM systems. Subsequently, those in the DRM industry became explicit in recognizing that DRM is in fact much more than copy protection alone. For example, research and development of rights expression languages (RELs) provided a means to express rights in a machine readable form, something that now appears as a basis for DRM. In addition, companies started to use the

Internet as a cost-effective means for content distribution. The growth of the Internet also made it possible to create new business models for content distribution, which gave rise to second generation DRM systems. Second generation DRM systems shifted their focus from copy protection to rights expression. This can be seen as a shift of technologies from being content-distributor-centric to that of being user-centric. A slew of technologies emerged in the late nineties which provided solutions ranging from kernel-level rights enforcement to sophisticated facilities such as superdistribution in a single package. What we have witnessed however is the failure of most of these technologies [3], as well as a general reluctance towards the prominent use of DRM in commercial applications. There are a number of reasons for these failures, some related to technology, and others to the economics of DRM. In this paper we consider how these two are related. In particular, we consider the role that technology must play in the specification of a minimal architectural framework for DRM. Such a framework provides the scaffolding upon which multi-vendor DRM solutions can be built, which we believe is a necessity in order for viable DRM markets to emerge. Without such a framework, monolithic one-vendor solutions will continue to be the norm, and these markets will continue to progress slowly.

It is instructive to compare the progress of DRM technology markets to other successful and more mature technology markets. In doing so, a number of important lessons come to light. First, let us consider the general notion of how such markets develop. It has been noted that any technology driven market goes through three different phases [6]. The first phase is simply the raw adaptation of technology in the market space. The second phase involves the development of customized end-to-end solutions in order to solve business problems. The third phase is the integration of the technology in end-to-end solutions that can offer services to a generic customer base. In the DRM industry, the first phase appears to be the development of rudimentary DRM solutions which relied solely on copy protection. These solutions were content-provider-centric and were promptly rejected by the users because they failed to address their needs. The rise of second generation DRM systems can be seen as the transition to the second phase of the DRM market lifecycle. At present, some have noted that the DRM industry appears to be in this second phase [7]. In particular, DRM vendors are busy developing customized end-to-end solutions for users. Due to the difficulty of the transition from the second to the third phase, the "distance" between them has been referred to as a "chasm"; many vendors are not able to make this transition [6]. In the third phase, vendors are able to provide stable solutions, and they can successfully embed their technologies into business solutions which can address the needs of generic customers. In this phase, stable solutions evolve which address the "tussle" between the vendors and the customers, and a *de facto* agreement is reached between them. In particular, vendors are incentivized to provide solutions that will maximize the usage and visibility of their technologies, while users demand a transparent experience that does not necessarily favor particular vendors. Thus, successful solutions involve a compromise that addresses the needs of the customer on one the one hand, and are profitable to the vendor on the other. The third phase also allows the vendors to market their products competitively [7]. As we have mentioned, it appears that the DRM industry is currently locked in the second phase. Transition to the third phase will be greatly facilitated by the development of a framework containing appropriately defined standard that can guide the development of vendor strategies. Indeed, from the vendor's perspective, the determination of where standards should *not* be defined is just as important as determining where they should be specified. As we will see, a layered architectural framework is useful in helping to decide these issues.

One of the most crucial requirements in the third phase is to provide stable solutions. DRM systems need to incorporate a range of services that can be offered to customers. These services will vary in their nature and complexity depending upon type of content and its usage model. Many DRM vendors tried to incorporate a range of services in their products, however they failed in trying to achieve this. For example, the IBM Cryptolopes project tried to incorporate complex services

into its solutions offering a range of services to customers; however, from a commercial perspective this project was a failure [5]. Most of the early DRM products collapsed under their own weight in trying to achieve everything. The biggest hurdles in developing stable DRM solutions are trust and security. No matter how user-centric a DRM solution is, its success will eventually depends upon the ability to enforce rights. That is, DRM is largely dependent on security solutions. There is however a major difference between security and rights enforcement. Rights enforcement is much difficult to achieve as it is concerned with controlling the usage of the content after delivering it to the user. This gives rise to trust. In many cases, the content provider must establish trust in the user before content can be delivered. It is possible that one security breach involving sensitive data can defeat the whole purpose of a DRM system. DVD encryption provides a good example of how inflexible security soltuions can cause problems. When DVD encryption was "cracked", the security system was inflexible and therefore it could not recover from the attack. However, this does not mean that DRM systems should not be employed. A requirement is that a system should be able to recover from security breaches in order to further exploitations. The system should therefore have excellent trust management capabilities which would allow dynamic trust establishment between the content owner and the user. Another problem faced by content distributors are the rapid technological changes in rendering platforms. A DRM system should also be able to adapt to these changes. To provide stable solutions, it is necessary to develop DRM services which will withstand rapid changes in platforms. These are the challenges faced by DRM vendors in developing stable solutions.

In the third phase of the market, the tussle between the customer and vendor should achieve an equilibrium. The solutions should be profitable to the vendor and simultaneously provide enough benefits to the customers. Only when such an equilibrium is reached, can the product survive in the market. If a DRM product overly favors one of the parties, then it will be rejected by the other. We have already seen in first generation DRM systems solutions which involve too much control over the user (in favor of the content provider), but these were rejected by users. On the other hand, content providers are reluctant to use systems which provide too much freedom to the users. In order to achieve an equilibrium, it is necessary to discuss the needs of both vendors and customers and more closely consider where conflicts of interest arise.

In the area of services, customers demand choices. A customer does not want to be overloaded with heavyweight solutions when a lightweight solution is all that is required. In many first generation systems, all the services were bundled in a single product and provided to the customer, who was forced to download the heavyweight product. Since most DRM vendors provide complete DRM solutions, tcustomers are locked into specific DRM vendors. What customers demand is independence of DRM vendors. The customer should be able to switch the DRM vendors with minimal overload. In this sense, DRM now has a reputation of getting in the way of using content. A customer will be reluctant to use the DRM solution if he can get access to the content cheaper through illegal means. Customers are generally not interested in buying the rights to a piece of content which is be restricted to use over a single device. DRM vendors need to address these needs and develop solutions which will allow enforcement of rights over multiple devices.

Vendors want solutions that will be profitable, which requires reaching a wide customer base. It is therefore necessary that DRM solutions should be able to use different content distribution models, and also allow the vendor to adapt the product to different business models. It is also necessary that new entrants in the industry are able to integrate their products with existing ones to provide generic DRM solutions.

In this paper we consider how an agreed upon architectural framework for DRM can facilitate the growth of DRM markets. In [4] we proposed a layered DRM framework for DRM technologies. In this paper we consider how such a framework can help to guide the development of technology along with the assist in the establishment of helpful standards.

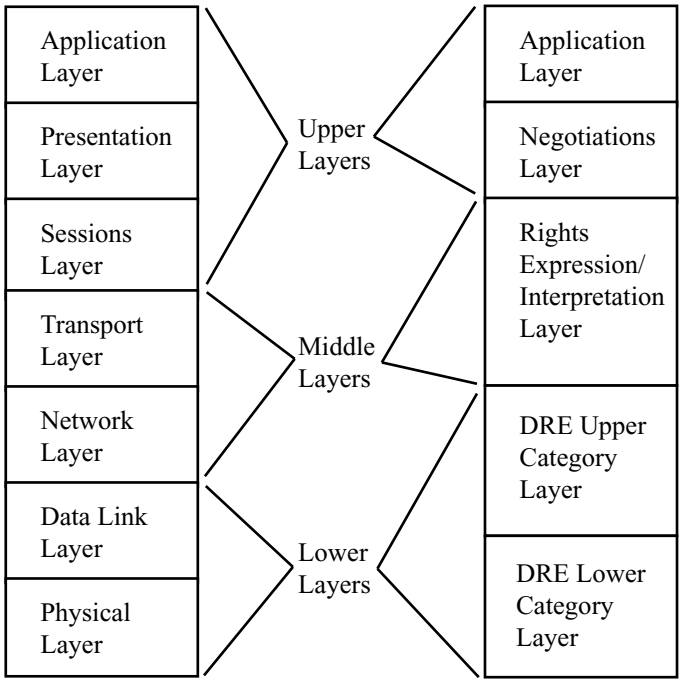

Figure 1: A breakdown of the OSI data communications layers and the proposed DRM layers into upper, middle, and lower layers.

2 Rationale for a Layered Framework

Consider the client-server model associated with a typical DRM system, where the user of the client machine wishes to purchase a piece of content, and the server side is responsible for delivering the content along with its associated rights. The rights are then enforced on the client machine. There are three basic processes that must be supported within this framework. At the highest level are the dealings of the client system with the server. An intermediate level is concerned with how exactly the rights are specified as well as how they should be interpreted in particular environments. At the lowest level the concern is how the rights are enforced on the client side. The client server dealings will be a part of upper layers. Rights enforcement technologies will be present in the middle layers. Figure 1 gives a detailed breakdown of the DRM layers.

Rights expression and interpretation (REI) form the minimal requirement of any DRM system. Since they constitute the minimal requirement of DRM systems, they are placed in the core of the framework. The REI Layer would provide a common denominator over which various DRM services can be built. Every DRM system would require the REI layer service. New services can be created using the REI service. Just as TCP, HTTP and UDP, etc., are various services created out of IP, REI can provide a common ground for creation of new services.

There are range of services demanded by the users. These services can be created independent of the underlying rights enforcement technologies. The functionalities of these DRM services would be determined by the end-to-end arguments necessary in the DRM system design. The service layers would help the DRM solutions adapt themselves to different business models. The service layers are divided into two parts. Application layer and Negotiations Layer. Functions which are more central to DRM like trust establishment, interoperability, content tracking, access control, security and watermarking will be implemented in the Negotiations Layer. Application specific functions like money transactions, personal trust establishment, pricing models, preview facilities and content search facilities will be implemented in the Application Layer. The service layers would

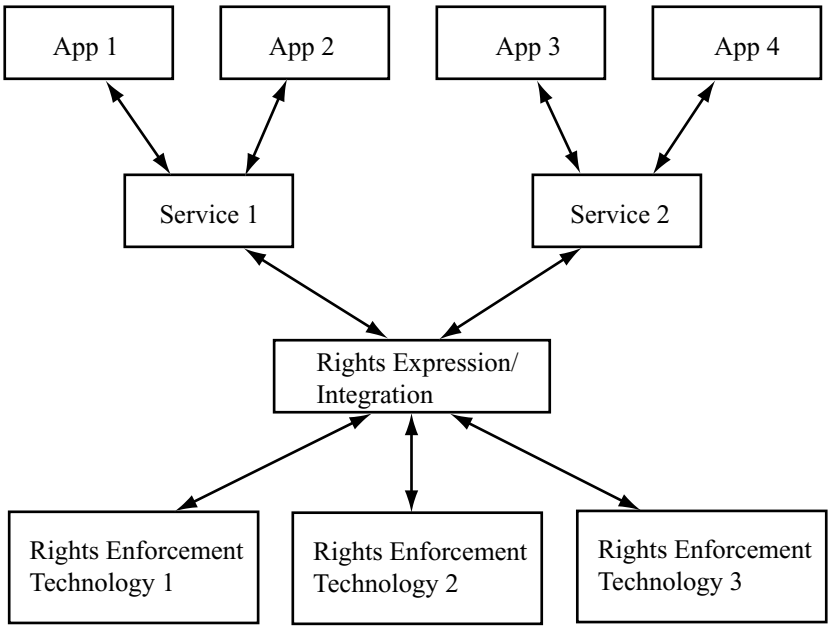

Figure 2: DRM as a layered system with an hourglass structure. In this case Rights Expression and Interpretation provides the minimal service, and this service is therefore located at the notch of the hourglass.

represent the upper dome of the hourglass shaped structure as shown in Figure 2.

The REI layer would be implemented over the Rights enforcement technologies (RET). Similar to the underlying networks that serve the purpose of actually transmitting the data, RETs attempt to enforce the specific rights associated with particular content items and users. RETs represent technologies that enable rights enforcement. Technologies such as secure containers, authorized domains, watermarking, and trusted platforms will be implemented in the RET layers. These rights enforcement technologies are bound to changes with advances in computer science and electronics, though their role would always remain the same. Thus if the core of the framework is limited to rights expression and interpretation, then the framework will be flexible enough to change with the changing requirements of DRM environments, without invalidating useful applications that have been previously built on top of the minimal DRM services.

2.1 Technologies Independent of Services

In most of the current DRM systems, the services provided by the system are bound to the technologies used for the enforcement of rights. DRM vendors generally have their rights enforcement software running on client devices. Thus the range of services provided to the users is heavily dependent on the rights enforcement solutions available in the DRM systems. In [4] we proposed breaking down the DRM process into layers. Layered systems help to buffer the services against the rapidly changing technologies. Our work is inspired by the highly successful OSI framework and the TCP/IP protocol architecture. The central idea behind the proposed DRM framework is identification of the minimal requirement of the DRM processes using this service as a separator of rights enforcement technologies and DRM services.

¿From the server's perspective, it does not matter exactly how rights are enforced on client system. What the server needs is an assurance that the rights will be correctly enforced on the client system. The server should also be assured that the client system understands the expressed rights and can interpret them correctly in order to enforce the rights. If these two goals can be

achieved, then the process of rights enforcement can be separated from the DRM services. The glue that holds together the rights enforcement and DRM services is the rights expression and interpretation process. This role is very similar to that of IP in telecommunication networks which holds together the networking services and the networking infrastructure. If we place the rights expression and interpretation layer in the middle, then it is possible to think of the DRM services in the form of an hourglass shape. Rights expression and interpretation (REI) provides the minimal DRM service and should be situated at the notch of the hourglass. Figure 2 shows how DRM can structured in order to form an hourglass shape. The lower dome consist of the rights enforcement technologies and the upper dome consist of the DRM services. The REI and the upper dome would deal with the end-to-end arguments and lower dome will be implemented on the client side. The REI layer shields the intricacies of digital rights enforcement from the service layers above. It provides a lowest common denominator over which new services would be created according to needs of the DRM environment, leading to specific applications in the upper layer of the DRM architecture. Such a framework would be flexible to the changing demands of DRM going forward.

Ideally, the DRM services can be truly independent of the rights enforcement technologies (RETs) only if it is possible to achieve trust between the server and the RET running on the client machines. We term the trust placed by the server in the client system as system level trust. Negotiations Layer plays a crucial role in establishing system level trust. The REI Layer provides the service of rights expression and interpretation to the Negotiations Layer operating above the REI Layer. The Application Layer operates on the top of the Negotiations Layer. Let us look at the range of services available to the Application Layer.

- System level trust in the rights enforcement technology running on the rendering device
- Service of rights expression and interpretation
- Rights enforcement

These three services provided to the Application Layer separate the services provided by the Application Layer form the rights enforcement technologies on the user systems. The Application Layer services can be developed independent of the underlying technologies running on client systems. Any change in the RETs only affects the system level trust in the Negotiations Layer and leaves the Application Layer unaffected. The Application Layer services are more business specific and play a major role in helping DRM systems adapt to different business models.

2.2 Tussle Spaces

The design of the Internet was inspired by technological challenges. As more people began using the Internet, naturally business models started developing around the Internet. The integration of business into the Internet led to the creation of tussles between Internet players. These tussles started to dominate the development of the Internet. The influence of these tussles, started threatening some of the basic tenets on which the Internet was built. Clarke et al. [2] emphasize the need for new design strategies to accommodate different tussles in the Internet players. It is important that these tussles do not affect the stability and flexibility of the Internet. Thus, they propose the following design principles that should be followed in order to deal with tussles:

- Do not design to dictate the outcome. Rigid designs will be broken; designs that permit variations will flex under pressure and survive.
- Modularize the design along the tussle boundaries, so that one tussle does not spill over and distort unrelated issues.

- Design for choice to permit different players to express their preferences.

In [4] we point out that the challenges currently faced by the DRM industry are similar to those faced by the telecommunications industry in the early eighties. There are however some sharp differences in the challenges faced by the DRM industry and the Internet. In the networking world, the technology came first and the business models later. The business models were developed to adapt themselves to the available technology. The design of the Internet and its flexibility later adapted to the changes in the business models and supported the emerging ones. In rights management industry, there are well established rights management business models in place. These models were proved and tested in the non-digital rights management world. Companies are generally reluctant to change their existing business models for newer ones. Any DRM technology should therefore be flexible enough to adapt itself to different business models. It should also be able to support any changes in the business models and should work for the new emerging business models.

With regards to tussles, DRM faces more severe challenges than those currently faced by the Internet. DRM is all about business and tussles are an integral part of business. There are three main players in the DRM industry: Content owner, content distributor and user. Each of these players have their own goals. The goal of the content provider is to have a choice in selection of employing a content distributor for his work. The goals of the content distributor include market success, ability to target a large user base, high control over user activity, and keeping out new entrants. The goals of the user include service provider independence, high rights expressive power and choice of services. It can be observed that these goals are conflicting and thus there exists different kinds of tussles among these players over different issues. Next we consider some of the important tussles developing in the DRM industry.

Usage control tussle. This is one of the biggest tussles in the DRM industry. The content distributor wants to have maximum control over the way the content is being used by the user. On the other hand, the user wishes to have maximum flexibility in the way the content is used. By its very nature, DRM is different than most of the industries. In DRM, the user is generally looked upon as the exploiter and the content distributor or the content owner is considered to be the one who is exploited. This is one of the reasons why the first generation DRM systems were content-distributor-centric and heavily emphasized copy protection. The copy-protection-oriented first generation DRM systems were rejected by users. The users demanded more expressive power and usage flexibility when it came to using digital data. The lack of choice of service and usage flexibility were some of the main reasons for the failure of first generation DRM systems. There is a tussle here. Any DRM systems which do not provide the users enough flexibility to use the content are going to be rejected by the users. The content providers will eventually lose out if the DRM system does not work out. DRM systems which provide greater flexibility to the users for using the digital content are more susceptible to security breaches than the DRM systems which exercise a greater control on content usage. The content owners and content distributors will be wary of introducing any sensitive digital content in DRM systems which are susceptible to security breaches. In this case the user will eventually lose out by paying more money as a result of failure of implementation of DRM system. This is a deadlock. Technology can help to solve the deadlock here.

The layered DRM framework solves this deadlock. The layered framework separates the RETs from DRM services. The DRM user is thus free to use his choice of RET. In a layered framework, usage flexibility allowed by the content provider totally depends upon the system level trust that the content provider has in the client RET software. The usage flexibility is high if the the content provider has a high trust in the user RET, whereas it is low if the the trust level is low. Thus the flexibility of the structure is modulated by the trust level between the user and content provider. The user now has a choice of level of usage flexibility he wants to enjoy. A user with sophisticated

RET will enjoy a greater flexibility as compared to the one with a rudimentary RET. Usage flexibility is also dependent on personal trust. A user with better trust history will be able to use the content with more freedom than the one with a worse trust history. By implementing these policies, a space is provided for the tussle where the involved parties can compete.

Service provider independence. Most of DRM system built today have the services dependent on the rights enforcement technologies. This forces the users to use a complete solution provided by a single content provider. These is a tussle between the user and the content provider here. The content provider wants to keep the user whereas the user wants to have a choice in selecting his own content provider. In the current DRM setup if a user has to quit one content provider and use a different one, then he has to download the RET software from the other content provider. This acts as a deterrent for changing the content provider. What is needed is a mechanism where a user has the freedom to change the content provider with minimal overhead on hid part.

Since the layered DRM framework separates the services from the RETs, a user having a single RET on his machine can change the content provider. Independence of services from RETs makes it possible to employ the services of different content providers over a single RET.

2.3 Tussles by Layer

Taking into consideration the different tussles in the DRM industry, each can be identified as being present in a specific layer in the proposed DRM framework. As mentioned in [2], such an identification and separation of the tussles is necessary so that one tussle does not spill over and distort other parts of the system. The separation of these tussles will also make it easier to study and manage these tussles independently.

- **Application Layer:** This layer deals with the business models that would be adopted by the different DRM vendors. Application Layer will experience tussle among the existing DRM vendors and the potential entrants in the DRM industry. The existing vendors will try to keep out the potential new entrants. On the other hand the new entrants will demand for a space in the existing market.

- **Negotiations Layer:** This layer will experience a tussle between the customers and DRM vendors. Negotiations Layer is a service layer. Users will demand flexibility of services. The users will demand a range of services from the DRM vendors. The users will want to have the freedom of changing the DRM vendor based on the services provided. The user will therefore expect minimal overhead while changing the DRM vendor service. The DRM vendors on the other hand will want to keep the customers and prevent them from going to a different vendor. The process of standardization will play a crucial role in addressing this issue [1]. A similar tussle is faced in the networking industry where users want the freedom to choose the ISP's whereas service providers want to take away that freedom [2].

- **REI Layer:** The REI Layer separates the services from the RETs. The tussle in this layer will be around the choice of RET. The users will want to use the RET of their choice. On the other hand the DRM vendors will want the users to use the RET developed by the DRM vendors. Currently most of the RETs are heavyweight and require an onerous download on the part of user.

- **Digital Rights Enforcement Upper Layer:** A tussle in the Digital Rights Enforcement (DRE) upper layer will be access control. The DRM vendors will want to have compete control over which softwares get the access to the content. The user on the other hand will

want to use the rendering device of his choice to view the content. The tussle can be solved by implementation of appropriate protocols in the Negotiations Layer.

- **Digital Rights Enforcement Lower Layer:** Tussles in this layer will be over the freedom to use the content over multiple devices. This is one of the major tussles in the DRM industry. The users want to have a complete freedom over the way the content is being used. The users demand to use the content over multiple devices of their choice. On the other hand the DRM vendors wish to have a strict control over which devices get access to the content. This tussle can be resolved by having sophisticated trust establishment mechanisms by which the DRM vendor will have a guarantee that the rights are not violated in when the content passes from one device to the other. SealedMedia technologies implement this functionality by using the concept of roaming licenses to emulate a physical license [8].

2.4 Innovation versus Standards

We discussed the tussles emerging in the DRM industry in the different layers of the DRM framework. As noted in Clarke et al. [2], the outcome of the tussles need not be defined by technologists. Any attempt to bias these tussles in the favor of a particular party will be rejected by the other one. It is necessary to create a right environment where an equilibrium can be reached among the players with conflicting interests. The creation of the right environment is actually defining the standards. Standards should be carefully defined so as to control the impact of tussles on the system architecture on one hand and allow a well controlled evolution of the technologies on the other hand by providing enough space for innovation. A layered architecture for DRM will help to achieve this equilibrium. As seen before, it is possible to identify and separate the tussles in the DRM industry according the different layers. Effective management of these tussles will depend upon how standards are defined in such a system. The definition of the standards will depend upon the interests of each of parties involved in the tussle and the impact of their interests on the layered framework.

2.5 e-Content Business Models

Most of the DRM systems are modeled on the rights management systems which existed in the non-digital world. One of the biggest challenges faced by the DRM industry is that the DRM systems should be flexible enough to adapt themselves to the existing business models and also the emerging ones. Some of the DRM business models discussed in [7] are:

Paid Downloads In paid downloads, the user pays to the content provider every time he buys content. Paid downloads emulate the physical world business model where one goes to a store and buys a book and has to pay every time a purchase is made. It has been pointed out that paid downloads work for high valued products. The issues with paid downloads are as follows [7]:

1. Complex to use content
2. Complex to use DRM technology
3. Device independence necessary

Subscriptions. Subscriptions are service based and hence is a more sophisticated business model than paid downloads. Subscriptions are advantageous to the content providers as well as the users. The subscription model helps the content providers to estimate the revenues well in advance. To the users, subscription is beneficial because it is easy to use content under subscription. One of the biggest hurdles in deploying subscription is the inefficiency of the rights enforcement technologies [7].

Pay-per-view and pay-per-listen. Pay-per-view and pay-per-listen business models are service based. Every time the service is utilized by the user, the user is supposed to pay to the content provider. This business model has been successful in video content. Video on Demand service is provided by many content providers with decent success in hotels and flights. The pay-per-view business model has been successful in time sensitive content, where the content has a little value after a specified period of time [7].

Usage metering. Usage metering is service based. The total charge put on the user is determined by the metered usage of the service. Usage metering works well with the low income group because they can control the usage and expect to be billed accordingly. In case of DRM usage metering can be well implemented because DRM is capable of recording the usage of the content and correspondingly report it to the content provider. Usage metering has more of market value then being helpful in collecting revenues. Usage metering can help in collecting usage patterns and customer preferences.

Peer-to-peer and Superdistribution. Peer-to-peer and superdistribution have started gaining importance in the DRM industry. Technologies like Napster and Kazaa have helped in sharing files over the network. Peer-to-peer networks can transfer data along the chain of users in the network. Superdistribution is a process where the content is distributed through a chain of users. Each user in the chain acts as a distributor himself and the payments propagate back along the distribution chain with each distributor getting his share of payment. It is desirable for the DRM industry to use the peer-to-peer technology to achieve superdistribution. If implemented, this can provide a very sophisticated and fast content distribution model which will help both the content provider and the user. The content provider will be able to reach a wide range of users with little investments on his part. The user will benefit with a cheaper rates and access to a huge content database.

All these business models are suited best for a selective content and a selective group of customers. A business model which is profitable in a particular environment may prove to be disastrous in another one. It is therefore necessary that the DRM vendors are able to adopt to any of these business models with ease. These business models offer various services depending on the need of the need of the customer. These services are implemented differently in each of these business models. These services are payments, monetary transactions, establishment of personal trust and risk assessment etc. The DRM vendors will desire that making changes to these services to change over to a different business model should not require to make changes to the complete DRM solutions. It should by possible to make the changes by having least impact on the other parts of the system. The DRM layered system addresses these issues by identifying and placing these functions in a separate layer so that changes can be made to them by not affecting the other layers of the system. The functions influenced by the business models are placed in the upper layers. Most of the functions mentioned able can be separately implemented in the Application Layer while some of them will require support from the functions in the Negotiations Layer.

The same is true for content distribution models. If a DRM vendor wants to switch over to a different content distribution model than the existing one, then it should be possible to do so with minimal overhead. The protocols implemented in the Negotiations Layer and the REI Layer will decide the type of distribution model adopted by a DRM vendor. Let us consider the case of superdistribution where the customer also assumes the role of a content distributor. In this case protocols can be implemented in the Negotiations Layer to check the capabilities of the customer to act as a content distributor. The propagation of payments along the distribution chain can be handled in the Application Layer. A layered DRM framework separates functions deciding the distribution methods from the rest of the system, making it possible for the vendor to adopt a different distribution strategy with minimal changes in the remaining system.

3 Vendor Economics

One of the major tussles in any industry is the space for new entrants, which is normally blocked by the established parties already active in the industry. This is essential for a healthy competition within the industry. Competition leads to better services and innovation. It is therefore the responsibility of the designers to provide enough space for the new entrants and the smaller players. The standards in the framework should also be defined so that it gives enough space for the vendors to provide attractive services to the users that will give them a edge over their competitors. It is essential for the existing DRM vendors to meet the changing needs of the users and ability to respond to the changes in the business models. DRM solutions are useless if there are security breaches in the DRM solutions. Technology should therefore provide means for the DRM solutions to detect security breaches and recover from them in order to keep the confidence of content owners. Let us look at each of these aspects to see what role technology can play to provide solutions for these challenges.

3.1 Space for New Entrants

Currently DRM vendors provide complete solutions to DRM. Interoperability of DRM is still in its initial stages. Thus the DRM vendors are expected to provide services as well as their own rights enforcement technologies. Rights enforcement technologies are sophisticated high technology solutions. A huge amount of investment is necessary to develop near foolproof rights enforcement technologies. This deters new entrants who do not have enough capital to invest in DRM. Also since services are not independent of the RETs, operating system and rendering device manufacturers do not get enough incentive to incorporate DRM in their products unless they decide to provide complete DRM solutions. As a result of this we have DRM vendors who try to provide complete solutions including rights enforcement, with little support from operating system and rendering device vendors. These rights enforcement technologies have overlay architectures and thus are susceptible to security breaches at kernel levels. This would not have been the case if enough support is provided by the operating system and rendering device manufacturers. It is also the case that these vendors try to meet every DRM requirement. The size of their solutions, changes in DRM requirements and rapidly changing rendering devices often make these DRM solutions obsolete.

The layered DRM framework divides the process of DRM in layers and essentially separates the services from rights enforcement technologies. As pointed out earlier, the range of services provided by the DRM vendors would depend on the amount of system level trust the DRM server has in the RETs running on user platforms. It is therefore the responsibility of the user to buy sophisticated RETs to enjoy a wider range of services. To enjoy wide range of services, the users would demand sophisticated RETs from the device manufacturers and operating system vendors. This is a justifiable incentive for the device manufacturers and operating system vendors to include sophisticated DRM solutions in their products. This provide a boost for investment of significant capital in the research and development of sophisticated RETs. This is possible because there is no obligation on the rendering device and operating system manufacturers to provide complete DRM solutions.

The separation of DRM services from the RETs makes it possible to provide DRM services independent of RETs. This makes it possible for the potential entrants in the DRM industry to provide DRM services. The potential entrants can provide attractive DRM services to the users without making large investments in the RETs. Since it is possible to provide a choice of service at the Application Layer and the Negotiations Layer, the new entrants can choose the choice of service they intend to provide without invading the market of other DRM vendors.

3.2 Space for Competition

As discussed earlier, the DRM vendors provide complete DRM solutions. Most of the times, users have to download the rights enforcement software to use the DRM services. This process locks the users in using the services of a certain DRM vendor. The separation of DRM services from the RETs, addresses this issue and makes DRM vendor independence possible. Given this, DRM should provide space for the DRM vendors to implement services with added value so that they have a edge over their competitors in providing DRM services to the users.

The Application Layer and the Negotiations Layer, both of which are service layers, address this issue. DRM vendors can provide attractive DRM services to the users, by providing different kinds of services in these layers. Different kinds of attractive pricing models can be implemented in the Application Layer. Range of system level services can be implemented in the Negotiations Layer. Lightweight DRM services implemented in the Negotiations Layer will address the needs of naive DRM users, while heavyweight DRM services will address the needs of sophisticated users. It is essential that standards are carefully defined so that they provides enough space for the DRM vendors to provide competitive offerings.

3.3 Survival

The requirements of the DRM industry are rapidly changing. It is necessary for the DRM vendors to adapt themselves to the new emerging business models. The technology should therefore provide the ability to employ different business models without making major changes in the already installed technology. Security breaches in the DRM systems are a major deterrent for the content owners to introduce their products in the DRM market. To survive the competition, the DRM vendors should be able to recover from the security breaches in their solutions. This is essential to maintain the confidence of the content owners and also prevent losing the market share. It is therefore necessary for the DRM technologies to provide protection against security breaches.

Complex services can be created in the Application Layer to adapt the DRM solution to different business models, to cater the needs of different users and stay alive in the competition. Here are some of the services can that be implemented in the Application Layer

- **Money transactions:** This service would include facilities for the payment of the purchase. This service can be very simple which would include means of payment by the user to the service provider, in case of normal distribution of content. This service will be very complex in case of superdistribution where the payments propagate along the distribution chain. Complex money transactions can be built for B-to-B applications.

- **Content tracking and usage:** The information on content usage and tracking of content can be provided to the user by means of the Application Layer. This information will be passed on to the Application Layer by the Negotiations Layer.

- **Risk assessment:** Risk assessment means calculating the total risk associated with the transaction. Risk assessment calculation depends upon a number of factors like personal trust, system level trust, nature of data, importance of data, nature of rights demanded by the user and vulnerabilities in the transmission medium etc. Application Layer can provide the service of risk assessment. Application Layer would need the services of Negotiations Layer to calculate the system level risk.

- **Pricing models:** Dynamic price calculation can be implemented in the Application Layer. Dynamic price calculation is calculating the price of the rights for some content on-the-fly. Corbis.com implements this functionality for calculating the price for the images sold under "rights managed" category. The price of an image is calculated depending on the nature of

rights demanded by the user. Complex algorithms can be used to determine the price of an image by using the transaction risk calculation. If implemented in this manner, this service will require support from the Negotiations Layer.

Content tracking and usage information gathering can be implemented in the Negotiations Layer. To survive in the industry, the DRM solution must have facilities for detection of violation of rights so that corrective actions can be taken to recover from the security breaches. In order to recover from the security breaches, it is essential to first detect security breaches. The service of detecting content usage and rights violations will be implemented in the Negotiations Layer. Client systems can provide audits on the usage of the content on the their systems. Sealed media technology uses this method to track the usage of content on the client systems [8]. Negotiations Layer can have standard protocols for maintaining and reporting the usage audits. Once the audits are obtained from the clients, a system can be implemented at the server part of the Negotiations Layer to detect any violations of rights. If it is found that unprecedented rights violations are taking place on certain systems, corrective actions can be taken to recover from the security breaches on those systems.

4 Conclusions

In this paper we point out that how a layered DRM framework will facilitate the development of stable DRM solutions which will help to manage the on going tussle between the customers and DRM vendors. The current technological setting the DRM industry has failed to address these problems resulting in large number of failures for DRM vendors. We also discussed how changing requirements in services and rapidly changing content rendering platforms are making it difficult for DRM vendors to implement stable solutions. The separation of DRM services from the rights enforcement technologies greatly facilitates the development of stable solutions. Finally we considered how a layered DRM framework can have a major influence on DRM vendor economics. Such a framework provides a space for competition among existing vendors as well as a space for potential entrants into the DRM industry. A layered DRM framework can thus facilitate the transition of vendors from the second phase of the DRM market to the third phase.

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