Using Social Factors in Digital Rights Management

Bader Ali and *Muthucumaru Maheswaran*
Advanced Networking Research Lab
School of Computer Science
McGill University
Montreal, QC H3A 2A7, Canada
Email: {bali2, maheswar}@cs.mcgill.ca

Abstract

This paper describes how social factors can be incorporated into digital rights management. Specifically, we outline a design for a social distribution network that is built by agents that have incentive to discourage piracy. We pose the social distribution network formation as a game theoretic problem and identify the games played by the two types of agents.

1 Introduction

The Internet with its pervasive presence is becoming an ideal platform for quickly distributing music, movies, games, and books to end-users. This is evident from the popularity of the many music stores such as iTunes, 7digital, Napster, movie stores such as iTunes, and e-book stores such as Amazon on the Internet. One of the challenging problems faced by Internet-based stores and digital content providers in general is protecting the digital content from *piracy* (unauthorized copy, use, and distribution).

Although there are several arguments to the contrary [3], the common perception is that piracy hurts the music and movie industry. A study [1] conducted by the Motion Picture Association of America has found that major U.S. motion picture studios lost $6.1 billion in 2005 due to movie piracy. Due to the magnitude of the financial losses associated with piracy, not surprisingly, many anti-piracy efforts are underway. We categorize these efforts based on the following factors:

- *Digital locking:* Software and hardware techniques (collectively referred to as the *Digital Rights Management* (DRM)) to control the rights end-users have to copy and use digital content. Although these efforts can slow down piracy, they cannot prevent it because attackers have so far succeeded in breaking the locks using the vulnerabilities in the techniques or the platforms.
- *Legal measures:* The DRM techniques [12] are often bolstered by laws that can be used to punish violators. The *Recording Industry Association of America* has brought lawsuits against individuals or organizations for consuming or distributing pirated content.
- *Reducing availability:* Increasingly, the Internet is becoming the preferred distribution mechanism for pirated content. This also provides another strategy to combat piracy – reducing the availability of pirated content. For example, this can be achieved by using legal means to take down distribution sites or inject polluted content into the distribution sites.

Despite significant advancements, implementing DRM on the Internet remains a hard problem. First, in some quarters, piracy is not considered a crime [3]. It is argued that piracy can increase social welfare and even benefit the content producers under certain conditions. Second, unlike other theft, no or very little social stigma is associated with digital piracy [6]. Third, it is hard for the content producer to closely monitor the behavior of the end-users to track DRM violations.

Our work takes a different approach to the problem. We assume people are connected by an *online social network* (OSN) (e.g., Facebook [2]). We overlay a *social distribution network* (SDN) over the OSN for distributing content. The SDN is centered at the *content provider* (e.g. iTunes) and is made up of distributors and consumers selected from the OSN. The SDN is built and maintained such that it uses economic incentives and social pressure [5, 8] between friends to reduce piracy.

In the normal scenario, a customer buys content directly from the content provider and is bound by the DRM measures applied by the content provider. With SDN, the customer buys the content from a neighborhood distributor. This distributor is a friendly neighbor of the customer in the OSN. The distributor is able to provide lower prices for the content than the content provider. (In most implementations, we expect the actual content distribution to take place directly from the content provider. The distributor sells a licence to use the content or a key to obtain the content from the content provider.) In return for the lower prices, the distributor expects the customer to abide by the DRM requirements for the content even when opportunities are available for violating them.

The SDN is a “grass roots” approach to anti-piracy. It recruits members of the OSN as distributors to fight piracy. It has many similarities to other social network based initiatives such as microfinance [7, 14, 11]. In microfinance, social connections within communities are leveraged to minimize the risk in lending. It has been observed (particularly in developing countries) that when the lender (e.g., a bank) does not have the resources to directly monitor borrower behavior, microfinance model can be low-risk alternative. In this model, the peers of the borrower from the same social network are enlisted to monitor and persuade the borrower to abide by the terms of lending.

2 Social Factors in DRM

We develop a new model for implementing DRM on the Internet. The salient aspect of our model is the addition of the social factors (in particular social pressure [5]) to the normal DRM scheme to increase its effectiveness. We start by presenting a system model that explains the different agents of our proposal and the relationship between the agents. Next, we develop the games to model the different interactions between the involved agents and analyze the different strategies that can be utilized in order to reach the desired goals.

2.1 System Model and Assumptions

We assume that all users are connected by an OSN. The content provider (e.g., iTunes) which is not part of the OSN periodically chooses some people from the OSN as distributors. Rest of the people are considered as consumers. The distributors are the local agents of the content provider within the OSN. A consumer wanting to buy content can reach the neighborhood distributor and get a cheaper price for a movie or song than directly buying it from the content provider. Because distributors are providing content at cheaper price, the consumers want them in their neighborhood. At least each consumer may want to have access to a distributor that has good discounts on content. The distributors expect the consumers to abide by the DRM requirements that is normally associated with the content. If the consumers do not abide by the DRM requirements, the distributors can impose punishments on the consumers by blacklisting them. Because peer monitoring (determining who exactly pirated the content) is tough problem, we propose to use group punishments. The group punishments can bring social pressure on the pirates to dissuade them. Alternatively, people who do not pirate content will distance themselves from the pirates so that they can continue to enjoy the discounted prices.

The SDN formation process consists of two phases. The first phase shown in Figure 1 selects the distributors and continuously evaluates them. The distributor selection is triggered when the content provider receives a request from a social network user seeking the distributor role. The content provider is interested in preventing or at least minimizing piracy and simultaneously maximizing its revenue. To achieve this dual objective, the selection process computes two parameters. The first parameter is called the *distributor potential* (DP) in Figure 1. This is a measure of the capacity of a node to be distributor. The DP can be governed by several factors and should be obtained by solving the distributor game posed in Section 2.2. The DP value can be impacted by several factors such as density of connections around the node on the social network. For instance, a node with highly connected clusters in its neighborhood can sell content to large number of users and at the same time could impose significant pressure to reduce piracy. Because DP is a parameter computed based on the topological structure of the social graph, it does not change unless the topology changes (i.e., new links made and old links removed). Another parameter computed for a distributor is *piracy rate* (PR) as shown in Figure 1. The PR is a rate that is computed by the content provider for each distributor. We assume that the content provider tags the content sold by each distributor using watermarks or fuzzy hashing techniques [15, 4]. The effectiveness of watermarks to identify content is disputed. Investigating watermarking is not within the scope of this study. Therefore, we assume the existence of a suitable method. Further, it should be noted that we do not intend to identify the content at a per consumer level. It is sufficient if the content can be identified at a much coarser group level.

We assume that the content provider would periodically scan the pirated content distribution sites and check whether any of the content distributed through the SDN is posted on those sites. If the SDN content is found, it is matched to a distributor using watermarks, fuzzy hashing, or other mapping techniques. Once the pirated content is attributed, the PR of the corresponding distributor is revised. The piracy event is also given to the distributor so that it could act as shown in Figure 2.

In the second phase as shown in Figure 2, consumers wanting to buy movies or music contact the distributors. The greediest strategy the distributors could adopt

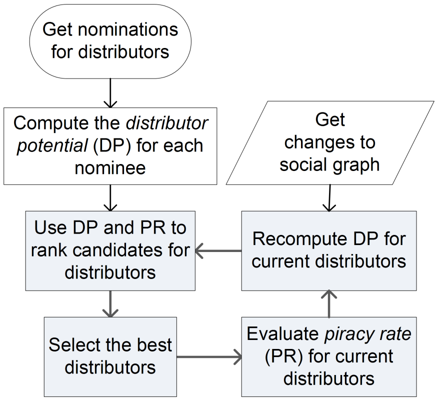
Get nominations for distributors
Compute the *distributor potential* (DP) for each nominee
Get changes to social graph
Use DP and PR to rank candidates for distributors
Recompute DP for current distributors
Select the best distributors
Evaluate *piracy rate* (PR) for current distributors

Figure 1: Flow chart for distributor selection process.

is to sell content to any customer wanting to buy. However, this no conditions attached selling is not desirable. The PR is also an important consideration. The content provider computes the PR and attributes it to the distributor. Eventually (after few rounds) a careless distributor will be punished by revoking its distributor status according to the process in Figure 1.

To be effective, a distributor should use a distribution scheme that leverages social relations to exert social pressure on the consumers in order to discourage content piracy. In our scheme, the distributor artificially map consumers into social groups where each consumer is associated with one group. The distributor will then associate a unique digital mark with all the content distributed to each social group. Therefore, for any given request, the distributor will identify the social group to which the consumer belongs, and then deliver to the consumer a copy of the marked content that is associated with that group. Using this scheme the distributor will be able to, in case his content is pirated, identify the groups from which the content was leaked and then punish the group by blacklisting all of its members and making them pay more for the content. Although, certain members could potentially be punished for the misbehavior of others, we believe that this scheme can be very effective in preventing content piracy from occurring in the first place. A consumer who considers pirating content will be under extreme pressure because he realizes that the consequences of this action would not only affect him but also the members of his group.

Thus, a critical aspect of the social group formation process is the maximization of the social pressure within the group. We believe that social pressure is maximized in social groups where its members are strongly connected with each other (very close friends). On social networks, cliques often indicate the existence of social groups that exhibit very strong ties [16]. Based on this, we propose a group formation process that is based on identifying cliques as groups. The clique formation is carried on a set of consumers that are within the neighborhood of the distributor. The size and stretch of the social neighborhood for a particular distributor depend on factors such as the network structural properties of the neighborhood and the limits enforced on the number of desired groups.

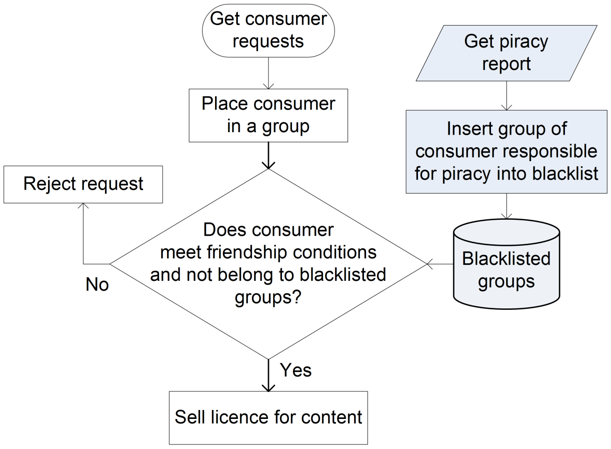
Get consumer requests
Get piracy report
Place consumer in a group
Insert group of consumer responsible for piracy into blacklist
Reject request
Does consumer meet friendship conditions and not belong to blacklisted groups?
Blacklisted groups
No
Yes
Sell licence for content

Figure 2: Flow chart for the consumer selection process.

2.2 Game Models

2.2.1 Distributor Game

The main goal of the *content provider* in the distributor selection process is to enlist the help of nodes in the social network to prevent or minimize content piracy. The content provider is particularly concerned about the strategy used by the distributors to reach the consumers. The content provider needs to compel the distributors to use a strategy that shows to the customers that pirating is not a high payoff strategy for them in the long run. The distributors' decision to adopt a particular distribution strategy solely depends on the costs and benefits associated with the strategy. We use a *distributor game* to model the selection process for a particular distributor and analyze the incentives that the involved parties have for the different choices.

A distributor game has two players: (i) the content provider, CP (the owner of the content) and (ii) the distributor, D, who will distribute the content on the content provider's behalf. The distributor game is initiated whenever a social network node (i.e., user) seeks the distributor role. In the first move, the content provider will either select or not select the candidate distributor. If the content provider decides not to select the candidate distributor, then the game ends. If selected by the content provider, then the turn goes to the distributor. In the game, the distributor's move depends on the distribu-

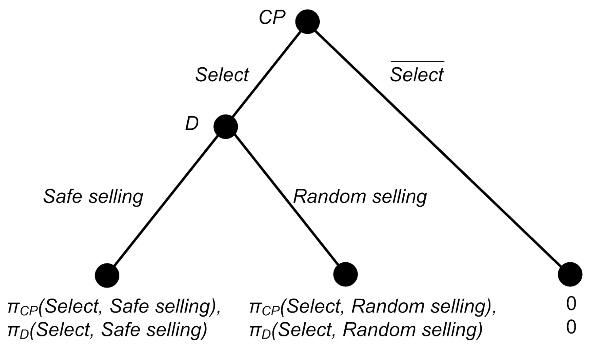
CP
Select
$\overline{Select}$
D
Safe selling
Random selling
π_{CP}(Select, Safe selling),
π_D(Select, Safe selling)
π_{CP}(Select, Random selling),
π_D(Select, Random selling)
0
0

Figure 3: Extensive form of the distributor game.

tion scheme that will be adopted by the distributor. The distributor can choose one strategy from "safe selling" or "random selling." Here, we use safe selling to refer to a conservative strategy where the distributor sells to only those consumers who he predicts will choose not to pirate because that is their high payoff strategy. While random selling is basically an unrestricted selling strategy, where the distributor will sell the content to any consumer without caring about the payoffs the consumer has for the cases of pirating versus not pirating. The game tree of the distributor game is shown in Figure 3.

The payoff values in the game reflect the players' preferences for the different outcomes. For the distributor game, the content provider prefers the outcome in which the distributor is selected and the distributor practices safe selling over the other outcomes because it results in lowering content piracy. Also, the choice of not selecting the distributor is preferred by the content provider over the case where the distributor practices random selling once selected. So in terms of the payoffs we have $\pi_{CP}(select, safe\ selling) > 0 > \pi_{CP}(\overline{select}, random\ selling)$. The distributor prefers the outcome in which he is selected and practices random selling. Because this strategy requires less effort than safe selling and can yield higher revenue which can increase the profit. Additionally, any outcome in which the distributor is selected is preferred over the outcome when he is not selected. Thus, for the payoffs we have $\pi_D(\overline{select}, random\ selling) > \pi_D(select, safe\ selling) > 0$.

Based on the payoffs, the combination of strategies that form a Nash equilibrium for a single distributor game are ($\overline{select}$, $random\ selling$). The reason is if content provider's strategy is to select the distributor then the distributor is always better off practicing random selling because it results in the highest payoff. Given the distributor's choice, the best strategy for the content provider is to not select the distributor. Thus, for a single distributor game, as long as the aforementioned players' preferences hold, no change in strategy by the content provider that can cause the distributor to cooperate by changing the selling strategy.

However, by considering a repeated distributor game, we open up the possibility of changing the players behaviors and strategies. In a repeated game, a player will be willing to cooperate and sacrifice short-term gains if he realizes that by cooperating he will avoid being punished in future encounters. In a repeated distributor game, the content provider could threaten to punish the distributor by not selecting him in the future. A cooperative equilibrium, in which the content provider expects the distributor to practice safe selling, can be realized if the distributor's short-term gains from practicing random selling is less than the long term losses that the distributor will incur from not being selected as a distributor in future games.

While we don't provide complete equilibrium analysis for the repeated distributor game in this work, we point out the essential factors that influence the equilibrium conditions. In repeated games, time plays an important role, a distributor who cares more about future profits will be more willing to cooperate because his long term losses will be high in case he defects. Also, the way in which the distributor is embedded within the social network (network embeddedness) can affect the distributor's behavior in different ways. A distributor with many friends on the social network will be able to distribute the content to more consumers and generate greater profits. For such distributors, the disincentive for any defection will be great because the future losses they incur will be high.

2.2.2 Consumer Game

In this section, we focus on the interactions that take place between the distributors and the consumers. When distributing content, the distributor is concerned about two things, maximizing his profit and minimizing content piracy. As discussed previously, one way for the distributor to prevent content piracy is to exert social pressure on the consumers in order to eliminate the incentive for piracy. Thus, for this analysis, we will assume that the distributors will always use safe selling as their distribution strategy. Here, safe selling refers to the distribution scheme based on social groups described in section 2.1

We use a consumer game to represent a sales transaction. The players of the consumer game are a distributor, D, and a consumer, C. The consumer game tree is shown in Figure 4. A consumer game begins whenever a consumer expresses interest in buying a content. In the game, the distributor will decide whether to sell or not sell the content to the consumer. If the distributor doesn't sell the content, the game ends. Once the content is sold, the consumer can choose to either pirate or not pirate

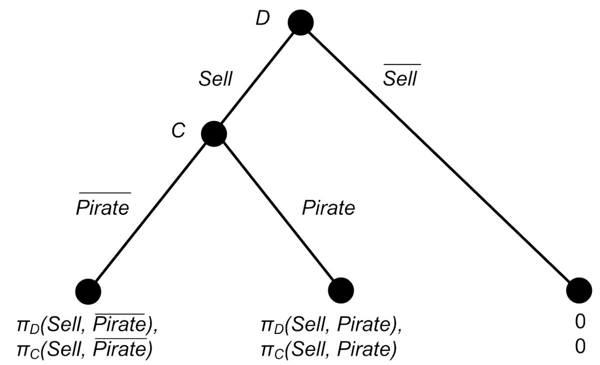

Figure 4: Extensive form of the consumer game.

the content. The distributor's preferences for the different outcomes of the game are $\pi_D(sell, \overline{pirate}) > 0 > \pi_D(sell, pirate)$, while the consumer's preferences are $\pi_C(sell, pirate) > \pi_C(sell, \overline{pirate}) > 0$. We note that the consumer game is very similar to the structure of the distributor game. When considering a single consumer game, the players' strategies that form a Nash equilibrium are $(\overline{sell}, pirate)$. That is, if the content is sold to a consumer, the best strategy he has is to pirate the content because it results in the highest payoff. Given this, the distributor is always better off not selling the content.

Once again, by considering a repeated consumer game, we can focus on the different strategies that can be utilized by the distributor in order to shift the equilibrium point to $(sell, \overline{pirate})$. One way to dissuade consumers from pirating the content is by providing enough disincentive for such behavior. The distributor can discourage piracy by punishing defecting consumers, who pirate content, in future encounters. In safe selling, the fact that the distributor will punish the social group to which the pirate belongs to by blacklisting the group, provides a large disincentive for two reasons. First, the consumer will be denied the advantage of obtaining new content at a discounted price in the future. Second, the fact that the punishment is applied to the consumer's friend in the social group puts an immense social pressure on the consumer because he risks severing the relationship with his friends. Thus, a consumer will be willing to overlook the short term gains from pirating if his long term losses are much higher.

3 Related Work

Here, we briefly discuss previous work by others in using game theory to investigate the Digital Rights Management (DRM) problem. The work in [9], presents a DRM game to model the strategies associated with various DRM approaches. The DRM game consists of two subgames, one associated with content acquisition, and the second one dealing with post content acquisition decisions. In the DRM game, the authors consider two strategies. One that punishes users for sharing content and another that rewards users for not sharing content. Analyzing the two strategies, the authors claim that an equilibrium can be established much easier when using a reward based strategy. To implement these strategies, a trust authority middleware infrastructure is suggested in order to rate the behavior of customers and reward them accordingly.

The Secret Incentives-based Escrow System (SPIES) applies game theory to DRM systems where content protection is of interest [13]. This system is suited for applications where a secret must be protected for only a limited period of time and shared between two parties. SPIES is based on providing negative incentive for distribution of digital content beyond authorized possessors. The system consists of three stages: exchange of the secret and placement of funds in escrow; registration of content holders; and release of escrowed funds to registrants. Using a game model of system, the authors show that for the secret provider, the best strategy is to use SPIES when the secret has value and the consumer has incentive to resell the content. The consumer of the content gains the most utility from purchasing the content, placing money in escrow, and not reselling or distributing the content, so that the escrowed funds are returned.

The work in [10] presents a system architecture that uses economic incentives to motivate users to keep the content within the subscription community on P2P file sharing systems. Similar to the previous work, the system makes use of an escrow authority, where the escrow service pays users for sharing content with authorized users. These payments are intended to motivate users to keep content within a subscription community. Users who receive the content outside of the subscription community are not affected by this process.

In [17], the authors analyze the different security policies adopted by the various participants of the digital rights management ecosystem using game theory. The paper presents two game models, a cooperative game among digital contents provider, rights/service provider and digital devices provider, as well as a non-cooperative game between providers and consumers. The authors derive the conditions for the existence of pareto optimal equilibrium.

The only common aspect between our work and the previous initiatives is the application of game theoretic modeling for the DRM problem. Our work is focused on the development of a new model called social distribution network for selling content on the Internet. We use game theoretic models to engineer the incentives and punishment strategies to elicit maximum cooperation to reduce piracy.

4 Conclusion and Future Work

In this paper, we presented a new model called social distribution networks (SDNs) for selling content on the Internet. We described basic idea behind SDNs and showed the games for making the key decisions in forming and maintaining the SDNs.

The key benefit of SDNs over existing approaches is that the SDNs leverage the social factors in addition to factors such as digital locking, legal measures, and availability reduction to fight piracy. Therefore, we argue that SDNs provide a stronger approach to implement DRM.

This paper is an early report on the key ideas behind the SDNs. Much work needs to done in SDNs.

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