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The Digital Rights Management Game in Peer-to-Peer Streaming Systems

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***Abstract*—In this paper we model the digital rights management (DRM) for peer-to-peer streaming (P2PS) systems as a game. We construct the DRM game from both content service provider (CSP) and user's aspects, and propose a design of DRM policy based on homogeneous peers and homogeneous digital goods, which gets the maximal utility for the CSP as well as the criterion whether the DRM is fit for a P2PS system. Another sort of games in this paper consider how a peer deals with digital goods with regard to various situations in P2PS systems with DRM, together with the CSP's response to the peer's actions. We construct different games to avoid three notorious misbehaviors of peers: freeriding, jailbreaking and whitewashing. We take examples to show how these games work in P2PS systems with DRM and how equilibria are established in these games. Numerical experiments are conducted to demonstrate the effectiveness of the strategies devised from these games.**

***Index Terms*—Digital rights management, game theory, peer-to-peer streaming systems.**

I. Introduction

The effectiveness of using digital rights management (DRM) has been furiously debated since the DRM technologies came out. Its restrictions to the use of digital goods seem to overprotect the copyright of the content providers, which brings end users much inconvenience. Researchers in the DRM field are apt to a more open architectural framework of DRM which should be vastly different from what they are today and strike a more reasonable balance between content providers and end users. Some desirable properties, such as reusability, portability and flexibility, have been well addressed in numerous previous research studies [1]–[3]. In [4], Heileman et al. provide a new game-theoretic approach that considers the strategic situations in DRM environments and propose a different DRM environment along with a new trust authority component that allows a content provider to effectively influence end users' actions by rewarding good behaviors instead of punishing bad behaviors. However, this approach is a general one that may not be appropriate for the situations in peer-to-peer streaming (P2PS) systems.

In a P2PS system, a peer of end user can entertain some streaming content offered by a content service provider (CSP). To make the streaming service functioning normally, the CSP expects each peer to not only act as a receiver of the streaming content but also share the content with each other. A variety of mechanisms are proposed to motivate the voluntary sharing of peers [5]. However, some selfish users would break the principle of P2P sharing and choose the freeriding in order to save their own costs. Many studies show that the freeriding is a common phenomenon in P2P systems [6], [7] and this freeriding is sustainable in equilibrium and possible to reach a social optimum outcome [8]. It turns out that the monitoring and managing the streaming content, as a major part of the DRM in a P2PS system, becomes a challenging issue because the interests of both the CSP and peers should be considered. At the same time, the DRM should protect the streaming service from security threats and avoid the misbehaviors of the peers in the system. Moreover, as the user's viewing experience of a streaming content is easily affected by the delay introduced by the execution of a complicated algorithm, the devised DRM strategy should be light-weighted in general. The downgraded service for the user caused by the delay also backfires the revenue for the CSP.

In this paper we study the effects of using DRM in a P2PS system. We first consider a game for both the CSP and users whether or not to choose DRM in a P2P system, then we discuss the strategies to discourage three misbehaviors of peers in the P2PS system with DRM: freeriding, jailbreaking and whitewashing. The numerical experiments are conducted to show the effectiveness of our strategies.

II. The DRM Game in P2PS Systems

We start this section with the modeling of the DRM game which considers the P2PS system with and without DRM, then derive the equilibrium price based on this model, and lastly acquire the maximal utility for the CSP in the equilibrium as well as the criterion whether the CSP should apply the DRM to a P2PS system.

A. Model of the DRM Game

We model the P2PS system with the assumption of having homogeneous users and homogeneous digital goods (i.e., a small segment of streaming content) in the system. The utility of a digital goods that a user acquires in a P2PS system without DRM could consist of two parts, one part is the basic utility of the acquired digital goods, and the other is the losing utility owing to the security threats and misbehaviors of other peers. When a user enters a P2PS system, it will confront with two choices (Fig. 1(a)), one choice is that the P2PS system has no

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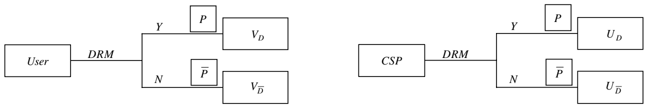

(a) User (b) CSP

Fig. 1. A general model for users and CSP to choose the P2PS system with and without DRM. P and $\overline{P}$ represent paying for the digital goods and not paying for the digital goods, respectively.

DRM and the user does not need to pay for the digital goods, but it may suffer potential security threats and unexpected service downgrading; the other is that the P2PS system has DRM and the user needs to pay for the digital goods, the user can thus encounter considerably less troubles. It is noted that in this work we mainly focus on the difference between the P2PS system without DRM and the one with DRM, therefore, we make many assumptions to simplify the model of the DRM game.

In the P2PS system without DRM, the gross utility a user could obtain from using a digital goods, $V_{\bar{D}}$, is denoted by $V_{\bar{D}} = V - L$, where V represents the basic utility of one digital goods and L represents the losing utility owing to the security threats and service downgrading when the user downloads and uploads that digital goods. When the P2PS system has DRM, the delay introduced by running the DRM system will have certain impact on the utility of the user, which should also be considered. We denote this influence as $H(t)$ where t is the delay caused by the DRM. Thus, the gross utility a user could obtain from the same digital goods in a P2PS system with DRM, V_D, is denoted as $V_D = VH(t) - P - (1 - Q)^{\alpha} L + Q^{\beta} C$, where P is the price of the digital goods, $Q \in [0, 1]$ is the turnover rate of the users when the P2PS system without DRM turns into the system with DRM, C is an extra utility obtained by the user due to the workload reduction saved by the turnover of one user, and α and β are positive constants. Since the security of the P2PS system is guarded by the DRM, the losing utility turns to be $(1 - Q)^{\alpha} L$. On account of the turnover in the P2PS system with DRM, the user's workload reduces due to fewer users in the system, so the user gets an extra utility $Q^{\beta} C$. Note that functions $(1 - Q)^{\alpha} L$ and $Q^{\beta} C$ are just used to indicate the impact of the turnover rate on the utility function of the user and are highly related to a specific system environment.

We characterize the influence function $H(t)$ as follows:

$$H(t) = \begin{cases} 1 & , \quad t \leq T; \\ -\frac{1}{4T^2}(t - T)^2 + 1 & , \quad T < t \leq 3T; \\ 0 & , \quad t > 3T. \end{cases}$$

If the delay is under a threshold T (i.e., $t \leq T$), $H(t) = 1$, the delay has no impact on the user's utility; the situation is the same as that in the P2PS system without DRM. If the delay is too long (i.e., $t > 3T$), $H(t) = 0$, users will run away from the P2PS system. When the delay is between T and $3T$, $H(t) = -\frac{1}{4T^2}(x - T)^2 + 1$, the delay will affect the utility of the user, which is fully consistent with the law of diminishing marginal utility.

For the CSP, we assume that it could obtain the utility U when one user receives one digital goods in the P2PS system without DRM. However, in the P2PS system with DRM, as users need to pay for the goods, some users may leave the system because of the DRM, and the CSP gets payment from the remaining users (Fig. 1(b)). The utility of the CSP contributed by one user in the P2PS system without DRM, denoted as $U_{\bar{D}}$, is $U_{\bar{D}} = U$. In the P2PS system with DRM, the utility contributed by one user is $UH(t)(1 - Q)^{\gamma}$ where γ is a positive constant. Moreover, the CSP can get a revenue $P(1 - Q)$ from the sale of the digital goods. Therefore, the utility of the CSP in the P2PS system with DRM is

$$U_D = UH(t)(1 - Q)^{\gamma} + P(1 - Q). \tag{1}$$

B. Equilibrium Price

In a free competition environment, the P2PS system with DRM may collapse if the CSP sells the digital goods at an unreasonable high price. If the CSP does not consider the interests of users and just increases the price of digital goods blindly, the users will give up using the digital goods when the price exceeds the utility the users can get from the goods. It is a natural way to get an equilibrium price based on the indifference between the utilities of a user in the P2PS system with and without DRM.

For a rational user, the utilities of the user in the P2PS system with and without DRM will be equal when the equilibrium is reached. That is, $V_D = V_{\bar{D}}$. The indifference between these two utilities can be represented by $VH(t) - (1 - Q)^{\alpha} L - P + Q^{\beta} C = V - L$.

Therefore, the equilibrium price of the digital goods is

$$P = V(H(t) - 1) + [1 - (1 - Q)^{\alpha}]L + Q^{\beta} C. \tag{2}$$

From Eq.(2), we can further discuss the relationship between the equilibrium price P and the turnover rate Q under the condition that the utility of a user reaches the balance in the P2PS system with and without DRM. It is easily seen that P is a monotone increasing function of Q when $Q \in [0, 1]$. As its inverse function, Q is also an increasing function of P. Thus, we can get the influence of the equilibrium price P on the turnover rate Q as follows:

Proposition 1: The turnover rate Q increases as the equilibrium price P increases when the utility of a user reaches the balance in the P2PS system with and without DRM.

Considering the function of $H(t)$, we can have the following observations from Eq.(2): When $P = 0$, $Q = 0$ only if $t \leq T$. It shows that when the digital goods is free in the P2PS system with DRM, there will be no turnover of users if the delay introduced by the DRM does not affect the user's utility. This is the same as the situation in the P2PS system without DRM. However, if the delay affects the user's utility (i.e., $H(t) < 1$ when $T < t \leq 3T$), then $V(1 - H(t)) > 0$. Thus, $[1 - (1 - Q)^{\alpha}]L + Q^{\beta} C = P + V(1 - H(t)) > 0$. Even when the digital goods is free in the P2PS system with DRM (i.e., $P = 0$), it is still that $Q > 0$, which means that some users will leave because of the delay introduced by the DRM system.

C. Optimal Strategy for the DRM Game

When the DRM game reaches the equilibrium, the utility of the CSP in a P2PS system with DRM depends on the turnover rate Q and the price P, with $U_D = UH(t)(1-Q)^\gamma + P(1-Q)$. Considering the equilibrium price P in Eq.(2), we get $U_D = UH(t)(1-Q)^\gamma + \{V(H(t)-1) + [1-(1-Q)^\alpha]L + Q^\beta C\}(1-Q)$. To simplify the discussion, we let $\alpha = 1, \beta = 1$ and $\gamma = 1$, then we get

$$U_D = UH(t)(1-Q) + [Q(L+C) + V(H(t)-1)](1-Q). \quad (3)$$

Maximizing this utility in the P2PS system with DRM leads to the following proposition:

Proposition 2: When the DRM game reaches the equilibrium, the maximal utility of the CSP is as follows:

$$U_D^* = \begin{cases} \frac{(U+L+C)^2}{4(L+C)} & , \quad U < L+C; \\ U & , \quad U \geq L+C. \end{cases}$$

Moreover, the equilibrium turnover rate Q^*, the equilibrium price P^* and the equilibrium transmission delay t^* are as follows:

1) If $U < L+C$, then $Q^* = \frac{-U+L+C}{2(L+C)}$, $P^* = \frac{-U+L+C}{2}$ and $t^* \leq T$;
2) If $U \geq L+C$, then $Q^* = 0$, $P^* = 0$ and $t^* \leq T$.

When $U \geq L+C$, $U_D^* = U = U_{\bar{D}}$, it suggests that the maximal utilities of the CSP in a P2PS system with and without DRM are indifferent. The CSP could not get any more utility if it uses DRM in the P2PS system. In other words, the CSP does not have any motivation to bring DRM into his P2PS system.

Proposition 3: The criterion for the CSP to apply DRM in the P2PS system is as follows:

1) When $U < L+C$, $U_D^* = \frac{(U+L+C)^2}{4(L+C)} > U = U_{\bar{D}}$, the CSP could get more utility in the P2PS system with DRM than without DRM;
2) When $U \geq L+C$, $U_D^* = U = U_{\bar{D}}$, the CSP would not choose the P2PS system with DRM.

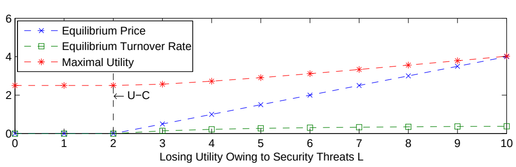

Fig. 2. The influence of losing utility owing to security threats.

When $U \geq L+C$, the CSP would not choose the P2PS system with DRM, so we just consider the case when $U < L+C$, i.e., $L > U-C$. According to Proposition 2, $Q^* = \frac{-U+L+C}{2(L+C)} < 0.5$, the upper bound of the turnover rate is 0.5, that is, the turnover rate should be less than 0.5 in order to get the maximal utility. Fig. 2 shows the case that $U = 2.5$ and $C = 0.5$. We can see that the CSP could set a higher price if the losing utility owing to security threats L is high enough. As a result, the higher the losing utility L is, the higher maximal utility U_D^* the CSP could get in the P2PS system with DRM.

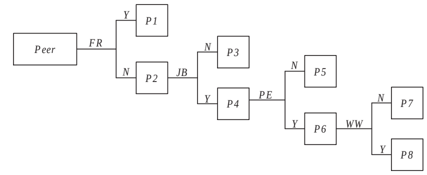

Fig. 3. A general model that illustrates a peer's actions in the P2PS system with DRM, where FR represents the freeriding, JB represents the jailbreaking, PE represents receiving penalty from the CSP, WW represents the whitewashing.

III. Games in P2PS Systems with DRM

In this section, we use game theory and currency mechanism to combat three misbehaviors of peers: freeriding, jailbreaking and whitewashing, in P2PS systems with DRM. We design effective strategies for the CSP to discourage such misbehaviors in the case of hidden actions.

A. Hidden Actions in P2PS Systems

In a P2PS system with DRM, peers may make strategic actions on the time when they join and leave the system. Since their actions are hidden from the rest peers of the system, many of them may take misbehaviors. Consider a peer and its actions in the P2PS system with DRM. Fig. 3 shows different situations after the peer chooses different strategic actions. We denote these situations as $P1 \sim P8$. When a peer receives the streaming content, it should share it with other peers according to the mechanism of the P2PS system. Some peer would break the rule of sharing and take the action of "freeriding" ($P1$). The peer can also choose to take the "not-freeriding" action that shares the streaming content with other peers ($P2$). Among the peers that share the streaming content with others, some peer may try to acquire extra interests by cracking the encryption of the digital goods, modifying the content and distributing the modified one to other peers. We call this action as "jailbreaking" ($P4$). For example, a peer may insert some advertisements in the digital goods and forward the modified digital goods along with advertisements to its neighbors to obtain the extra interests from the advertisements. The peer can also take the "not-jailbreaking" action ($P3$). If the peer takes the jailbreaking action, it may escape the penalty from the CSP ($P5$) or suffer the penalty from the CSP ($P6$). When the peer's expected interests, after getting the penalty from the CSP, drop below a new comer's interests in the P2PS system, the peer may choose to leave the P2PS system and rejoin the system with a new identity. Such action is called "whitewashing" ($P8$). The peer may also take the "not-whitewashing" action that keeps its identity unchanged during the whole process ($P7$). How can effective strategies be devised to combat these misbehaviors in the P2PS system with DRM?

B. Game for the Freeriding

In a P2PS system, peers are expected to share the streaming content with other peers to make the streaming service work normally. Clearly, such service would cease the function if all peers decide not to forward any streaming content. However, a peer could strategically choose the freeriding probabilistically so as to save its forwarding costs without destroying the service. Such a hidden action is not easily observable nor readily identified since the data packets are distributed on a best-effort approach and the network topology keeps changing as peers join and leave the network. How can the CSP provide incentives for the peers to perform the forwarding task?

We model this situation as a principle-agent game in [9]: the CSP, as a principle, employs a set of n peers of agents, N, to forward a digital goods to a receiver of the goods. The possible actions of peer i ($i \in N$) form a set A_i, $A_i = \{0, 1\}$, and the effort exerted by peer i is $C(a_i)$ where $C(a_i) \geq 0$ for $a_i \in A_i$. Here $a_i = 0$ indicates the "freeriding" and $a_i = 1$ indicates the "not-freeriding". We assume that the cost of taking the freeriding is 0 while the cost of taking the not-freeriding is $c > 0$, i.e., $C(0) = 0$ and $C(1) = c$. The outcome is determined according to a success function $G : A_1 \times \cdots \times A_n \longrightarrow [0, 1]$, where $G(a_1, \ldots, a_n)$ denotes the success probability when peers adopt the action profile $a = (a_1, \ldots, a_n) \in A_1 \times \cdots \times A_n = A$.

If the CSP pays peer i an amount $p_i \geq 0$, then the utility of peer i under the action profile $a = (a_1, \ldots, a_n)$ is given by $u_i(a) = p_i G(a) - C(a_i)$. The action profile of all peers excluding peer i is denoted as $a_{-i} \in A_{-i}$, i.e., $a_{-i} = (a_1, \cdots, a_{i-1}, a_{i+1}, \cdots, a_n)$. For simplicity, we assign the payment p_i for each peer i as p. Thus, peer i's own utility is $u(a_i) = pG(a_i, a_{-i}) - C(a_i)$.

In a P2PS system, more efforts contributed by peers will lead to a high probability of success. Formally, $\forall i \in N, \forall a_{-i} \in A_{-i}, G(1, a_{-i}) > G(0, a_{-i})$. In addition, we assume that $G(a) > 0$ for any $a \in A$. The marginal contribution of peer i, $\triangle_i(a_{-i}) = G(1, a_{-i}) - G(0, a_{-i})$, is the increase in the success probability due to peer i moving from taking the freeriding to not taking the freeriding, given the actions of the others are fixed. The best strategy of peer i can be determined as following: *If $p > \frac{c}{\triangle_i(a_{-i})}$, peer i does not take the freeriding; if $p < \frac{c}{\triangle_i(a_{-i})}$, peer i takes the freeriding; in case $p = \frac{c}{\triangle_i(a_{-i})}$, peer i is freely choosing either of these two alternatives.*

The reason behind this strategy is that, $p > \frac{c}{\triangle_i(a_{-i})}$ if and only if $u(1, a_{-i}) = pG(1, a_{-i}) - c > pG(0, a_{-i}) = u(0, a_{-i})$. In this case, peer i's best strategy is to choose $a_i = 1$, i.e., peer i will not take the freeriding in order to obtain a higher utility, given other peers keep their actions unchanged.

Assume that the success probability when one peer takes the freeriding among the n peers is θ. The success probability when m peers take the freeriding among the n peers is $1-\theta^{n-m}(1-\theta)^m$. Consider that each peer may take the freeriding with probability x and not take the freeriding with probability $1-x$, given other peers' actions are fixed, the expected success probability when peer i takes the freeriding is $E[G(0, a_{-i})] = \sum_{m=0}^{n-1} C_{n-1}^m x^m (1-x)^{n-m-1}[1-\theta^{n-m-1}(1-\theta)^{m+1}]$; and the expected success probability when peer i takes the not-freeriding is $E[G(1, a_{-i})] = \sum_{m=0}^{n-1} C_{n-1}^m x^m (1-x)^{n-m-1}[1-\theta^{n-m}(1-\theta)^m]$. Therefore, the expected utility when peer i takes the freeriding with probability x is

$$\begin{aligned} E[\pi_p] &= p(E[G(1, a_{-i})] - c)(1-x) + pE[G(0, a_{-i})]x \\ &= p \sum_{m=0}^{n} C_n^m x^m (1-x)^{n-m}[1-\theta^{n-m}(1-\theta)^m] - (1-x)c. \end{aligned}$$

In Fig. 4, we can see that the expected utility of peer i decreases as the probability that peer i chooses the freeriding increases. A peer which always takes the freeriding will receive the lowest payoff, and the strategy for the peer to acquire the highest payoff is to take the not-freeriding all the time. It shows that peers are willing to share the digital goods with each other in order to get a higher utility.

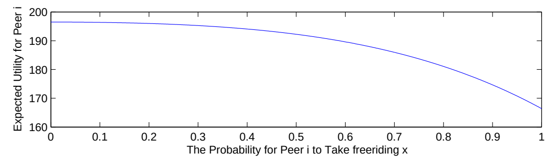

Fig. 4. The expected utility for peer i. Here, $n = 5$, $p = 200$, $c = 3$ and $\theta = 0.3$.

C. Game for the Jailbreaking

Even when DRM is implemented in a P2PS system, a peer could strategically choose the jailbreaking probabilistically to acquire some extra interests in addition to the reward from the CSP for forwarding the digital goods successfully. This jailbreaking action certainly infringes the right of the CSP and at the same time pollutes the digital goods in the P2PS system. How can the CSP provide DRM strategies to suppress such actions?

We consider a mixed game for this situation: the peer can either choose the jailbreaking with probability r or choose the not-jailbreaking with probability $1 - r$. The CSP will play a strategy either punishing the jailbreaking action severely with probability s or not punishing it with probability $1 - s$. Under this mixed game, the peer will get a reward R for forwarding the streaming goods if the peer does not take the jailbreaking. The peer will get an extra reward E if it takes the jailbreaking without being caught by the CSP. As a result, the interests a peer gets for taking the jailbreaking without penalty is $R + E$. If the peer's jailbreaking action is caught by the CSP, the peer will suffer a penalty W. In this game, the expected payoff for the peer is $E[\pi_p] = r[(R + E)(1 - s) - Ws] + R(1 - r)$.

If the expected payoff is no larger than zero, that is, $E[\pi_p] = r[(R + E)(1 - s) - Ws] + R(1 - r) \leq 0$, the peer will not choose the jailbreaking action. Let $W = \lambda R$ and $E = \mu R$, where $\lambda > 0$ and $\mu > 0$. The probability of $E[\pi_p] \leq 0$, $P\{E[\pi_p] \leq 0\}$, is shown in Fig. 5. We can see that if the CSP puts no penalty on peers' jailbreaking (i.e., $\lambda = 0$), then $P\{E[\pi_p] \leq 0\} = 0$. It means that the peer has a strong motivation to take the jailbreaking. However, if the penalty W is much larger than the extra reward E (i.e., $\lambda \gg \mu$), $P\{E[\pi_p] \leq 0\}$ is close to 1. That is, the peer has almost no motivation to take the jailbreaking. Fig. 6 further shows that when the penalty W is much larger than the extra reward E, a small probability for the CSP to catch the jailbreaking (i.e., s is small) could have the peer's expected

TABLE I
THE EXPECTED PAYOFF FOR PEER'S STRATEGY

State	Expected payoff
$P1$	$pG(0, a_{-i})x$
$P2$	$(pG(1, a_{-i}) - c)(1 - x)$
$P3$	$(pG(1, a_{-i}) - c)(1 - x)(1 - r)$
$P4$	$[(pG(1, a_{-i}) - c)(1 - x) + E]r$
$P5$	$[(pG(1, a_{-i}) - c)(1 - x) + E](1 - s)r$
$P6$	$-Wsr(1 - x)$

payoff not positive (i.e., $E[\pi_p] \leq 0$), even if the peer takes the jailbreaking with a high probability (i.e., r is large). We can also see that the peer could acquire a maximal utility if it does not take the jailbreaking (i.e., $r = 0$).

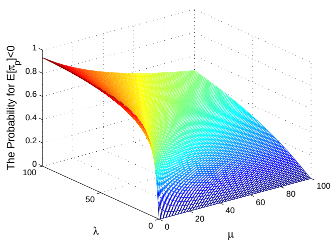

Fig. 5. The probability for $E[\pi_p] \leq 0$.

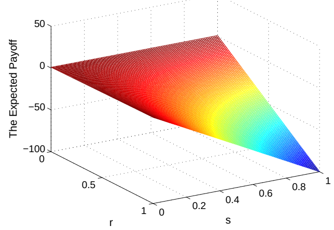

Fig. 6. The expected payoff for the peers, here $W = -100$, $E = 2$, $R = 1$.

D. Game for the Whitewashing

Let us consider the game that the peer plays a mixed strategy involving the freeriding and jailbreaking with probabilities x and r, and the CSP makes the punishment with probability s, as shown in Fig. 3. The outcomes are situations $P1 \sim P6$. Since the probability for the peer to forward the digital goods successfully is $G(1, a_{-i})$, the reward R is $pG(1, a_{-i}) - c$. We summarize the payoff of every situation in Table I. Then, the expected payoff of peer i is

$$\begin{aligned} E[\pi_p] &= [(pG(1, a_{-i}) - c)(1 - x) + E](1 - s)r - Wsr(1 - x) \\ &+ (pG(1, a_{-i}) - c)(1 - x)(1 - r) + pG(0, a_{-i})x. \end{aligned} \quad (4)$$

When the expected payoff of peer i is not positive ($E[\pi_p] \leq 0$), the peer will not choose the freeriding and jailbreaking. However, our strategy can be skewed by the feasibility of cheap pseudonyms [10]. For example, a peer that takes the jailbreaking may choose the whitewashing after suffering a severe punishment. It will leave the P2PS system and rejoin the system again with a new identity. The record of its deviltry before the whitewashing would be vanished. How can we reduce the effect of cheap pseudonyms?

There are two types of cheap pseudonyms, permanent identity (PI), whose cost is infinite, and free identity (FI), whose cost is free. The identity cost of each peer is a positive finite value between the cost of FI and that of PI. That user may decide to take the whitewashing if its identity cost is less than the expected payoff after the penalty imposed on the jailbreaking. Let the identity cost be Y, if we want to discourage the peer's whitewashing behavior on a repeated basis, we should let $E[\pi_p] \geq -Y$.

When the expected payoff $E[\pi_p]$ is no less than the opposite of the identity cost Y, as a result, the peer will not take the whitewashing even after suffering a severe penalty for the jailbreaking, just as the situation $P7$ shown in Fig. 3.

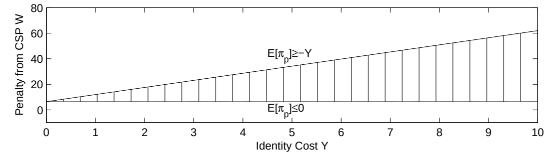

Fig. 7. The decision domain of the punishment, where $E = 6$, $x = 0$, $r = 0.6$ and $s = 0.3$.

According to the discuss above, $-Y \leq E[\pi_p] \leq 0$. Let $pG(1, a_{-i}) - c = 1$, we can see from Fig. (7) that the decision domain of W is the marked region guarded by line $-Y \leq E[\pi_p]$ and line $E[\pi_p] \leq 0$, which becomes wider as Y increases. As a result, the CSP could have more choices of the punishment W if the identity cost Y is large. When the identity cost approaches zero, the decision domain of W nearly reaches to a fixed point. This suggests that the punishment W should not be too severe, otherwise the peer will take the whitewashing when $E[\pi_p] < -Y$.

IV. CONCLUSION

In this paper, we model the DRM for P2PS systems as a game for the CSP and users, derive the equilibrium price of the digital goods, and maximize the utility of the CSP in the P2PS system with DRM based on that equilibrium price. This game model is effective in deciding whether DRM should apply in the P2PS system. We also present effective strategies to avoid three misbehaviors of peers: freeriding, jailbreaking and whitewashing. These strategies have the peers acquire the maximal utility if the peers do not take these actions. Experiments are conducted to demonstrate the effectiveness of our strategies.

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