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A game theoretical model for collaborative groups in social applications

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ABSTRACT

In this paper, we address the problem of the free riding behaviour that takes advantage of collaborative educational social groups without contributing back to other participants posts. Free riders are active users who ask questions and draw knowledge from the community but provide very limited or no contributions back to it. Since the survival of a collaborative educational community is highly dependent on its active users and their contributions, motivating free riding users to take an active part would naturally augment the value the community provides and ensure its survivability. As a solution, we formally analyse the impact of the free riding behaviour by means of repeated game theory where classical and generous Tit for Tat are used. Such analysis shows the impact of such behaviour on educational communities and raises the need for other strategies that motivate free riding users to cooperate under the threat of being punished by cooperative ones; hence, we introduce reputation based Tit for Tat strategies. Our study suggests adding reputation as a parameter in users' profiles in collaborative groups to improve their survivability.

1. Introduction

Recently, social applications have been gaining more popularity on the Internet and a great deal of user generated content has been produced with a plethora of users consuming them. Many have seen the opportunities of using the popularity of social applications in different fields such as education; and educators have already started working on using social applications to foster collaboration among groups of learners. These groups, usually called online communities, can exist in forums, emails, chat systems, questions and answers sites, and most recently social networking sites. Till now, the success of social applications for collaboration has not been consistent and the ability of these social applications to stimulate their subscribers to contribute varies greatly. The work on encouraging the participants to contribute has been more of an art than science as the reasons behind what makes people participate are still vague and unclear (Vassileva, 2012; Oum & Han, 2011). Saying that, there is a combination of factors that have been studied and claimed to result on guaranteeing the active contribution of the participants ranging from psychological to economical views (Vassileva, 2012).

In this paper, we adopt the *social exchange theory* where users are rational agents aiming at maximising their benefits (Cook, Cheshire, Rice, & Nakagawa, 2013). In an educational online community where knowledge exchange is the basis, requesting help and answering are the main trade. The users' benefits increase when other users collaborate with them. An act of balanced reciprocation between the community members will ensure the increase of benefits between the users in what is known as the *generalized exchange* (Cook et al., 2013).

Reciprocation is in fact the key success factor in educational social applications. Unfortunately, even if a community is successful it continuously faces challenges. A free riding behaviour could arise where some participants will try to take advantage of the group and request help from the other participants while ignoring requests of others, even though this might not be done intentionally. Such a situation is referred to as *tragedy of the commons* (Ostrom, 2008). The existence of such free riding behaviour may demotivate participants from collaborating and may affect the survivability of the group, as it decreases contributions caused by a multitude of factors such as lack of interest and lack of trust in the community to cite a few. To understand this problem, many empirical studies (Oum & Han, 2011, Paulini, Maher, & Murty, 2014, Lori Foster, Meriac, & Cope, 2002, Sadlon et al., 2008) were conducted to identify the reasons behind the motivation of learners. However, in such studies it is hard to replicate the result and analyze the different variables' impact separately (Vassileva, 2012). An analytical method

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to study the problem using controlled variables and understand the impact of each of them on the survivability of the online community is required.

The problem of learners' motivation in online communities shares many similarities with the prisoner's dilemma game which is a model analysed using *game theory* that helps to understand situations where reciprocation is needed (Falk, Armin, & Fischbacher, 2006). Therefore, to analyse such a free riding behaviour and its impact on group collaboration, we use game theory as well to formulate the interaction among all participants as a repeated non-cooperative game based on the prisoner's dilemma game.

In our investigation, we create a model where a number of participants formed a group inside a social application for the purpose of collaborating. We simulate the results of the participants adapting different behaviours. Using classical and generous based Tit for Tat strategies, we show the impact of having free riding behaviour on educational social applications' groups. Then we show how a reputation based Tit for Tat strategy can solve the problems found on the previous two strategies. Our analysis proves that free riding threats the survivability of communities and raises the need for a strategy that motivates free riding users to cooperate under the threat of being punished by other cooperative users if they were not of benefit to the whole group. Therefore, instead of a strategy that makes the player look for his own good; a strategy that considers the common good of the group should be considered. In other words, instead of a strategy that makes the participant look at the contributions between the other participants and himself individually (direct reciprocation); a strategy that makes the participant look at the contribution of the other participants with the whole group can be a solution to the free riding problem (indirect reciprocation). A reputation-based Tit for Tat, where the reputation of the participant in relation with the whole group is considered as a parameter to regulate cooperation among all members of a group would minimise the gain of free riding participants and help educational social applications thrive.

In summary, the contributions of our paper are:

- Proposing an analytical model for collaborative groups in social applications based on repeated game theory.
- Simulating participants' behaviours using different existing Tit for Tat strategies.
- Analysing the impact of what we refer to as free riding behaviour in collaborative groups survivability.
- Proposing a new tit for tat strategy based on group reputation to motivate free riding members to cooperate under the threat of being punished by cooperative members. This strategy is in fact a new contribution to game theory.

The rest of the paper is structured as follows. Section 2 presents the game theory model. In Section 3, we show the different Tit for Tat strategies. Section 4 presents some related work in the field of motivating users in online communities and game theory. Finally Section 5 concludes the paper and outlines our future work.

2. Game definition

In a social application, users can cooperate by helping others in their requests, by participating in their discussions or simply commenting in their contributions. Still, users can also defect from cooperating and not contribute. In order to show the impact of free riding on the group survivability, we need to study different participant behaviours and strategies. For this end, we propose to model them as a game.

Using game theory, this situation of cooperating and defecting can be modelled as a non-zero non-cooperative game (Sloep, 2009). It's modelled as a non-zero because the benefit can be shared rather than being strictly transferred to one person only. Also, it was modelled as a non-cooperative because each person makes his decision independently from the other. Such games are usually modelled against the famous Prisoner's Dilemma game invented by two Rand corporation scientists in 1950s (Axelrod & Hamilton, 1981). The prisoner's dilemma game represents the situation of two criminals caught by the police at the same time. These criminals have two strategies to independently select from. They can either confess (defect) or not (cooperate). The results of the possible outcomes is outlasted in Table 1 where:

1. R: Reward is to be prisoned for 1 year
2. P: Punishment is to be prisoned for 5 years
3. S: Sucker is to be prisoned for 10 years
4. T: Temptation is to be set free.

These constants must satisfy the following two conditions:

1. $T > R > P > S$
2. $2R > T + S$.

Using the dominant strategy technique, the best strategy for a criminal when both criminals do not know the other's decision is to "defect" to avoid the sucker which is the worst case since $T > R > P > S$. However, in the case of playing this game for infinite number of times, the best strategy will be "cooperate" since $2R > T + S$.

The prisoner's dilemma game as is cannot resemble a collaborative group where decisions between two participants are not simultaneous but taken in two different stages. A modified version of the prisoner's dilemma game which is the iterated asynchronous prisoner's dilemma game has been introduced in the literature. To accommodate these changes in the game, we can use the model proposed in Nowak and Sigmund (1994) summarised in Table 2.

These values should be calculated so that they do not violate the previously mentioned criteria of the prisoner's dilemma.

2.1. Collaborative game settings

In this section we explain the settings and introduce the assumptions we considered when formulating the game. Consider that we have a group of (N) participants in a social application, each user is a member of m groups and posts made by users are restricted to groups. Each user is able to:

1. Post a request.
2. Answer others' requests.
3. Ignore a request because s/he is not able to answer it.
4. Ignore a request although s/he is able to answer it. Such a behaviour is known as "selfish" or "free riding".

We also assume that :

1. The social application is keeping track of all requests and responses of each participant.
2. The social application is updating each user with the cooperation status of the other users.

Table 1
Prisoner's dilemma payoff matrix.

	Cooperate	Defect
Cooperate	R(−1), R(−1)	S(−10), T(0)
Defect	T(0), S(−10)	P(−5), P(−5)