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Tradable Reputation and Online Economic Efficiency: A Field Experiment in Second Life

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ABSTRACT

The online world has developed from a source of information to a complex economic and social environment. However, many online environments fail to function efficiently due to the lack of reliable reputation and anonymity of users. We propose a tradable reputation mechanism and conduct a virtual field experiment, using Second Life as an experimental platform, to investigate the role of reputation trading, based on our game theory analysis of the economic influence of tradable reputation. We introduce an avatar market that allows users to buy and sell avatars in terms of the reputation. Our main theoretical results show that reliable reputation is induced in a separating equilibrium where users are separated based on their ability in fulfilling tasks or transactions. We generate five hypotheses to test in the field experiment. We also describe a computer system that realizes the proposed mechanism as a basis for the field experiment.

Keywords

Reputation, Virtual Worlds, Online Economy, Game Theory, Field Experiment

INTRODUCTION

Over the past decades the online world have gone from mainly a source of information to a complex social, economic, and entertainment environment such as that of eBay, Amazon, MySpace, Second Life, or World of Warcraft(WoW). The role of reputation in facilitating transactions and other voluntary interactions between avatars in the online world is as important as it is in the real world. However, the traditional notion of reputation fails to sustain an effective economy and society in many online settings due to the anonymity of users. The primary purpose of this study is to propose a tradable reputation mechanism with an avatar market to the online world, and conduct a field experiment in a virtual world, Second Life, to investigate the role of such a mechanism in establishing reliable reputation. Our goal is to use virtual world as an experimental platform to generate insights regarding the pervasive reputation issue in the online world. The field experiment is also accompanied by a game theory analysis, which provides a basis for our testable hypotheses in the experiment.

Field experiments have the advantage of combining the controls of lab experiments and the external validity of behaviors in natural settings (Harrison and List 2004, Reiley and List 2007). Experimental economists have intensively examined the potentials of virtual environment which visually mimic complex physical space for research on human interactions (Bainbridge, 2007, Bloomfield, 2007, Nicklisch and Salz 2008). Our study shows the potential of field experiments for research in Information Systems, which concerns a large set of issues regarding online communities, virtual worlds, social networks, and electronic commerce.

Reputation has an important economic function in resolving issues of moral hazard and adverse selections in interactions. For example, it can reduce the agency costs for buyers and sellers, and can improve matching of people who are searching for friends. Early study shows that reputation rewards people for their high ability in certain aspects, and channel resources into the most valuable place(Ba and Pavlou 2002). However, many online environments suffer from the temptation to avatars to misbehave, due to the anonymity of users. The main contribution of this study is to propose a market for avatars to establish trust and facilitate cooperation. We describe an avatar market as a marketplace where avatar owners exchange the account and password of the avatar for money from avatar buyers. It is worth noting that the value of an avatar comes from the reputation history associated with the avatars. Avatars are users' online representation of themselves, whether in the form of a

three-dimensional model, a two-dimensional icon (picture), or a text construct. Reputation in the online world is closely attached to avatars, instead of the real identity of the user. In the context of Second Life, WoW, or eBay, reputation is a summary describing users' performance in a certain aspect, such as eBay users' feedback scores. Due to the separability of reputation from users, tradable reputation has a great potential in the online world. In fact, we already observe variations of buying and selling avatars for reputation. For example, WoW players may go to Accounts.com to trade their accounts for real money, while the price depends on the skill levels and experience levels of the account, which is indeed a reputation of the user in the WoW context.

An avatar market benefits an online environment from several aspects. First of all, the avatar market prevents agent from misbehaving. In most online environments, avatars are essentially free, which provides opportunities to misbehave without bearing reputational consequences. Friedman and Resnick (2001) pointed out a social cost resulting from the nature of free avatars. Our theoretical analysis shows that misbehaving will lead to a loss in avatar prices, and when the avatar market is properly priced, it is optimal for agents to exert effort and improve reputation of their avatars. Also, an avatar market enhances the predictability of reputations by separating different types of agents. We show that a separating equilibrium exists in which high type agents will always purchase avatars with high reputation, while low type agents will always purchase avatars with low reputation. In other words, reputation in our case becomes a perfect indicator of how capable an agent is of providing services. Further, the avatar market deals with the end-of-game effect, since even for their last period of providing service, agents will be well motivated by the market value of the avatar. An avatar market also better allocates resources and improves efficiency by allowing agents to start with reputation that suits their ability, and avoiding the inefficiency of a high-ability newcomer pooling with low-ability newcomers as a new avatar.

The rest of the paper is organized as follows. In the next section, we provide a review of related literature, followed by an introduction to our economic model of the avatar market for virtual worlds. In the following two sections, we describe system development and discuss the implementation of the field experiment and testable hypotheses. We conclude in the last section.

LITERATURE

A large body of research has studied reputation (Kreps, Milgrom, Roberts, and Wilson 1982, Fudenberg and Levine 1989, 1992, Friedman and Resnick 1999, Mailath and Samuelson 2001). In all these studies, reputation is assumed to accumulate and update based on the observed outcomes. Different from them, the reputation in our paper is based on auditing and does not require observability of agents' history by consumers. On the one hand, this difference changes the information structure regarding outcomes and enhances reputation's role in inducing effort as discussed in the introduction. On the other hand, it provides a credible basis for reputation updating. As shown by Dellarocas and Wood (2008), reputation relying on users' reports of privately observed outcomes is subject to potential reporting bias. Thus, our paper is positioned to examine the impact of the different information and incentive structures as provided by audited reputation.

The avatar market has been studied in economics as reputation tradings. Mailath and Samuelson (2001) examined the situation of reputation replacement where one agent can sell reputation to a group of competitive buyers at the end of a period. They focused on the price of reputation as determined by competition. The idea of an avatar market can be viewed as a generalization of reputation replacement to multiple sellers and multiple buyers. Tadelis (1999, 2002) raised the notion of reputation as a tradeable asset in an overlapping generation setting with two types of agents. The two studies established that a market for reputation is sustainable: agents are willing to pay for a high reputation. However, the papers also concluded that no equilibrium in the market can sort out the two types of agents. Our current paper differs from Tadelis (1999, 2002) by introducing an audit process to reveal partial information regarding service quality before consumption. Our different information structure impacts agents' incentive, and we are able to achieve a separation of agents in the avatar market. A recent paper Xu et.al (2008) studied a market for manufacturing firms with conventional products to trade their firm names. The current paper differs from Xu et.al (2008) in our focus on the online environment and propose a different auditing procedure, which leads to a different incentive structure for agents.

ECONOMICS ANALYSIS OF AN AVATAR MARKET

Model Setup

We model the online environment in an infinitely repeated game with three entities: consumers, agents, and an auditor. Both consumers and agents are online users, and they assume avatars to perform activities. Agents provide services to consumers, such as landscaping, party planning, advertising, or tour guiding. The auditor examines the quality of the services and assigns reputation to agents. Agents with higher cost of effort than others are called low types, and we assume the proportion of high types is λ_H , and their cost coefficient is k_H . Similarly, $1 - \lambda_H$ of agents are low types with a cost coefficient k_L . We

denote effort as w , and cost of effort as $k_\theta w^2$, $\theta = L, H$. With an effort w , the services have a probability of w to be successful, and $1-w$ to be a failure. Consumers are homogeneous and risk-neutral, and benefit with value 1 from successful services and with 0 from failed services.

We use a simple reputation system consisting of reputation 1 and 0. In each period, the auditor audits each agent with probability α , and assigns reputation 1 if the audited outcome is successful, and assigns 0 if the outcome is a failure.¹ We study two markets: the avatar market and the service market. The avatar market allows agents to buy and sell their avatars, and we denote the price for avatars as V_0 and V_1 . We assume that shifts in the avatars' ownership are unobservable to consumers, since reputation is only associated to agents' avatars but not to agents as individuals. The service market is for trading of services.

The timeline of events in each period is as follows. First, agents choose their avatars: they may continue with their current avatars, buy avatars, or create a new avatar. We assume an avatar with reputation 0 is free, that is, $V_0 = 0$. Second, agents determine their effort to maximize expected payoff. The level of effort is based on the tradeoff between effort cost $k_\theta w^2$ and expected benefit $\alpha(w\tilde{w}_j + wV_{j+1})$, where \tilde{w}_j is consumers' expectation on effort levels of reputation j , $j = 0, 1$. Next, the auditor audits agents' services. Agents' payoff is contingent on the audited outcome in the sense that upon a failure in audit, the agent receives no payment for the current service. We also assume that demand is greater than supply such that consumers pay their expected value \tilde{w}_j of the service based on reputation.

Separation

We will be concerned with steady states, such that agents' effort choices w_j , avatar values V_j , and proportions λ_H are independent of time. Agents' objective can be expressed as follows.

$$\begin{aligned}\pi_j^\theta &= \max_{w \in [0,1]} \alpha(w\tilde{w}_j + wV_1) + (1-\alpha)(\tilde{w}_j + V_j) - k_\theta w^2 - V_j \\ &= \max_{w \in [0,1]} (\alpha w + 1 - \alpha)\tilde{w}_j - k_\theta w^2 + \alpha wV_1 - \alpha V_j,\end{aligned}$$

where the first two terms consist of agents' expected profit from services, while the rest represents agents' expected gain in avatar value. We further assume $2k_\theta - \alpha > 0$. This ensures that neither type of agents will exert the highest effort 1 because the marginal cost of effort for both types is higher than the marginal revenue when effort is 1. The opposite case, where both low type and high type agents exert the highest effort, is trivial and not part of the focus of this paper.

We define a steady-state separating equilibrium that describes the one-to-one correspondence between agents and reputation of avatars as follows.

Definition: A **steady-state separating equilibrium** consists of a set of values $\{V_j, w_j\}$ such that all the following conditions are satisfied.

- (1) $\pi_1^H > \pi_0^H$,
- (2) $\pi_0^L > \pi_1^L$,
- (3) $\tilde{w}_j = w_j$,
- (4) $\lambda_L w_0 + \lambda_H w_1 = \lambda_H$.

¹We also confine our analysis to services with an outcome that is verifiable by the auditor but is unobservable by consumers. If consumers can observe the outcome, reputation becomes unnecessary because consumers pay based on their observations. However, it is important for the auditor to verify the outcome, so that the auditor can credibly make changes to reputations and enforce a contingent payment contract with agents, based on verification.

Conditions (1) and (2) are incentive compatibility conditions to ensure that agents do not deviate to the other type of avatar reputation. Condition (3) states that consumers have rational expectation of effort in equilibrium. Condition (4) comes from the steady-state requirement that in each period the proportion of high type agents at reputation 1 is the same. This can also be interpreted as the market clearing condition. Intuitively, the number of low type agents who have passed an audit, $\alpha\lambda_L w_0$, must be just enough to supply the high type agents who have failed an audit and need to purchase an avatar with reputation 1, which is $\alpha\lambda_H(1 - w_1)$.

In the following, we solve for a steady-state separating equilibrium by deriving effort levels of each type of agents and avatar prices.

High Type Agents' Effort and Profit: We first analyze a high type agent, who occupies an avatar with reputation 1. The profit is as follows,

$$\pi_1^H = \max_{w \in [0,1]} (\alpha w + 1 - \alpha) \tilde{w}_1 - k_H w^2 + \alpha w V_1 - \alpha V_1.$$

The optimal effort level w_1 is obtained by the first order condition regarding w_1 , together with the fact that $\tilde{w}_1 = w_1$ holds in equilibrium.

$$w_1 = \frac{V_1}{\frac{2k_H}{\alpha} - 1},$$

$$\pi_1^H = k_H w_1^2 + (1 - \alpha)w_1 - \alpha V_1.$$

Low Type Agents' Effort and Profit: Here we turn to a low type agent with reputation 0, whose objective is to solve the following maximization problem:

$$\pi_0^L = \max_{w \in [0,1]} (\alpha w + 1 - \alpha) \tilde{w}_0 - k_L w^2 + \alpha w V_1.$$

Similarly, solving for optimal effort level w_0 as well as profit π_0^L leads to:

$$w_0 = \frac{V_1}{\frac{2k_L}{\alpha} - 1},$$

$$\pi_0^L = k_L w_0^2 + (1 - \alpha)w_0.$$

Next, we determine V_1 using the steady state condition. We denote the proportion of high type agents as λ_H and the proportion of low type agents as $\lambda_L = 1 - \lambda_H$. A steady state equilibrium requires that, at the beginning of each period, there are just enough avatars with reputation 1 for high type agents to start with. In other words, the proportion of avatars with reputation 1 is equal to that of high type agents, or:

$$\lambda_L w_0 + \lambda_H w_1 = \lambda_H.$$

Rearranging the above equation leads to

$$V_1 = \frac{\lambda_H \left(\frac{2k_L}{\alpha} - 1\right) \left(\frac{2k_H}{\alpha} - 1\right)}{\lambda_L \left(\frac{2k_H}{\alpha} - 1\right) + \lambda_H \left(\frac{2k_L}{\alpha} - 1\right)}.$$

Existence of a separating equilibrium: We now prove the existence of a separating equilibrium with w_1 , w_0 , V_1 , λ_L by showing that agents do not have incentive to deviate to avatars with a different reputation. The existence conditions are summarized as follows.

Proposition 1: Under the binary reputation mechanism with audit, a steady-state separating equilibrium exists if $\frac{k_H^2(2k_L-1)Y}{k_L} - \frac{2k_L-1}{2k_H-1} < \frac{\lambda_L}{\lambda_H} < k_H(2k_H-1)Y-1$, where $Y = \frac{1}{(2k_H-1)^2} - \frac{k_L^2}{k_H^2} \frac{1}{(2k_L-1)^2}$.

The proof is provided in the appendix. It is worth noticing that a large $\frac{k_L}{k_H}$ is crucial for the existence of separation. Intuitively, k_L and k_H are the essential differences between the two types, and they lead to different incentives and consequently different choices of avatars in terms of the reputation. We can imagine that as this essential difference diminishes, the two types become the same, and separation becomes impossible or unnecessary.

SYSTEM IMPLEMENTATION

With the desirable results from economic analysis, we have developed a computer system to fulfill the proposed reputation mechanism featuring the avatar market. The system can be implemented on Second Life, and as a self-sustaining implication, it can be easily applied to other online environment. We next describe the system with Unified Modeling Language, including one class diagram to show the system structure, and four sequence diagrams to illustrate processes in each part of the system.

System Overview

The system contains two main parts: the reputation system and the avatar marketplace. The system implemented on Second Life interacts with exogenous environments including Second Life and PayPal as the payment method in avatar trading. Figure 1 depicts the overview of the system.

The system is written using PHP (PHP Hypertext Preprocessor), which is a cross-platform server-side programming language especially suited for Web development. PHP was chosen as the programming language because of its widespread presence in the Web industry, and its wide range of program modules that allow for the use of many platform independent increasing features. The system is built using Zend Framework 1.5 to increase abstraction and to simplify development. Zend Framework requires PHP version 5.1.4 or later. For usability reasons client side programming is done using JavaScript with jQuery. jQuery is a lightweight cross-browser JavaScript library that simplifies many JavaScript operations and makes Web development easier.

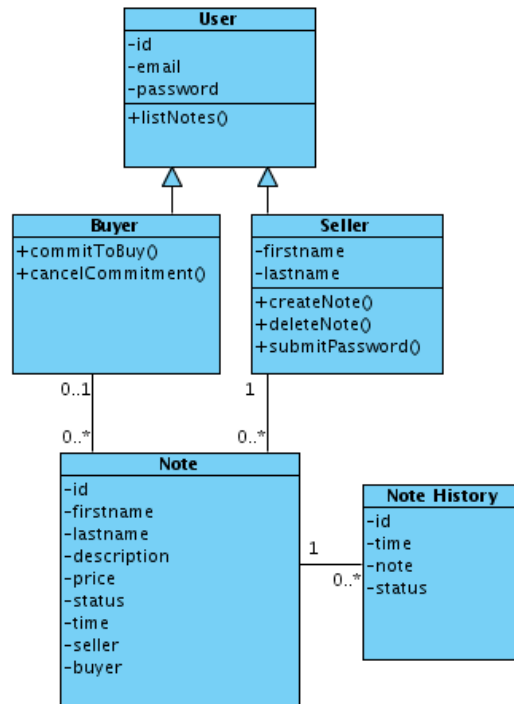


Figure 1. Class Diagram

The system uses SQL database for data storing, and the database handling is done via Zend Framework. Zend Framework uses PDO (PHP Data Objects) which provides lightweight and consistent interface for accessing databases. PDO requires version 5.1 PHP interpreter and it supports all commonly used database systems, e.g. MySQL, IBM DB2 and Microsoft SQL Server. The system is currently built and tested using MySQL database.

Avatar Reputation System

The sequence of actions in the reputation system is described in Figure 2. The main function of the avatar reputation system is for auditors to update avatars' reputation based on their audit result. In each predefined time period, avatars are chosen at a certain probability, which can be easily set and changed as a system parameter. Our auditors carry out transaction with the service providers. They evaluate the service based on their knowledge and experience and update the avatars' reputation based on their evaluations. Specifically, avatars' reputation level is numerical. New avatars' reputation is set at 0 by default. Avatars' reputation level s increase with positive evaluations from the auditors, and decrease with negative evaluations.

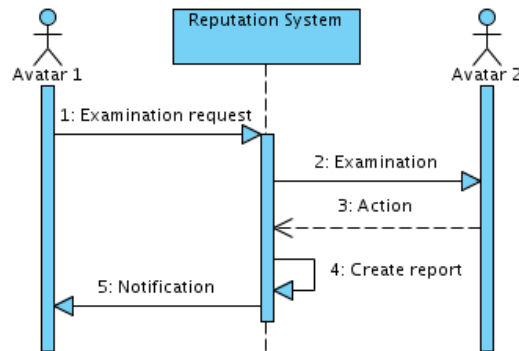


Figure 2. Sequence Diagram for The Avatar Reputation System

Avatar Marketplace

The avatar marketplace is described in Figure 3, which provides a safe and secure way for people to buy and sell Second Life avatars in terms of the reputation based on the reputation system. People can search for avatars on sale in different categories. Only Second Life users can place a selling note. To sell an avatar, the user submits the avatar's name, price, and description to the system. The system adds the avatar's reputation from the reputation system to the selling note. When a potential buyer wants to purchase an avatar, he/she commits to buying and submits his/her email address to the system. After a purchase commitment, the avatar's note will be locked. When the note is locked it cannot be seen by anyone other than the buyer and the seller. The notes are locked in order to prevent multiple purchase commitments. Buyer will pay to the system; if payment is not received within a certain period of time the note will be unlocked, as depicted in figure 4.

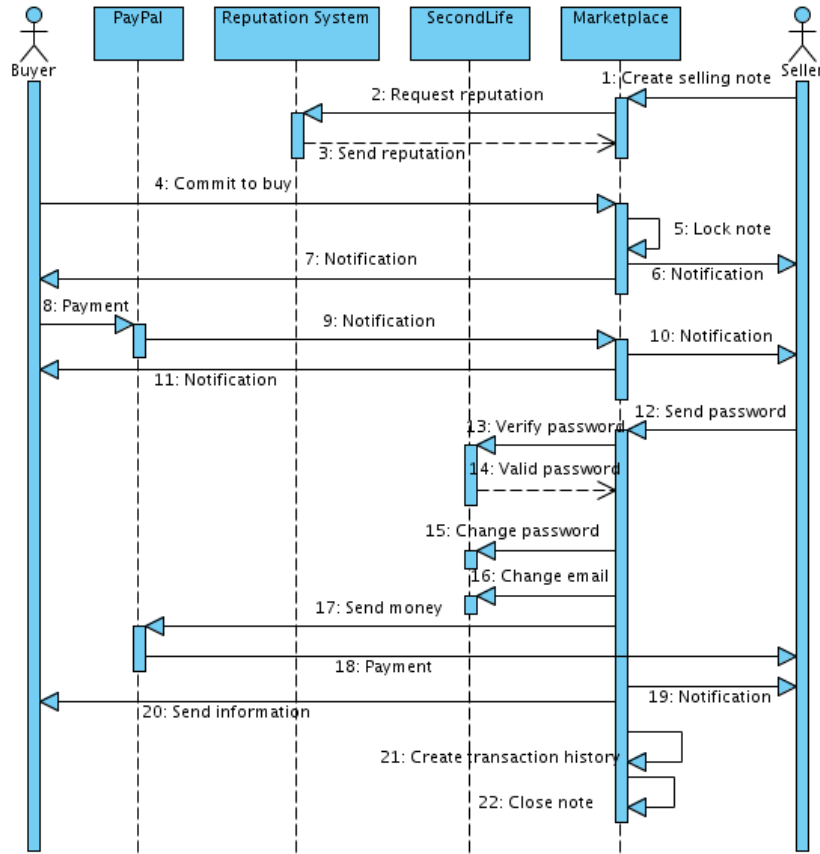


Figure 3. Sequence Diagram for The Marketplace

When the payment is received, the system will notify the seller and ask for the avatar's password. After receiving the seller's password, the system will verify the password's validity.

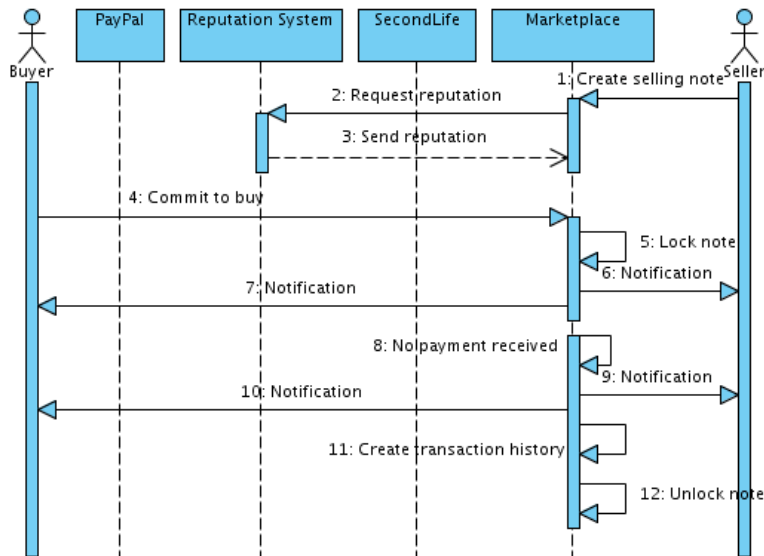


Figure 4. Sequence Diagram for The Marketplace When No Payment Received

If the password is invalid the money will be sent back to buyer, and the selling note will be deleted; the process is depicted in figure 5. If the password is valid the system will transfer the money to the seller, immediately change the password, and send the new password to the buyer. Using this procedure transactions are always safe and secure. To protect anonymity, all payments will be done using PayPal.

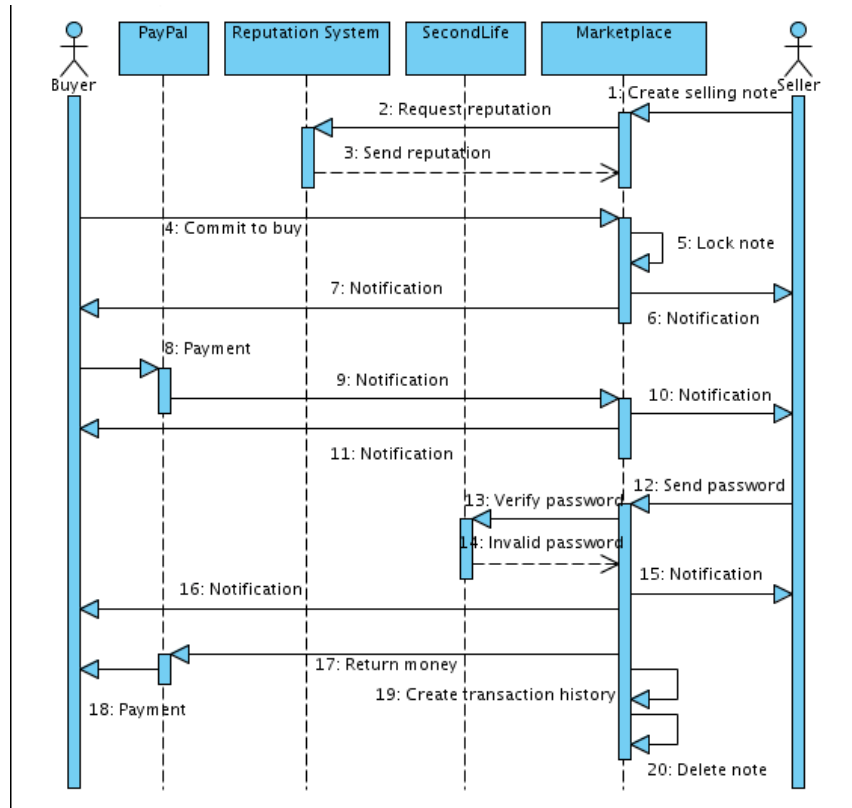


Figure 4. Sequence Diagram for The Marketplace When The Password is Invalid

EXPERIMENTAL DESIGN

The experiments are conducted in Second Life, a virtual world featuring user-performed services and user-created objects. Second Life is one of most popular virtual worlds, and is distinct in its resemblance to the real world in terms of the social and economic structures. The experiments started in January 2009 and are planned over a 3-month period.

Description of Second Life

Second Life is an online virtual world developed by Linden Lab and launched in June, 2003. Users of Second Life, who call themselves ``residents'', connect via their personal computer running special software with servers that interchange the information between users over the internet. The software simulates a large, complex, three-dimensional environment filled with user-created artificial objects, such as houses, high ways, trees, clothes, and most importantly services, such as tour guide, freelancing scripter, advertiser, etc. Residents are represented by avatars, which can subjectively walk, fly, swim, or dance, and can participate in individual and group activities. Second life has gone far beyond being a community for social networking; it is also a fully-functioning economy with its own currency (the Linden Dollar, or *L*), which can be converted to U.S. dollars, businesses, arbitrage opportunities, and recognizable economic trends. Residents can create and trade virtual objects and services with one another. With 15 million residents, Second Life has a total Linden Dollar supply of over 5 billion. In August 2008, more than 15 million transactions took place among the residents. Many other virtual worlds with a business context have such economic features. Castronova (2001) studied the macroeconomics of a virtual world called ``Norrath'' and showed that it had a nominal hourly wage of about \$3, and a GNP per capita between that of Russia and of Bulgaria. Indeed, as people spend more and more time and money in their business in virtual environments, the economic aspect of virtual worlds, although not mature, deserve attention from researchers.

Method

For the experiment, subjects will be randomly approached on the streets and be asked whether they would assist us. Participants will be offered Linden dollars in exchange for providing effort, that is, to give or take a tour guide for thirty minutes. Participants will be randomly assigned the role of tour guide or tourists. Similar tasks will be repeated 10 rounds, and avatars' role will not change during the experiment. We will design a set of different tours, and each avatars as tour guide will be assigned one tour at random. A one-hour training session will be offered to avatars, so that they can get familiar with the tour and also how to give a tour. We then divide tour guides into two equally-sized groups, ``C" and ``R" denoting controlled groups and regular groups. The following description of experiment applies to both groups, except that group ``C" will not participate in the marketplace for tokens.

A special numbered token will be designed to indicate a tour guide's performance in the past. For example, a token with a number i means a tour guide has a record of successfully addressing all requests and giving a complete tour in i past rounds. When tourists come to a guide, they pay a certain amount of linden dollars based on the number on the token. The token numbers are essentially an avatar's reputation as a tour guide. We introduce tokens purely for experiment purpose. Since our randomly selected subjects are unlikely to be willing to exchange their avatars for our experiment, we can capture their behaviors in trading reputations with a token representing their reputation levels.

Before each round of experiment, tourists will be given a series of requests they can ask the tour guide. Depending on the tour guides' familiarity to the tour and their ability to remember the information from the training session, they may or may not be able to address the tourists requests. Each tour guide, at the beginning of the experiment, has to click on an object at a specified location, and that click will enable a ``detector" to record a set of activities carried out by the guide in the following 30 minutes. These activities include which spots on the tour that the guide has been to, how long has she stayed in each spot, messages exchanged between she and her tourist, etc. These activities will be used to evaluate the avatar's performance as a tour guide in this round, and the evaluation result determines whether her token number will increase or decrease by 1. For the purpose of randomization, we use a random evaluation process, meaning each set of activities has a less than one probability to be analyzed. Tour guides are notified the random evaluations rule; however, when they are performing service in a particular round, they are not aware if their performance are been evaluated. We also alter the probability of evaluation in each round, and the probability will be announced to tour guides. It is also worth noting that, despite some sets of activities will not be used for evaluation, we still utilize these activity records for testing hypotheses.

At the end of each round, tour guides will be told to visit a marketplace that enables them to buy and sell tokens with Linden dollars, and prices will be determined with a second price sealed bid auction. In other words, tokens will be reallocated at the end of each round. When the experiment finishes with all ten rounds, avatars can sell their tokens to the experiment organizer.

A reward scheme will be announced before the experiment. Avatars as tour guides will be rewarded in three parts. They each will receive a fixed participation reward at the end of each round, and this reward increases as more rounds going on. Besides, they keep the payments from their tourists in each round. Also, they are rewarded through selling their tokens at the end of the experiment.

Hypotheses

Knowing that a higher token will generate a higher payment from tourists, which consists part of their total reward, there is a benefit for all tour guides to purchase a higher token, which leads to a high demand for higher tokens. However, since there is a chance that the tour guide is incapable of performing a good tour or addressing all requests, she also faces the risk of lowering the token and thus bear a loss in terms of the value of the token. Therefore, we test

H1: *In the marketplace, the price for a higher token is higher than that of a lower token.*

We want to stress the point that the marketplace for tokens, or in other words the marketplace for tour guides' reputation, provide disincentive for avatars to shirk, since shirking can potentially decrease tour guides' token, and in turn impact the value of token and the payments determined by their tokens. There are various ways of shirking, for example, a tour guide may not cover all spots in the tour just to save time, or a tour guide may not address some requests from the tourist. Therefore, we will also test

H2: *The average token level in group ``R" is higher than the average token level in group ``C".*

Meanwhile, we also recognize an opposite force on tour guides' incentive for effort. Due to our random evaluation process, which echoes the random audit procedure widely adopted in real business, tour guides may have incentive to shirk since for a

positive probability, they will not get caught. In fact, if the benefit from shirking, meaning the amount of time saved for other entertainment, outweighs the expected cost of being caught in evaluation, we expect tour guide to take their chances and perform lousy services. Our variation in probability of evaluation provides a basis to test whether the above argument is a consideration in tour guides' decision for effort. Therefore, we test

H3: *The average performance in group "R" is higher when the announced evaluation probability is high.*

We are also interested in comparing tour guides' reactions when evaluations impact only future payment and when evaluations impact both future payment and the value of their tokens.

H4: *Controlling for the announced evaluation probability, the average performance in group "R" is higher than in group "C".*

As our theoretical analysis shows, it is possible to achieve a separation in the reputation market based on agents ability levels. In our experiment, controlling the token level, a tour guide's performance history as recorded by our "detector" is an approximation of her ability to perform the service. A separating equilibrium corresponds to the scenario that a tour guide with high performance maintains a high token level, while a low-performance tour guide maintains low token level.

H5: *In group "R", tour guides' average token level is higher when the average performance level is also high.*

CONCLUSION

In this study, we proposed a field experiment to examine the impact of an audited reputation and an avatar market on sustaining an effective virtual world. We first use a game theory model to describe a virtual world with agents providing services to others. We show that, with an avatar market for agents to buy and sell avatars in terms of the reputation, agents can be separated based on their abilities in providing services, and meanwhile they are motivated to exert effort to keep their avatars' reputation in good standing. Our main theoretical finding is that the avatar market promotes reliable reputation with a proper pricing scheme.

We then developed and described an application based on our theoretical results to implement audited reputation and an avatar market. The application contains a reputation mechanism to keep track of avatars' reputation, and a marketplace that supports buying and selling of avatars in terms of the reputation. The application is developed as a self-sustained program and can be implemented in different virtual worlds.

Based on our economic model and system implementation, we are currently conducting a 3-month field experiment in Second Life. We have generated five hypotheses to examine the impact of tradable reputation on avatars' incentive to exert effort, the impact of audit on avatars' incentive for effort, as well as the separability of the market.

Overall, our study shows the potential of field experiments for research on virtual worlds, online communities, and social networks. Field experiments in virtual world environment allow the analysis of economic activities in the field controlling for important factors like social embeddedness. Therefore, our field experiment will, hopefully, be the starting point for further research in virtual worlds, providing Information Systems researchers with better understanding on the interaction between reputation, audit, and virtual worlds performance.

APPENDIX

Proof to Proposition 1. For high type agents, knowing consumers' belief w_1 and w_0 , they must prefer reputation 1 to 0.

Denote w_0^H and π_0^H as optimal effort and profit if a high type agent chooses reputation 0 instead, and we have

$$w_0^H = \frac{k_L}{k_H} w_0,$$

$$\pi_0^H = k_H w_0^{H2} + (1 - \alpha)w_0.$$

High type agent will not deviate to 0 if the profit from 1 is higher, and this condition requires $\pi_1^H \geq \pi_0^H$, or

$$k_H (w_1^2 - w_0^{H2}) \geq (1 - \alpha)(w_0 - w_1) + \alpha V_1.$$

Define $X = (1 - \alpha) \left(\frac{1}{\frac{2k_L}{\alpha} - 1} - \frac{1}{\frac{2k_H}{\alpha} - 1} \right)$ and $Y = \frac{1}{(\frac{2k_H}{\alpha} - 1)^2} - \frac{k_L^2}{k_H^2} \frac{1}{(\frac{2k_L}{\alpha} - 1)^2}$. Given $k_L > k_H$, we have $Y > 0$. It is easy to verify that $k_H(w_1^2 - w_0^{H2}) = k_H Y V_1^2$. We therefore simplify the above inequality into

$$k_H Y V_1 \geq X + \alpha \quad (1)$$

Similarly, we define w_1^L and π_1^L for low type agents.

$$w_1^L = \frac{k_H}{k_L} w_1,$$

$$\pi_1^L = k_L w_1^{L2} + (1 - \alpha) w_1 - \alpha V_1.$$

For π_0^L to be greater than π_1^L , the following condition must be satisfied,

$$\frac{k_H^2}{k_L} Y V_1 \leq X + \alpha \quad (2)$$

Even under existence, we also need to verify that equilibrium parameters, especially the effort levels are within the range $[0, 1]$. It is easy to see that both high and low effort are positive. To ensure they are also no greater than 1, we need

$$V_1 \leq \frac{2k_H}{\alpha} - 1 < \frac{2k_L}{\alpha} - 1. \quad (3)$$

Thus, only solutions $\{w_0, w_1, V_1\}$ satisfying conditions (1), (2), and (3) are supported as a separating equilibrium.

Recall that $V_1 = \frac{\lambda_H (\frac{2k_L}{\alpha} - 1) (\frac{2k_H}{\alpha} - 1)}{\lambda_L (\frac{2k_H}{\alpha} - 1) + \lambda_H (\frac{2k_L}{\alpha} - 1)}$. It thus follows that (3) is satisfied.

Solving (1) for $\frac{\lambda_L}{\lambda_H}$, we obtain the following,

$$\frac{\lambda_L}{\lambda_H} \leq \frac{k_H Y}{X + \alpha} \left(\frac{2k_L}{\alpha} - 1 \right) - \frac{\frac{2k_L}{\alpha} - 1}{\frac{2k_H}{\alpha} - 1}.$$

Similarly solving for (2), we obtain the second condition as

$$\frac{\lambda_L}{\lambda_H} \geq \frac{\frac{k_H^2}{k_L} Y}{X + \alpha} \left(\frac{2k_L}{\alpha} - 1 \right) - \frac{\frac{2k_L}{\alpha} - 1}{\frac{2k_H}{\alpha} - 1}.$$

To summarize, if $\frac{\frac{k_H^2}{k_L} Y}{X + \alpha} \left(\frac{2k_L}{\alpha} - 1 \right) - \frac{\frac{2k_L}{\alpha} - 1}{\frac{2k_H}{\alpha} - 1} \leq \frac{\lambda_L}{\lambda_H} \leq \frac{k_H Y}{X + \alpha} \left(\frac{2k_L}{\alpha} - 1 \right) - \frac{\frac{2k_L}{\alpha} - 1}{\frac{2k_H}{\alpha} - 1}$, a steady-state separating equilibrium exists under the binary reputation mechanism with audit. Proposition 1 proved.

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