International Journal of u- and e- Service, Science and Technology
Vol.8, No. 8 (2015), pp.333-342
http://dx.doi.org/10.14257/ijunesst.2015.8.8.34

A Trust Model of E-commerce Based on Iterated Prisoner's Dilemma Game

Chun Guan [1], Jun Hu [2*] and Xinzhou Lu [2]

[1]*Dept. of Computer Science, Nanchang University, Nanchang 330031, China*
[2]*School of Software, Nanchang University, Nanchang 330047, China*
**Corresponding Author: Jun Hu, Email: hujun@ncu.edu.cn*

Abstract

Along with fierce e-commerce market competitions, some sellers may be worried about losing their customers so they bribe advisors by material means. The behavior of the advisor not only depends on their intrinsic properties, but also depends on their motivation that they may provide untruthful information to obtain additional material reward. The balance between profit and information truth constitutes the iterated prisoner's dilemma game. A trust model of electronic commerce based on iterated prisoner's dilemma game theory is proposed in this paper. Experimental results show that it can effectively inhabit advisor fraud.

Keywords: *Trust, model, e-commerce, iterated prisoner's dilemma*

1. Introduction

Trust is a kind of key issues in the contemporary e-commerce market, some sellers may also be unable to deliver its goods with the same quality as promised at first, but for selfish profit purposes, the sellers will cheat buyers maliciously. Therefore, buyers need a means to identify different products provided by different vendors and choose the sellers who can meet the requirements of the seller and make buyers gain the maximization of the benefit. Reputation mechanism is a kind of very special and effective way to evaluate the sellers [1, 2]. In this system, if the buyer does not have enough experience to identify potential sellers, He may ask other buyers (In the paper, we regard these buyers or other e-commerce transactions whom are asked as advisors) to get the seller's information. According to the report of seller's information provided by advisors, the buyer will establish the basic impression of reputation for sellers [3, 4]. But if the intrinsic characteristics of the advisor are malicious, they will not provide true information of sellers.

Many different solutions are presented to solve the problem of untruthful feedback. It suppresses this kind of the fraud by the establishment of the model of the integrity of advisors [5, 6]. Normally, among these solutions, the buyer can submit a report fully with reference to its own characters and wishes, regardless of the lack of utility to the whole market mechanism due to its untrue report. These methods set up trust model only according to the internal characteristics of advisors. In fact, in every market trading mechanism, both the seller and the buyer influence are interactive.

Some solutions are discussed for the specific situation of shortage of goods or quality deficiencies; it is believed that in order to compete for the limited supplies, advisors provide untruthful information [7, 8]. In fact, in the contemporary e-commerce market, in most cases, they are in oversupply situation. There are few sellers who couldn't buy scarce goods then slander these high quality sellers maliciously. More commonly, some sellers will give the buyer some benefits to win customers, induce them to make favorable comments or denigrate rivals. So these solutions appear somewhat narrow in applicability and do not conform to the market environment realistically.

ISSN: 2005-4246 IJUNESST

Along with fierce market competitions, some sellers may also be worried about losing their customers so they bribe advisors by material means. More specifically, after doing successful deals with sellers, some buyers will be required to give higher evaluation than that of the actual level of evaluation, and will be promised to give material rewards. Meanwhile, if after a few unsuccessful transactions, if the buyer provides untruthful feedback, these malicious sellers lure the buyer with material rewards not to submit a negative feedback. From a certain extent, it can make up the deal for their losses. In this sense, it seems to be a better choice for buyers to provide untrue evaluation. But on the other hand, that buyers positively exchange the real information can help buyers more quickly find high quality sellers. Therefore, how to develop strategies for buyers and gain the maximum of their largest profits, there is still no good way to deal with in literatures.

According to the above discussion, we believe that the advisor will not make the expected behavior driven by the interests in the e-commerce market. That is, the behavior of the advisor not only depends on their intrinsic properties, but also depends on their motivation that they may provide untruthful information to obtain additional material reward. To solve the problem of advisor untruthful feedback, a trust model based on iterated prisoner's dilemma game theory is proposed in this paper.

2. Related Work

The prisoner's dilemma is a classic model in game theory. A motivating story is a police investigation of two suspects in a robbery case. The police have enough evidence to convict both of the suspects on a lesser charge of breaking and entering, and require at least one of the suspects to become a witness in order to convict the other in the robbery charge. Both are placed in separate interrogation rooms and are given the choice to either squeal on the other, which is a defection, or to keep silent, which is cooperation. Both of the suspects are given this choice simultaneously and the jail time given to one will not cause an equal reduction in the jail time of the other. The game is non-zero sum. Although Dilemma itself only belongs to the nature of the model, it is widely used in the reality of price competition, military strategy, and *etc.*, [9, 10].

Iterated prisoner's dilemma is an extension of classic prisoner's dilemma, put forward by Robert Axelrod. It has been widely used to model real-world conflicts with a simplified decisions (defect or cooperate). In the game, two players select one of the two choices and get payoff from their decisions. Due to the existence of this kind of psychological “revenge”, when it makes each round of participants make the decision, it will fear the opponent's revenge, then it eventually tend to collaborate [11].

The effect of the number of opponents is studied on the evolution of cooperation among players in network-based iterative prisoner's dilemma game. Ishibuchi uses the grid network as the experimental environment, through experiments, and verifies that the cooperation is the inevitable trend in the evolution of the iterative prisoner's dilemma game. In the literature, it makes two experiments, one is under no noise interference environment, node makes its decision completely in accordance with the independent choice; the other is in the presence of a neighbor node which gives advice and reference, the node makes a decision. By checking the network quality, the number of side and other index, it comes to the conclusion [12].

What is the most important source of information to guess the internal strategy of your opponents? Park proposes to use an incremental active learning for modeling opponents with iterative prisoner’s dilemma games. It plays games against them and infers their strategy from the experience. It refines the other's models incrementally by cycling “estimation” and “exploration” steps. Experimental results with Iterative Prisoner's Dilemma games show that the proposed method can reveal other's strategy successfully. [13]

The reliability of human behavior in situations where cooperation is beneficial for all but is hindered by individual incentives not to cooperate is a central research question in economics and the social sciences. Jurgen analyzes an optimal decision, global optimal relationship and trigger conditions of human behavioral decision by the iterative prisoner's dilemma experiment. The study shows that in the social and economic fields, the necessity for human behavior toward cooperation is established on the basis of mutual profitable cooperation for everybody and that every individual's intrinsic tendency is tend to be uncooperative. They suggest that it adds a new participant in each round of test, and observes their impact on the whole game, then, they finally verified the theory of Axelrod, and found that at first the participants who chose collaboration strategy played a positive role in the whole game, but the ones who chose defection strategy do the opposite. Mutual cooperation with the first partner is positively correlated with the continuation of a nice strategy, whereas mutual defection leads subjects to give up their nice strategy [14].

Cooperation happening among selfish individuals exists widely both in human and animal societies. Migration, a new approach to understand the evolution of cooperative behavior, immediately arouses wide attention. Yang proposes a simple rule that when the individual hunts for new encounters a preference for selecting potential co-players is incorporated. By the approach of Monte Carlo simulations, they find that aspiring to interact with wealthy encounters promotes cooperation and also leads to cooperation’s outbreak. They propose a mechanism to examine the effect of migration on cooperation with application of local and historical game information [15].

Barlow compares different abstract connection topologies, encoded as combinatorial graphs, to see what impact they have on the behavior of agents being trained to play the iterated prisoner's dilemma. Results show that the structure of the connection topologies has a large impact on the play profile generated by an evolutionary algorithm training agents to play the iterated prisoner’s dilemma. It means that the connection topology is an important factor in the emergence of cooperation. Their study demonstrates that the impact of the number of states an agent is allocated has a large impact in prisoner’s dilemma on graphs, echoing and extending the result [16].

For the study of e-commerce trust, Hoogendoorn puts forward a trust model based on relative trust with other representatives of this field, compared with a single benchmark addressee judgment in 2014. Two models for trust dynamics are presented and empirically analyzed. Within the literature on trust, a variety of properties have been expressed concerning the desired behavior of trust models. An extensive validation study has been performed to show that human trust behavior can be accurately described and predicted using such computational trust models. The theory believes that human behavior trust judgment should not be simply the experience of the addressee as the benchmark, but at the same time considering the comprehensive situation of trusted competitors, integrate multiple attribute judgment. Meanwhile, it deals with the node and copes with the emergency of the reality. It is very worth learning from considering its node’s rival [17].

Zhang presents a kind of incentive mechanism based on trust, by recommending the buyers chose some other trusted buyers as advisors, advisors provided purchase advice. Honest sellers were more likely to be selected, and honest sellers would offer more lower prices with more high quality products to advisors, because advisors would help guide more buyers to purchase their goods, thus form a good circle. This mechanism caused that in order to obtain the choice of consultancy qualification. Some buyers would seed more personal interests and exaggerate the description of the product, which led to serious problems of the untruthful feedback [18].

Rizvi presents a centralized trust model driven by a third-party auditor to establish trust. By adopting a third-party auditing system, end users can have a baseline to evaluate services or providers, whom they have never worked with. The trust model involves third-party auditors to develop unbiased trust between service providers and service users. Furthermore, to support the implementation of the proposed trust model, they rank service providers according to the trust-values obtained from the trust model. The final sore for each participating service providers are determined based on the third-party assessment and the feedback received from service users [19].

Yuan puts forward a trust model based on Indirect Information to calculate the trust value. They consider the problem of predicting trustworthiness for an unknown agent in the large-scale distributed setting. Traditional approaches derive unknown agent's trust essentially by combining trust of third parties to the agent with the trust of these third parties, or simply by aggregating third parties' feedbacks about the unknown agent. In contrast, their method uses different kind of information, which is semantic similarity of the unknown agent with other agents. The information they utilize comes from the users' local information, so it can easily be obtained in the theory. But the trust model is only initial assessment with user's local information. In the complicated network environment, this model is not very well [20].

3. A Trust Model of E-commerce

3.1. Foundation of Iterated Prisoner's Dilemma Game

The prisoner's dilemma is a kind of typical model of game analysis; it reflects the individual optimal decision-making, but not the global optimal choice. For example, in a typical prisoner's dilemma, the police arrested two suspects, named A and B, but there is not enough evidence to testify against them, so the police imprison A B separately, and provide both sides with the same choices.

1. If one party pleads guilty and accuses each other (defection), at the same time the other party remains silent, the defection will be release and the other party will be sentenced to ten years

2. If both parties remain silent (cooperation), the parties will be sentenced to six months.

3. If both betray each other, they will be sentenced to 2 years.

Obviously, both parties choose cooperation for the global optimal decision-making (known as the Pareto Optimality in economics), but because each prisoner is selfish, they don't care about each other. In this case, their situation is analyzed by themselves as follows:

If the other party keeps silent, my defection will let me release.

If the other party betrays, I also have to betray to let me get a lower sentence.

Therefore, both sides of the rational thinking will lead to betray their final decision This is the only possible in a single prisoner's dilemma Nash equilibrium in payoff matrix are showed in Table 1 and Table 2.

Table 1. Payoff Matrix

	Cooperation	Defection
Cooperation	R、R	S、T
Defection	T、S	P、P

Table 2. Symbol Table

Symbol	Score	Description	Explanation

T	5	Temptation	The income gained by Successful Single Defection
R	3	Reward	Gained by Cooperation
P	1	Punishment	Gained by Mutual Defection
S	0	Suckers	The loss of solitary defection

In terms of personal choice, T>R>P>S, and in terms of the whole profit, obviously, 2R>T+S or2R>2P.

In several prisoner's dilemma games, it stipulates that participants must repeatedly determine their decisions, and remember their previous confrontations, due to the existence of the psychology of participants' "Tit for Tat", if it is betrayed in the last round, it is likely to choose defection again in this round; Meanwhile, if his or her own defection strategy is found, he or she will also get a defection, it may choose to watch each other's reaction in the next round. The repeated game for a long time will make both parties give up greedy strategy, and ultimately transform Nash equilibrium to Pareto Optimality by natural selection.

In contrast, in the e-commerce market, on one buyer's shopping behavior, his decision is from two aspects: on one hand, it is from the seller's cumulative trust in the historical transaction. On the other hand, it is from other advisors' recommendation. For advisors, what decision they are faced with is prisoner's dilemma.

If they choose cooperation, and give honest assessment, after confirmation, they will get promotion of reputation value.

Meanwhile, in a global perspective, if everyone chooses cooperation, the effective access to information in e-commerce market will be more and more quickly, and advisors themselves also can get better recommendations when shopping.

If they choose to betray, on one hand, if confirmed, their credibility will be cut down, meanwhile, if all advisors make this kind of decision-making, it will be more and more difficult for the recommended network to obtain the effective information. But on the other hand, untruthful evaluation could provide these advisors with material rewards. For example, some buyers can get a rebate by deliberately exaggerating the products of the seller, they can get or competitor's material rewards by maliciously slandering some products of the sellers.

3.2. Analysis of Advisor Game Strategy

In this paper, the game analysis is based on the following assumptions:

1. Assuming that there are n nodes in the electronic commerce trust network (nodes can be understood as buyers and sellers in e-commerce market), they are rational and selfish. It specifically means that these nodes may not take the initiative to voluntarily provide true information about other nodes without the drive of outside interests. And they regard getting the maximum of their own interests as the criteria of the behavior decision.

2. Global time is divided into time frame $t_1,\ t_2,\ \ldots,\ t_n,$, and each node completes a transaction or a recommendation within a time frame.

3. In the process of global trade, the number of average interaction is m.

4. Each interaction may have a profit and loss.

5. The losses and profit caused by the interaction between different buyers are equal.

In this paper, interaction between the nodes (trading, assessment, recommendation) is simulated as the game. The decision space of every node $i \in \{1,\ 2,\ \cdots,\ n\}$ in every interaction is $P_i = \{C_i,\ D_i\}$, Among them, C stands for cooperation, D stands for defection, In each interaction, the node will choose a strategy.

In iterated game, we assume that the probability of a node to take collaboration strategy is P. When P is zero, the node will not take collaboration strategy; When P is 1, the node will always take collaboration strategy. According to the principle of iterated game, node returns will gradually decay in each iteration as δ ($\delta < 1$), it reflects the historical interaction behavior of the node will have influence on future behavior. We agreed in each round of games, name I node itself, and name -i G for other nodes. Supposing G is the benefit of one iteration of the node, L is the loss of one iteration of the node. Therefore, the utility function of one certain time frame is:

$$u_i^{t_n} = P_{-i}^{t_n} G - P_i^{t_n} L$$

Based on the game theory, after completing the entire game process, the utility function for each node is:

$$U_i = (1-\delta)\sum_{n=0}^{\infty} \delta^n u_i^{t_n}$$

The Nash equilibrium analysis for tit for tat strategy is as follows:

The specific content of the strategy is: Firstly, assuming that every node begins with a collaborative game, in every iteration in the future, every node decides its behavior by simulating the opponent's decision. The probability model is:

$$P_i^{t_n} = \begin{cases} 1, & n = 0 \\ p_{-i}^{t_{n-1}}, & n > 0 \end{cases}$$

If all the probability of node collaboration is 1, then according to the above decision rule, the cooperation between nodes will continue. If we consider this situation, in the second iteration, the node I will change its probability to be $p_i^{t_1} = \theta$ ($0 < \theta < 1$), then its rivals –i will set their third iteration strategy as $p_{-i}^{t_2} = \theta$, and in accordance with the decision which -i made in the last iteration, the node i will reset the probability as $p_i^{t_2} = 1$. After repeating this process, we can get two sequences:

$$p_i^{t_n} = \{1,\ \theta,\ 1,\ \cdots\}$$

$$p_{-i}^{t_n} = \{1,\ 1,\ \theta,\ \cdots\}$$

Putting the above two sequences into the utility function:

$$\begin{aligned} U_i &= (1-\delta)\sum_{n=0}^{\infty} \delta^n (p_{-i}^{t_n} G - p_i^{t_n} L) \\ &= (1-\delta)[(G-\theta L) + \delta(\theta G - L)](1+\delta^2+\delta^4+\cdots) \\ &= \frac{(G-\theta L)+\delta(\theta G - L)}{1+\delta} \end{aligned}$$

For the above utility function, under the condition of $U_i \geq 0$, the Nash equilibrium is obtained:

$$\frac{G}{L} \geq \frac{\theta+\delta}{1+\theta\delta}$$

Let’s compare the TFT strategy, Nash equilibrium of Grim Strategy and Nash equilibrium of single-step trigger strategy as follows:

Grim strategy, assuming that at first, all nodes use and keep cooperation strategy, until an iteration, the opponent of i node adopts defection strategy, so i will always adopt defection strategy after i node.

Single-step trigger strategy, also assuming that all nodes take collaboration strategy at the beginning and keep it until that in an iteration, the collaboration probability of the opponent i node is below a certain threshold, then the i node will change the collaboration probability to be 0, but it can only change for once, after that, it will imitate the behavior of its rivals.

With the above two kinds of strategy model, Nash equilibrium is obtained:

Grim Strategy:

$$\frac{G}{L} \geq \theta + \delta$$

Single step trigger strategy:

$$\frac{G}{L} \geq \theta + \delta - \theta\delta^2$$

Compare these three strategies, under certain conditions (that is, under the same conditions of θ, δ), the smaller the critical value of the strategy it is, it shows it is easier to realize the strategy of Nash equilibrium, namely, the strategy, under certain condition, the more easier to achieve Nash equilibriums, relatively speaking, the buyer and the seller is more likely adopt the strategy of the game in relative e-commerce transactions,

By comparing three strategies of mathematical model, the critical value of TFT strategy is the minimum, namely, TFT strategy is the most likely adopted game strategy of the e-commerce market participants. As below, the game analysis is established on the basis of TFT strategy.

3.3. A Trust Model of E-commerce based on Iterated Prisoner's Dilemma Game

Based on the above discussion about game in this paper, a new reputation model in e-commerce based on iterated prisoner's dilemma game is presented to suppress advisor defection acts, so as to solve the problem of advisor untruthful feedback.

1. Conditions for establishing model

This paper introduces the concept of market supervision α for e-commerce, and greater market supervision, on behalf of the more favorable market order. Strength of the advisor is expressed as θ, which is a normal distribution. Let advisor gives a buyer the value π in one iteration, then, $\pi = k\alpha + h\theta + c$, wherein C is the market uncertain factor.

For simplicity, the consumption number of buyer in the same seller recommended by advisor, is expressed as m_t, and the expected profit of buyer in an iteration is expressed as π_t, then, $m_t = \lambda\pi_t$.

The utility function of advisor in an iteration can be expressed as: $u = \omega_t - c(\alpha_t)$, wherein $c(\alpha_t)$ means the supervision cost function, ω_t means the advisor expected profit, $\omega_t = \beta m_t$, β is the advisor profit to give advice.

2. The trust model based on iterated prisoner's dilemma game

This article discusses only the case t = 1 and 2, the other iterations situation can be extended. According to the aforementioned assumption, can be obtained:

$$E(\pi_2 \mid \pi_1) = E(k\alpha_2 \mid \pi_1) + E(h\theta \mid \pi_1) + E(u_2 \mid \pi_1) \ = hE(\theta \mid \pi_1)$$

Assuming buyers have rational expectations, then when the game gets equilibrium, $\overline{\alpha_1}$ is approximately equal to the actual selection of advisors. By observing π_1, buyers can know $h\theta + u_1 = \pi - E(\alpha_1)$. Buyers can infer θ by π_1.

Set:

$$\tau = \frac{\mathrm{var}(h\theta)}{\mathrm{var}(h\theta) + \mathrm{var}(u_1)} = \frac{h^2\sigma_\theta^2}{h^2\sigma_\theta^2 + \sigma_u^2}$$

Among them, σ_θ and σ_u mean variances.

The rational expectation is computed as followed:

$$E(\theta \mid \pi_1) = (1-\tau)E(\theta) + \tau(\pi_1 - k(\overline{\alpha_1})/h)$$
$$= \tau(\pi_1 - k(\alpha_1)/h)$$

Given $\tau > 0$, the game equilibrium profit in e-commerce is:

$$\omega = \lambda\beta h E(\theta \mid \pi) = \lambda\beta\tau(\pi - k(\overline{\alpha}))$$

By computing ω_1 and ω_2, the utility model can be obtained as followed:

$$U = \lambda\beta k\overline{\alpha_1} + \lambda\beta\tau(k\alpha_1 + h\theta + u_1 - k(\alpha_1)) - \frac{b\alpha_1^2}{2} - \frac{b\alpha_2^2}{2}$$

When the advisor utility function in e-commerce is optimized, the first order condition is:

$$\alpha_1 = \lambda\beta k\tau / b$$

Among them, β and k are constant, and α_1 increases with the increase of λ and τ. It shows that when the game conducts over two stages, the advisor do not like single game that choose the supervision of zero, that is not defection without any thought.

In fact, when the game iterates a lot of times, except that the last iteration of supervision is zero, all other supervisions are positive, it shows that a constraint exist to suppress the advisor defection without hesitation, eventually suppress and eliminate untruthful feedback phenomenon.

4. Experiment and Simulation

A matrix with 100 unit length and 100 unit width is used to simulate behaviors of electronic commerce nodes in this experiment. The first decision is to initialize all nodes cooperation strategy, and its utility is 1000, all node behaviors comply with “tit for tat” strategy, at the end of each iteration, advisor utility and cooperation rate are calculated. Experiment results are shown in Figure 1.

Experimental simulation results show that along with the iterative continuously, e-commerce nodes find that choosing defection strategy gains far less than that of cooperative strategy, so they tend to choose more cooperative strategy, the cooperation rate rise. Meanwhile, from the cooperation rate and advisor utility trend, it can be seen that with the increase of cooperation rate, all advisor utility increase, more and more of their total profit, and ultimately tend to equilibrium.

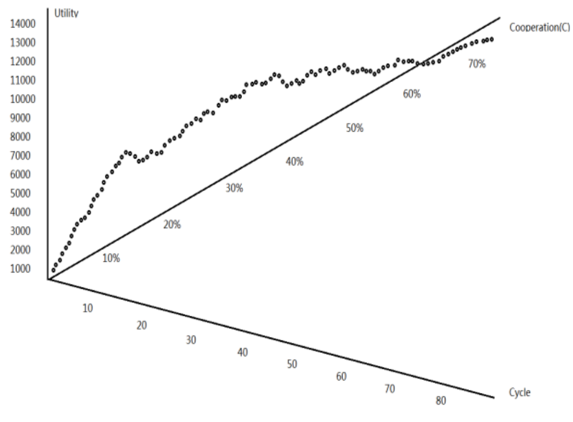

Figure 1. Simulation of E-commerce Node Behaviors based on Iterated Prisoner's Dilemma Game

5. Conclusion

Nowadays, trust plays an important role in the e-commerce market. Some sellers may also be unable to deliver its goods with the same quality as promised at first, but for selfish profit purposes, the sellers will cheat buyers maliciously. Other sellers may also be worried about losing their customers so they bribe advisors by material means. More specifically, after doing successful deals with sellers, some buyers will be required to give higher evaluation than that of the actual level of evaluation, and will be promised to give material rewards. The balance between profit and information truth constitutes the iterated prisoner's dilemma game. A trust model of electronic commerce based on iterated prisoner's dilemma game is presented to solve the untruthful feedback problem in this paper. Experimental results show that it can effectively inhabit advisor untruthful feedback.

Acknowledgements

This work is supported by the National Natural Science Foundation of China (Grant No. 11226042) and the Science Research Foundation of Jiangxi Educational Committee (Grant No. GJJ12050).

References

[1] P. Sun and C. Ku, “Review of threats on trust and reputation models”, Industrial Management and Data Systems, vol. 114, **(2014)**, pp. 472-483.
[2] A. Adamopoulou and L. Symeonidis, “A simulation testbed for analyzing trust and reputation mechanisms in unreliable online markets”, Electronic Commerce Research and Applications, vol. 12, **(2013)**.
[3] G. Joshua, Z. Jie and C. Robin, “Improving trust modeling through the limit of advisor network size and use of referrals”, Electronic Commerce Research and Applications, vol. 12, **(2013)**, pp. 112-123.
[4] V. Sokratis, P. Milan and Z. Nicola, “A reference model for reputation systems”, Decision Support Systems, vol. 61, **(2014)**, pp. 147-154.
[5] H. Yan and Y. Zhang, “A trust model in P2P based on fuzzy set theory”, Journal of Applied Sciences, vol. 13, **(2013)**, pp. 2532-2537.
[6] G. Ouyang and X. Chen, “Trust model based on P2P network”, Journal of Networks, vol. 8, **(2013)**, pp. 2013-2020.
[7] N. Manh Hung and T. D. Que, “A computational trust model with trustworthiness against liars in multiagent systems”, Computational Collective Intelligence: Technologies and Applications, **(2012)**, pp. 446-455.
[8] L. Xin, D. Anwitaman and R. Krzysztof, “A Trust beyond reputation: A computational trust model based on stereotypes”, Electronic Commerce Research and Applications, vol. 12, **(2013)**, pp. 24-39.
[9] D. Ashlock, E. Y. Kim and W. Ashlock, “A fingerprint comparison of different prisoner’s dilemma payoff matrices”, IEEE Symposium on Computational Intelligence and Games, **(2010)**, pp. 219–226.
[10] B. J. Alexander, “Examination of graphs in Multiple Agent Genetic Networks for Iterated Prisoner's Dilemma”, IEEE Conference on Computational Intelligence and Games, **(2013)**.
[11] R. M. Axelrod, “The Evolution of Cooperation”, NY, Basic Books, **(2006)**.
[12] H. Ishibuchi, T. Sudo, K. Hoshino and Y. Nojima, “Effects of the number of opponents on the evolution of cooperation in the iterated prisoner's dilemma”, IEEE International Conference on Systems, Man and Cybernetics, **(2013)**, pp. 2001-2006.
[13] H. Park and K. Kim, “Opponent modeling with incremental active learning: A case study of Iterative Prisoner's Dilemma”, IEEE Conference on Computational Intelligence in Games, **(2013)**.
[14] F. Jurgen and L. Ulrike, “Once Nice, Always Nice? Results on Factors Influencing Nice Behavior from an Iterated Prisoner's Dilemma Experiment”, Systems Research and Behavioral Science. vol. 31, **(2014)**, pp. 327-334.
[15] Z. Yang, T. Wu and L. Wang, “Hunting for wealthy encounters promotes cooperation in spatial Prisoner's Dilemma games”, European Physical Journal, vol. 86, **(2013)**.
[16] L. Barlow and D. Ashlock, “The impact of connection topology and agent size on cooperation in the iterated prisoner's dilemma”, IEEE Conference on Computatonal Intelligence and Games, **(2013)**.
[17] M. Hoogendoorn, S. W. Jaffry, M. P. Van and J. Treur, “Design and validation of a relative trust model”, Knowledge-Based Systems, vol. 57, **(2014)**, pp. 81-94.
[18] J. Zhang, R. Cohen and K. Larson, “Combining trust modeling and mechanism design for promoting honesty in e-marketplaces”, Computational Intelligence, vol. 28, **(2012)**, pp. 549-578.
[19] S. Rizvi, J. Ryoo, Y. Liu, D. Zazworsky and A. Cappeta, “A centralized trust model approach for cloud computing”, 23rd Wireless and Optical Communication Conference, **(2014)**.

[20] F. Yuan and S. Liu, "A computational trust model based on indirect information", Journal of Information and Computational Science, vol. 11, **(2014)**, pp. 1545-1553.

