Vulnerability of Reputation Management System due to Tolerant Evaluation

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Abstract. Reputation management system is effective for promotion of cooperative behaviors in online transaction. However, it may be hard for a trader to evaluate his/her partner accurately on the transaction because of his/her fear for the retaliatory evaluation or of the expectation to positive evaluation from his/her partner. Traders have not only the strategy for behaviors but also that for evaluations. In order to analyze the influences of inaccurate evaluation in the reputation management system, we model an online consumer-to-consumer market. The results show that the dominant strategy among traders for evaluation is cooperative while that for behavior is non-cooperative. The domination of non-cooperative behaviors is derived from that the tolerant evaluation cannot eliminate those behaviors. We conclude that reciprocal evaluations by unmalicious participants cause an inflation of reputation and may prevent the reputation management system from functioning properly.

1 Introduction

The importance of the development of online transactions and the reputation management systems is widely insisted (Kollock, 1999), (Dellarocas, 2000). Especially, an online market among consumers in which many consumers participate uncertainly as sellers and buyers usually demands a reputation management system due to choose trustable transaction opponents essentially. A reputation management system (RMS) is a system of which participants in an online market can evaluate transaction opponents and share their information each other. One of the goods examples of successive markets using such a RMS is eBay. The eBay has a RMS in which participants evaluate opponents qualities.

Evaluations in the RMS are almost positive. The case study of the eBay online trading by Resnick and Zeckhauser (2001) report that a ratio of positive opinions in the system exceeds 99%. Baron (2001), by the way, points that a dissatisfied considering giving negative feedback might fear that the other trader would retaliate negative feedback. Does the 99% of traders satisfy their transactions really? Or do the evaluations have some kinds of biases? Miyata and Ikeda (2001) survey for users of the internet auctions in Japan. They found the following opinions in the survey. "When I write an opponent negative evaluation, I fear that the opponent may write a negative evaluation about me later". "When a user evaluates her partner positively, she expects reciprocal evaluation from the partner". These opinions suggest a possibility of that even an unmalicious participant evaluates inaccurately because of a fear of a retaliative evaluation for one's own evaluation and an expectation of a high evaluation from one's partner. In a summary, the RMS using interactive evaluations essentially distinguishes non-cooperative participants, however in practice, over-positive evaluations emerge and the participants may not judge good partners. Why does the RMS in online markets bring the over-positive evaluations? What kind of influences does the bias have for the soundness of the market?

Generally, it is natural that a person returns a positive or negative evaluation for the other person who evaluates one positively or negatively. Such attitude is called as reciprocal. Thompson (1967) investigates that people behave for a partner's action reciprocally when they interact. Does the RMS in online markets functionalize effectively if person's attitude is reciprocal when one wants to evaluate the other? The purpose of the RMS is to promote cooperative behaviors among participants due to evaluate their behaviors and chare the information. However, this discussion suggests that the participants have not only strategies of behaviors but also those of evaluations because they have the fears and the expectations for the reactions from their opponents when they evaluate them.

We develop a model of reciprocal evaluations. The model describes transactions and interact evaluations in an online market based on a hypothesis of which the evaluations are reciprocal. The goal of this research is obtain how evaluating participants' partners reciprocally has an influence on the soundness of the online markets?

In Section 2, we explain a relationship between some studies treating evolution of cooperation using the prisoners' dilemma games and a RMS of the online markets. We construct a simulation model in Section 3. Section 4 shows experiments and results of the simulation. Section 5 discusses mechanisms and their background of which the inflations of reputation emerge and the RMS cannot work effectively by which participants in the markets evaluate their opponents reciprocally. In Section 6, we conclude.

2 Prisoners' Dilemma Game and Reputation Management System

In this Section, we discuss that an online transaction market is able to be described a model with prisoners' dilemma games and show basic ideas for the model of the market with the reputation management system.

2.1. Online Transactions and Prisoners' Dilemma Games

A player who participates in an online transaction always has an incentive to cheat others (i.e., to defect) due to anonymity and the ease of entry and exit from transactions. For example, a buyer may demands to discount by irrational complaints though a seller provides an item with high quality. In contrary, a seller can sell an item off at a higher price with low quality and denies complaints from the buyer. Non-cooperative actions, in addition, are exemplified the delay for responses, the cancellation of transactions, the imposition of shipping and handling, and so on. These actions can be described as a prisoners' dilemma game. In the game, there are two players, whom we can refer to as player-1 and player-2, and they cannot communicate with each other directly because they are in solitary confinement in a prison. Each player has two strategies, namely cooperation (C) and defection (D). We can consider these strategies within a payoff matrix, as shown in Table 1.

Table 1: Payoff matrix for prisoner's dilemma

		Action of player-2	
		C	D
Action of player-1	C	R_1, R_2	S_1, T_2
	D	T_1, S_2	P_1, P_2

The necessary conditions for prisoner's dilemma are the following two inequalities (1):

$$\begin{cases} T_i > R_i > P_i > S_i \quad , i = 1,2 \\ 2R_i > T_i + S_i \end{cases} \qquad \textbf{(1)}$$

In the prisoner's dilemma of an online transaction, a seller can take two possible actions: cooperation, i.e., sending goods with high quality, and defection, that with low quality. Likewise, a buyer can also cooperate or defect, i.e. no complaints about goods or claims to discount by irrational complaints. Under the situation, if a trader acts cooperative, one keeps being exploited with non-cooperative traders. To keep the online market safely, a manager of the market needs a system which protects cooperative actors and exploit non-cooperative actors.

2.2. Model of Reputation Management System and Evolution of Cooperation

Evolutionary dynamics of cooperative behaviors is being discussed by many papers with various interests and approaches e.g. Axelrod (1984). Cohen et.al. (2001) is a systematical and exhaustive paper about the evolution of cooperation in the iterated prisoners' dilemma game. The main result of Cohen is that "context preservation" is an important trigger for promotion of cooperative behaviors. The context preservation is derived from a situation that individuals located in a two-dimensional lattice torus space have fixed von Neumann neighborhood as opponents of games.

The Cohen's context preservation model restricts that the information of which the individuals can refer to for their next actions is just opponents' actions before one period. In other words, they focus on the evolution of cooperation under a situation without reputation management systems because the individuals cannot use indirect information concerning opponents' actions. Besides, in the Cohen model, the individual imitates a strategy of whoever has the highest payoff of her neighbors when her strategy evolves. This rule is also premised on that the individuals' actions and strategies are visible from the others.

Yamamoto et.al. (2004a,b) develop a model of what a new entry person enters an online market by imitating a strategy of whoever has the highest payoff. The model assumes that the participant strategies do not change and a new participant enters the market as alternated. The model follows a situation of which winners of the market invite their friends. The individual who has higher payoff invite her acquaintances to the market and they can imitate her strategy.

Generally speaking, the higher the participant gains payoff, the more she can survive in markets. The evolution of individual strategy is studied with two approaches: one using the genetic algorithm (GA) such as Yao and Darwen (1999), Ashlock et.al. (1995) and Nowak and Sigmund (1998), and the other imitating the neighbor's strategy such as the Cohen model or the Yamamoto model. In this paper, we develop a model as not imaging a particular situation such as Yamamoto et. al. (2004a,b) but describing a general adaptive process of which the fittest strategy for the market is dominant. Our purpose is to discuss on the essential traits of the reputation systems.

It is natural that the other participants' payoffs and strategies are invisible on the markets because they are inner status of persons. In turn, we cannot watch the others' penny in purse and inside their heads. Therefore, we assume the neighbors' payoffs and strategies are hard to see and the adaptation process of individual strategies follows the GA as a method of which the individuals who fit in the market can survive evolutionarily.

We discuss on the influence of which tolerant reputation gives on a RMS by comparing three models with the model of reciprocal evaluations introduced above. They are a model of correct evaluations, that of invisible payoffs, and that of visible payoffs with basic prisoners' dilemma.

3 Model of Reciprocal Evaluations

In order to design a simulation model of an online marketplace, we discuss on transactions within the framework of the prisoner's dilemma, in which the players are represented by buyers and sellers. In this paper, we treat of a market such that sellers and buyers deal with each others in the bidding. The sellers and buyers are actors who have their strategies and deal with the others automatically. We describe the sellers and buyers as agents in our model.

3.1Agents

Agents are two types: Sellers and Buyers. An agent makes two types of decisions. One decision making is about one's behavior of the trading, whether one deals with one's partner cooperatively or non-cooperatively (defectively). Another one is about one's evaluation of the partner, a positive evaluation or a negative one.

An agent, x, has an action strategy $Act^x = (a_i^x, a_p^x, a_q^x) \in [0,1]^3$ and an evaluation strategy $Eva^x = (e_i^x, e_p^x, e_q^x) \in [0,1]^3$. The probability of cooperating on the first dealing is a_i^x. The probability of cooperating if the other agent cooperated on the previous dealing is a_p^x, and a_q^x is the probability of cooperating if the other agent defected on the previous dealing. On the other hand, the probability of positively evaluating (appreciation) on the first dealing is e_i^x. The probability of appreciation if the other agent cooperated on the dealing this time is e_p^x, and e_q^x is the probability of appreciation if the other agent defected on the dealing this time. For a simplicity a la Cohen, the agent has one step memory for strategies, and let $a_i^x = a_p^x$ and $e_i^x = e_p^x$. Using this notation, we can define the basic strategies of the prisoner's dilemma. If an agent has (a_p^x, a_q^x)=(1,1), she is a perfect cooperator, so we call her strategy All-C. When (a_p^x, a_q^x)=(1,0), the strategy is called tit-for-tat (TFT), and (0,0) is the strategy of a perfect defector, or All-D.

Each agent can have one single role, either buyer or seller. All the buyers put in position on a two-dimensional lattice torus Buyers' space and all the sellers are also on the same sellers' space. Shown in Figure 1, a buyer chooses one seller from her neighbors in the sellers' space. Same as a seller's decision. So, possible trading partners of a seller (a buyer) are defined as the fixed four buyers (sellers) located on von Neumann neighborhood in the buyer's (seller's) space.

An agent evaluates a trading partner on her evaluation strategy for every dealing action. A reputation of an agent is defined as summing up evaluations for one. Using this reputation, agents choose their partners to deal it.

A dealing process on a market consists of four phases: bidding, trading, evaluation, and learning of strategies.

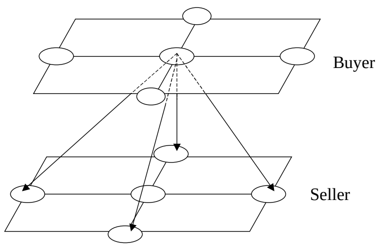

Fig. 1. Neighborhoods of tradable sellers for a buyer

Bidding: A buyer bids for a seller who has the highest reputation in one's neighbor. After the biddings of all the buyers, the sellers contract trading actions with particular buyers who have the highest reputations in the bidders for them.

Trading: For all contracts, a buyer, *b*, and a seller, *s*, deal with each other following their action strategies, Act^b and Act^s. Based on the strategies, *b* (*s*) selects one's action, of two alternatives, cooperation (C) and defect (D).

Evaluation: After trading, b (s) evaluates s (b) on one's evaluation strategy, Eva^b (Eva^s). The order of evaluation is random for every trading, so the probabilities of what b and s are the first evaluator is 0.5, respectively. When the first evaluator, x, evaluates the second evaluator, y, one's evaluation, E(y<-x) in {P,N}, is decided by which if Act^y=C then P (positive) with the probability e_p^x, so N (negative) with the probability 1-e_p^x. Likewise, if Act^y=D then P (positive) with the probability e_q^x, and N (negative) with the probability 1-e_q^x. The evaluation of the second evaluator is the same value of that of the first evaluator, so E(x<-y) = E(y<-x). The reason is explained later.

Learning strategy: After a set period of simulation, agents learn their strategies. Using the GA with trading payoffs as a fitness function, an agent's action strategy Act^x and evaluation strategy Eva^x evolve.

In the evaluation phase, why is the evaluation of the second evaluator the same of that of the first? Thompson (1967) shows that, people tend to act reciprocally to their partners when they interact. If the partner acts favorably, the person evaluates it positively, and if the partner acts unfavorably, the person did it negatively. From the view of Heider's balance theory (1958), an impression of an interaction between x and y depends on the opponent's impression. When the evaluation of x is positive, that of y is also positive, and vice versa. From these insights, it is appropriate to assume that an evaluated person evaluates one's partner reciprocally based on the partner's evaluation. In the evaluation phase of our model, the second evaluator decides a reciprocal (tit-for-tat) evaluation (reciprocal) of the partner. Therefore, we assume E(x<-y) = E(y<-x).

3.2 Reputation Management System

An agent x's evaluations, E^x, are recorded on a reputation management system (RMS). The RMS is managed intensively, and the agents can directly refer to the reputations of all agents. We define a reputation of an agent. A set of a history of evaluations to an agent, x, at a period of t is formulated as the Equation (2).

$$T_t^x = \left\{ E_k^x \middle| k \in \{0,1,\cdots,t\} \right\} \tag{2}$$

A number of what the value of the evaluation is P (positive) in T_t^x is defined as $\left|T_{P,t}^x\right|$, and a number of what the value of the evaluation is N (negative) in T_t^x is as $\left|T_{N,t}^x\right|$. A reputation of an agent, x, at a period of t, R_t^x, can be calculated as difference of the sum of positive evaluations and that of negative evaluations. See Equation (3).

$$R_t^x = \left|T_{P,t}^x\right| - \left|T_{N,t}^x\right| \qquad \textbf{(3)}$$

A model of reciprocal evaluations is constructed as the extension of a model of correct evaluations, which is also constructed as the extension of a model of invisible payoffs, and which is as the extension of a model of visible payoffs with basic prisoners' dilemma. So, we explain four models in a methodical way.

In the model of visible payoffs based on the Cohen model, agents deal with the neighbor agents and do not evaluate their actions interactively. The information the agent can refer is only one's partner's action on the previous trading. The buyers and sellers have no difference in the model. The model of invisible payoffs is different from the model of visible payoffs in the point of the cooperation of agents, from imitating to GA. By introducing a RMS reflected with agents' actions correctly to the model of invisible payoffs, we make a model of correct evaluations. So, it is $E_t^x = A_t^x$ in the model of correct evaluations. Finally, when agents have strategies of evaluations in the model of correct evaluations, the model becomes a model of reciprocal evaluations.

The model of reciprocal evaluations and the three models are compared in Table 2.

Table 2: Comparison of the models

	Reciprocal Eva.	**Correct Eva.**	**Invisible Payoffs**	**Visible Payoffs**
RMS	with reciprocal evaluation	with actions correctly	None	None
Invisibility of a partners' payoff	Invisible	Invisible	Invisible	Visible
Bidding	for whoever has the highest reputation	for whoever has the highest reputation	None	None
Trading	a trading partner selected by bidding	a trading partner selected by bidding	all agents located on von Neumann neighborhood	all agents located on von Neumann neighborhood
Evaluation	evaluations based on an agent's evaluation strategy	trading actions with accuracy	None	None
Learning strategy	GA	GA	GA	imitating a neighbor agent's strategy

4 Simulation Experiments

We simulate our model developed in Section 3 with the agent-based approach. The simulations are carried out using C language. The parameter settings are as follows, the number of agents is 100, the number of periods for a generation is 100, and the number of generations is 200.

4.1 Model of visible payoffs based on the Cohen model

Cohen et.al. (2001) developed a basic model of the evolution of cooperation without a RMS. So, we examine the model as a pilot study.

Results of the simulations of the model are shown in Figure 2, with the vertical axis indicating the average (Ap, Aq) of all the agents and the horizontal axis indicating the simulation generation. Figure 2 shows that the All-D (perfect defector) strategy is dominant at first, and in time the tit-for-tat (TFT) is dominant. As is explained by Cohen, this mechanism is explained as follows: in the initial random state, the All-D strategy is the most advantageous strategy because it can perfectly exploit agents whose strategies are the All-C. When the All-D strategy is dominant, two TFT agents, who are located in each other's neighborhoods due to mutation, can overcome neighbor All-D agents because two TFT agents can gain higher payoffs than the neighbor All-D agents. The TFT agents then can form their colonies. As a result, the TFT strategy is dominant, and cooperation emerges.

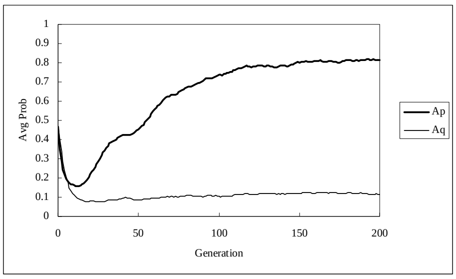

Fig. 2. The evolution of strategy in Cohen model

4.2 Model of invisible payoffs using GA as learning strategies

In the basic model explained above, we assume that the other agents' actions an agent dealt with and neighbor agents' payoffs are visible from the agent. But that is unnatural. On the other hand, this model premises that neighbor agents' payoffs are invisible from the agent. Results of this model are shown in Figure 3.

As shown in Figure 3, the All-D strategy is dominant in the model, while the TFT strategy is dominant in basic Cohen model. Why? Invisibility of neighbors' payoffs prevents two TFT agents who are located in each other's neighborhoods from surviving because a difference between payoffs of the All-D agents and those of the

TFT agents is a slight. According to the GA, the surviving probability of agents (a fitness function) is proportional to the payoffs of agents. Therefore, the All-D strategy continues dominant. The result indicates that the evolution of cooperation is hard when agents can use just dyadic information (which agents gain through their own experiences).

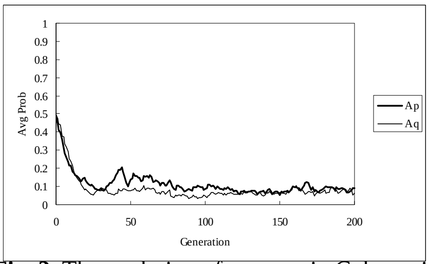

Fig. 3. The evolution of strategy in Cohen with GA model

4.3 Model of correct evaluations

A RMS is a system of which visible information is not only dyadic actions of whom the agent deals with directly, but also histories of innocent bystanders. We develop a model of a RMS which can record agents' actions correctly as a basic model for our research purpose. We refer to it as a model of correct evaluations. In this model (and a model of reciprocal evaluations explained later), it is able to choose trading partners because of using agents' reputations. We then introduce a bidding process to the model to choose trading partners.

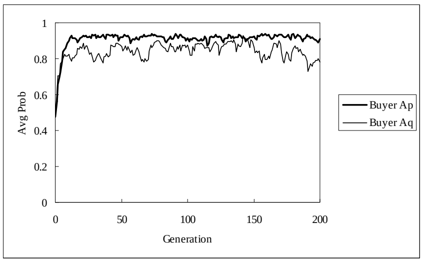

Fig. 4. The evolution of the buyers' strategies in the model of correct evaluations

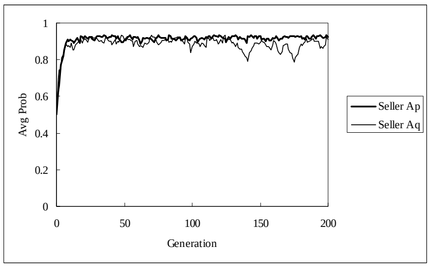

Fig. 5. The evolution of the sellers' strategies in the model of correct evaluations

Figure 4 and 5 show the average (Ap, Aq) of the buyers and sellers in this model. All the agents can see the information of all the agents' actions. If an agent acts non-cooperatively and therefore one can gain a high payoff at that time, one is not chosen by the others for the bidding process because all the agents know one’s irrelevant action. One cannot exploit the All-C agents when one does not take part in any trading. Therefore, the All-D agents cannot survive in the model. Besides, the TFT agents are more disadvantage than the All-C agents. When the TFT agent deals with the All-D agent, one acts defectively as a punishment for the All-D agent. This is why a history of the TFT agents has irrelevant records. As a result of these processes, the All-C strategies become dominant strategies.

4.4. Model of reciprocal evaluations

People's actions cannot be recorded on the real RMSs correctly. Because they tend to have psychological pressures that they are afraid of others' revenges for themselves when they evaluate the others, and to have expectations of which they want others to evaluate him positively. It may be general that individuals behave strategically in the evaluation phase. From the point of view, we introduce the evaluation function, Eva, discussed in Section 3. The evolutions of the buyers' and sellers' actions are shown in Figure 6 and 7. Figure 8 and 9 show, on the other hand, the evolutions of the buyers' and sellers' evaluations.

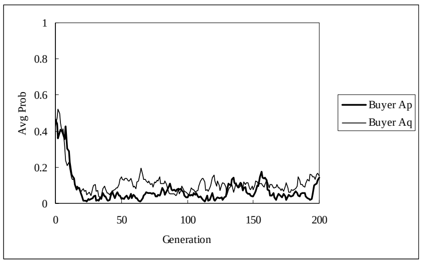

Fig. 6. The evolution of the buyers' action strategies in the model of reciprocal evaluations

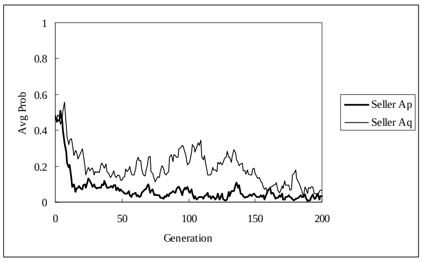

Fig. 7. The evolution of the sellers' action strategies in the model of reciprocal evaluations

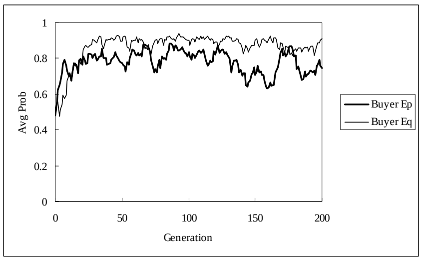

Fig. 8. The evolution of the buyers' evaluation strategies in the model of reciprocal evaluations

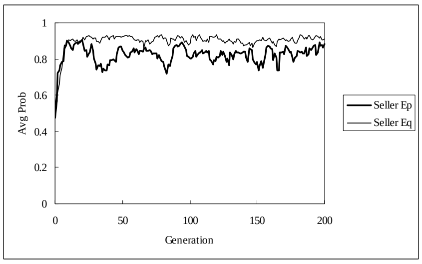

Fig. 9. The evolution of the sellers' evaluation strategies in the model of reciprocal evaluations

As shown in Figure 6 and 7, dominant action strategies of both the buyers and sellers are the All-D strategies; while Figure 8 and 9 show that dominant evaluation strategies of them are the All-C strategies. Because the agent who evaluates trading partners tolerantly tends to be chosen as a trading partner. So the All-C strategy has the advantage in the evaluation strategy. The agent whose evaluation strategy is the TFT punishes non-cooperative agents, so one has a history of one's revenge for non-cooperative ones. On the other hand, the All-C agents have no history of the revenges. Therefore, the All-C agents are more advantageous than the TFT agents because the All-C agents are free riders for the punishment of non-cooperative partners. However, it is the mechanism that brings that the function for the punishment of non-cooperative agents cannot work and the agent whose action strategy is the All-D has the advantage. There are no agents, then, whose evaluations are the TFT strategies when the other agent acts non-cooperatively. Therefore, the dominant action strategies are the All-D.

5 Conclusion

As shown in the simulation results, individuals who evaluate tolerantly have an advantage because evaluating tolerantly is being chosen as a trading partner. As is well known that the wise man keeps away from danger, we can often experience a situation of what people are hesitative about punishing non-cooperative actions. However, tolerant evaluations are regarded as a free riding for costs of punishing non-cooperative actions. Besides, we think it is hard to eliminate the tolerant evaluations because they are not based on malicious attitude. The tit-for-tat strategy which punishes non-cooperation is an evolutionary stable strategy in the game theory, however, this action costs for punishing in real life. The free riding for costs for punishing non-cooperators is known as a second order free riding problem (Axelrod, 1986). Our results show that the RMS in online markets has such a problem intrinsically due to reciprocal evaluations. We have an important theme for study on designing a RMS in how participants share the cost to develop the online trading actions in the future.

In the RMS, inaccurate evaluations are permitted due to share the information introduced on participants' subjective evaluations. Many papers pointed the necessity for exploiting malicious evaluations and arbitrary evaluations in collusion. For example, Dellarocas (2000) shows that the combination of “Controlled Anonymity” and “Cluster Filtering” makes the online trading robust for inequitable evaluations. Kamber et.al. (2003) studied a distributed hast table can prevent malicious groups in a peer-to peer environment. Does the RMS work effectively and the participants share the accurate evaluations if it exploits malicious evaluations? We conclude that a trap of the RMS is never exploiting the non-cooperative actions because the participants evaluate reciprocally and they prefer to tolerant participants for their evaluations. That is to say, the reputations cannot work as signals for the quality.

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