Association for Information Systems
AIS Electronic Library (AISeL)

AMCIS 2012 Proceedings | Proceedings

Strategies of Mobile Agents on Malicious Clouds

YUNGLIANG LAI
National Yunlin University of Science and Technology, Yunlin,, yungliang.lai@gmail.com

Hsueh-Chi Shih
National Yunlin University of Science and Technology, Yunlin, mr.calvin.lai@gmail.com

Jehn-Ruey Jiang
Computer Science & Information Engineering, National Central University, Jhongli, jrjiang@cs.ncu.edu.tw

Strategies of Mobile Agents on Malicious Clouds

Yung-Liang Lai
Dept. of Computer Science & Information Engineering, Taoyuan Innovation Institute of Technology, Taiwan
yungliang.lai@gmail.com

Hsueh-Chi Shih
Dept. of Information Management, National Yunlin University of Science and Technology, Taiwan
shihhc@mis4k.mis.yuntech.edu.tw

Jehn-Ruey Jiang
Dept. of Computer Science & Information Engineering, National Central University, Taiwan
jrjiang@csie.ncu.edu.tw

ABSTRACT

Cloud computing is a service model enabling resources limited mobile devices to remotely execute tasks on the clouds. The Mobile Agent is a software program on behalf of the software installed in the mobile device to negotiate with other mobile agents in the clouds, which provides a diversity of automated negotiation based applications in Mobile Commences. However, the negotiation plans carried by mobile agents are easily be eavesdropped by the malicious cloud platforms, since the codes of mobile agents are read and executed on the cloud platform. Thus, the sellers can take cheat actions to increase their profits, which is to tailor the negotiation plans to seize buyers' profits after eavesdropping on buyers' negotiation plans. In this paper, we consider the buyers can take actions to resist the sellers' cheatings, that is the buyers can tailor their plans with extremely low demands before migrate to the cloud platform. Above situations are modeled as a mathematical model, called the Eavesdropping and Resistance of Negotiation (ERN) Game. We develop a simulator to simulate an artificial market for analyzing the behaviors on ERN Game. The simulation results show buyers' resistances deter sellers from cheating and cooperative strategies are adopted by buyers and sellers.
.

Keywords

Cloud Computing, Mobile Agents, Malicious Cloud, Negotiation, Trade Network Game, Mobile Commerce.

INTRODUCTION

Cloud Computing is an emerging service model enabling mobile devices utilizing the cloud resources to reduce the energy consumptions and to execute diverse services on the clouds. A Mobile Agent is a software program having the ability to be executed in the clouds on behalf of the software installed in the resources limited mobile devices such as PDA, smart phone, or tablet PC to remotely execute jobs or to interact with other mobile agents. Integrating the mobile agents into the clouds, the mobile devices have the ability to execute a diversity of applications for Mobile Commerce (Aversa et al., 2010, Shih et al., 2007, Oberheide et al., 2008).

The mobile agents are able to negotiate with other mobile agents on behalf of users (Fasli, 2007, Bartolini et al., 2005). The mobile agents are thus used to build services in Mobile Commerce (Tsaur, 2012, An et al., 2010). Security is one of the most important considerations in the mobile agent based applications (Cavalcante et al., 2012). It is generally agreed that the mobile agents are hard to prevent the eavesdropping attack form cloud platform (Oberheide et al., 2008, Dadhich, 2010). When the mobile agents dispatched to a malicious cloud, the malicious cloud can eavesdrop on the negotiation plan carried by the mobile agents, which is called the "Malicious cloud eavesdropping attack". It is hard to prevent such attacks from two facts: (1) The malicious cloud can read and execute any instruction of the mobile agent (Adane, 2007). (2) The malicious cloud can eavesdrop in the interception or secret communications of mobile agents (Cavalcante, 2012).

Based on "Malicious cloud eavesdropping attack", the sellers' mobile agents can cheat buyers' mobile agents in negotiation to seize buyers' profits according to negotiation plans of buyers' agents discoursed by malicious cloud platform. As illustration in Fig. 1, a buyers' mobile agent is executed on the malicious cloud platform on behalf of the software

installed in the mobile device for negotiation with other mobile agents. The malicious cloud can eavesdrop over the buyers' negotiation plans and disclose them to the sellers' mobile agents. Thus, the seller's mobile agent can tailor its negotiation plan to seize buyer's profits. Knowing sellers may cheat in negotiations, a buyer can resist seller's cheating by adjustment of his negotiation plan with extremely low demand (i.e., very low demand price) before migrating to the cloud platform in order to decrease the deal price in negotiation for decreasing the sellers' profits. The above resistance from buyers may make the sellers adopt honest strategies.

Since cheating behaviors will discourage people for using mobile agents based negotiation applications on the clouds, it is necessary to study following two research questions in above-mentioned buyers' resistance against the sellers' cheating: (1) What is the analytic behavior model of buyers and sellers? (2) What are the strategies co-evolved by buyers and sellers?

Aiming at Question (1), we model the above situations between buyers and sellers as a Normal-Form Game in Game Theory (Branzei, 2008), which is called Eavesdropping and Resistance of Negotiation game (ERN game). The ERN game is helpful for analyzing the strategies adopted by buyers and sellers with their corresponding utilizations. Aiming at the Question (2), we develop a simulator to simulate an artificial market consisting of buyers and sellers on the ERN game, based on the Trade Network Game model developed McFadzean and Tesfatsion (2001). The simulation results show the buyers' resistances will deter from sellers' cheating behaviors and the cooperative strategies of buyers and sellers will be emerged.

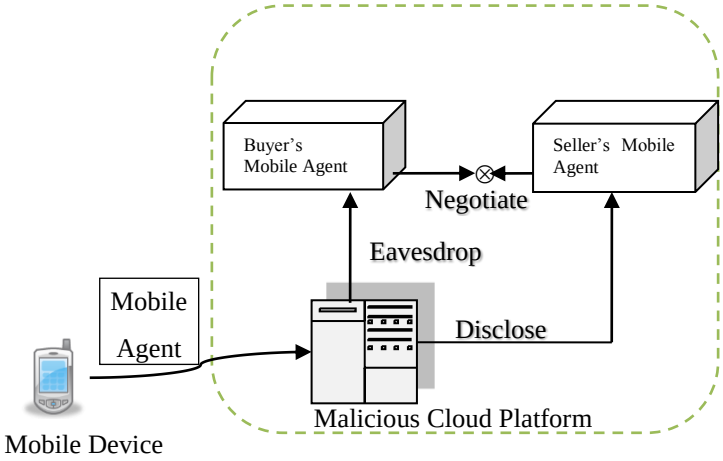

Figure 1. Illustration of malicious cloud eavesdropping attack.

Most of researches studying behaviors in negotiations focus on the human based negotiations. The analysis results of the researches are based on the assumption that the negotiation plans are unknown due to the nature of human. However, this assumption may be unsuitable for computer-assisted negotiations. To the best of our knowledge, this paper is the first to study the behaviors on negotiations, under the assumption that the negotiation plans are known. We formally define the model and perform simulation of the behaviors of buyers and sellers in the ERN game. In the following sections, we will first define the model of the ERN game. And then, we present the simulation results of behaviors of the artificial market on the ERN game, based on our simulator. The last section is the conclusion of this study.

EAVESDROPPING AND RESISTANCE OF NEGOTIATION GAME

We first introduce some preliminaries and then model the misbehavior and the resilience between the buyers and sellers. In the last subsection, we formally formulate the Eavesdropping and Resistance of Negotiation (ERN) game.

Preliminaries

Negotiation is a series of stages for seeking an agreement point for multiple negotiation issues. One agreement point represents a point in the multiple dimensional space, where each dimension represents one negotiable issue, such as price, quality, etc. An agent has a set of options in the multidimensional space. When the agreement is successful made in the negotiation, one agreement point will be decided by the agents. The preference of an agent is modeled as a utilization function for valuing its options. An option for an agent is vector $P = [p_1, p_2, \ldots, p_N]$, where N is the number of the negotiable issues.

The utilization of an option *x* for an agent *i* is detonated by $U_i(x)$, where agent *i* is a buyer agent or a seller agent. In the end of negotiation, the agents will make a *deal agreement* at the *agreement point* (x^*), where utilization $U_i(x^*)$ is maximized for each agent *i* at the same option x^*.

A negotiation example is illustrated in Fig. 2, which has one negotiation issue (price) between buyers and sellers. The utilization of price functions for a buyer agent and a seller agent are denoted by U_b and U_s, respectively. The U_b is a monotonic decreasing function, and U_s is a monotonic decreasing function. Moreover, an option P* is the agreement option belonging to the options of buyer agent and the options of seller agent.

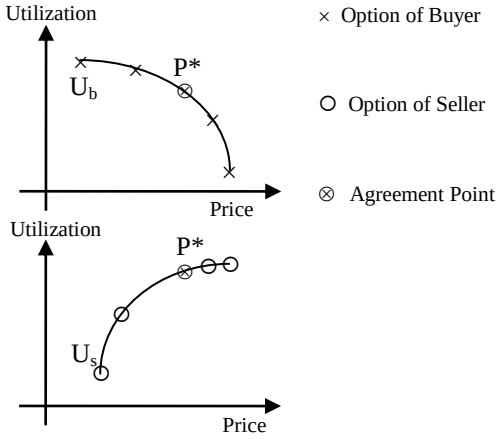

Fig. 2. Relationship between Utilization and Price for a seller and a buyer in negotiation

Now, we define the negotiation process in negotiation. The buyer agent carries on the negotiation plan with the price range $[P^B_{min}, P^B_{max},]$ and the seller agent has the negotiation plan with the price range $[P^S_{min},P^S_{max}]$. TheP^B_{min} and P^B_{max} (P^S_{min} and P^S_{max}) are the minimum price and the maximum price of a buyer (seller) agent. The buyer agent will negotiate with the sellers from P^B_{min} to P^B_{max} and the seller agent will negotiate with buyers from P^S_{max} to P^S_{min}, as illustrated in Fig. 3. In a number of rounds, they are able to make a *deal agreement* at the price P* before deadline.

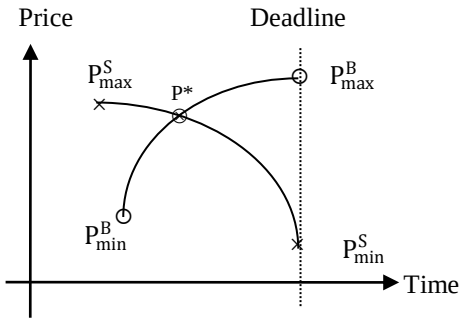

Fig. 3. Illustration of negotiation with deadline between the buyer agent and the seller agent. This example shows the seller and the buyer make an agreement at the agreement pint P* before deadline.

Behaviors Analysis of Buyers and Sellers

The seller's cheating and the buyer's resistances are modeled in this subsection. Each buyer agent has two possible actions: the honest action and the cheating action. Each buyer agent also has the same two possible actions.

1. [***Cheating action of seller***]: The cheating action of the seller means the seller submits an adjusted negotiation plan with lower price to seize buyer's profit on eavesdropping on buyers' negotiation plans.
2. [***Honest action of seller***]: The honest action of the seller means the seller submits a true negotiation plan to negotiate with buyer.
3. [***Cheating action of buyer***]: The cheating action of the buyer means it submits an adjusted negotiation plan with extremely lower prices.
4. [***Honest action of buyer***]: The honest action of the buyer means the buyer submits its true negotiation plan to negotiate with sellers.

There are four possible cases between the buyer and the seller, which are analyzed as follows.

Case 1: Honest Buyer vs Honest Seller

In this case, the buyer and the seller will make the deal agreement at the regular price P_{HH}. The utilization of the seller is $U_B(P_{HH})$ and the utilization of buyer is $U_S(P_{HH})$, as shown in Fig. 4 (a).

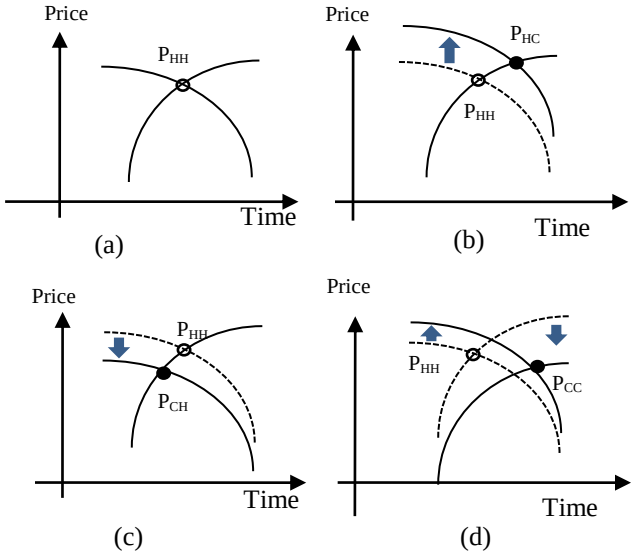

Fig. 4. Illustration of four possible cases between the seller and the buyer.

Case 2: Honest Buyer vs Cheating Seller

In this case, the buyer submits its true negotiation plan, but the seller submits its adjusted negotiation plan with higher price to seize the buyer's profit, as illustrated in Fig. 4(b). The deal agreement is made at the price P_{HC}. Compared with the case 1, the deal price of deal agreement is increased. The relationship of the prices between the case 2 and the case 1 as follows.

$$P_{HC} > P_{HH} \tag{7}$$

The buyer's utilization is $U_B(P_{HC})$ and the seller's utilization is $U_S(P_{HC})$. Since the utilization function U_B of the buyer is monotonically decreasing and the utilization function of the seller is monotonically increased, the relationship of the utilizations of the buyer and the seller is as follows.

$$U_B(P_{HC}) < U_B(P_{HH}) \tag{8}$$

$$U_S(P_{HC}) > U_S(P_{HH}) \tag{9}$$

Case 3: Cheating Buyer vs Honest Seller

In this case, the buyer submits his adjusted negotiation plan with extremely lower price, but the seller submits its true negotiation plan. The deal agreement is made at the price P_{CH} as illustration in Fig. 4(c), where the buyer's utilization is $U_B(P_{CH})$ and the seller's utilization is $U_S(P_{CH})$. The relationship of the deal prices between the case 3 and the case 1 is as follows.

$$P_{CH} < P_{HH} \quad (10)$$

The buyer's utilization is $U_B(P_{CH})$ and the seller's utilization is $U_S(P_{CH})$. Since the utilization function U_B of buyer is monotonically increasing and the utilization function U_S of the seller is monotonically decreased, the relationship of utilization functions of the buyer and the seller is as follows.

$$U_B(P_{CH}) > U_B(P_{HH}) \quad (11)$$

$$U_S(P_{CH}) < U_S(P_{HH}) \quad (12)$$

Case 4: Cheating Buyer vs Cheating Seller

In this case, the buyer submits an adjusted negotiation plan with extremely lower prices, and the seller also submits its adjusted negotiation plan with lower prices. The deal agreement is made at the price P_{CC} as illustration in Fig. 4(d), and the buyer's utilization is $U_B(P_{CC})$ and the seller's utilization is $U_S(P_{CC})$. The deal price of the deal agreement will be increased, so the relationship of the prices between the case 4 and the case 1 is as follows.

$$P_{CC} < P_{HH} \quad (13)$$

Since the utilization function of buyer (U_B) is monotonic decreasing and the utilization function of seller (U_S) is monotonic increasing, the utilization of the buyer will be lower and the utilization of the seller will be higher.

$$U_B(P_{HH}) < U_B(P_{CC}) \quad (14)$$

$$U_S(P_{HH}) > U_S(P_{CC}) \quad (15)$$

Modeling of ERN Game

The payoff table of the ERN Game is defined in Table 1. And, the relationship of the utilizations of the buyer and the seller in the four cases are summarized in Eqs (16) – (19).

Table 1. Payoff Table

Buyer \ Seller	Honest	Cheat
Honest	$U_B(P_{HH})$, $U_S(P_{HH})$	$U_B(P_{HC})$, $U_S(P_{HC})$
Cheat	$U_B(P_{CH})$, $U_S(P_{CH})$	$U_B(P_{CC})$, $U_S(P_{CC})$

(1) Buyer's Utilization

$$U_B(P_{HC}) < U_B(P_{HH}) < U_B(P_{CH}) \quad (16)$$

$$U_B(P_{HH}) < U_B(P_{CC}) \quad (17)$$

(2) Seller's Utilization

$$U_S(P_{CH}) < U_S(P_{HH}) < U_S(P_{HC}) \quad (18)$$

$$U_S(P_{CC}) < U_S(P_{HH}) \quad (19)$$

SIMULATIONS

In this section, we simulate an artificial market for analyzing the co-evolutionary of strategies in the ERN game. The economics model is based on the Trade Network Game model, which consists of buyers and sellers for simulating the trade market. We develop a simulator based on the Trade Network Game model by McFadzean and Tesfatsion (2001), to simulate a artificial market consisting of buyers and sellers playing ERN game for analyzing their behaviors.

In the simulation, we simulate a virtual market, which has 10 sellers and 10 buyers. The simulation runs 3000 trading iterations, where buyers and sellers evolve their strategies within 30 generations. In each generation, the 90 percent elite agents will be selected into the next generation. The payoffs of buyers and sellers in playing ERN game are listed in Table 2.

Table 2. Payoff Table used in the Simulations

Buyer \ Seller	Honest	Cheat
Honest	4, 4	0, 5
Cheat	5, 0	1, 1

The strategies adopted by the buyers and the sellers are analyzed in the simulations, as shown in Fig.5. The buyers and sellers evolve their strategies by generation to generation. We evaluate the strategies adopted by buyers and sellers by four types. Type 1 is: honest buyers and honest sellers. Type 2 is: honest buyers and cheating sellers. Type 3 is: cheating buyers and honest sellers. Type 4 is: cheat buyers and cheat sellers.

The simulation results of strategies adopted by buyers and sellers are shown in Fig. 5. In beginning, many types are emerged. After a number of generations, the type 4 (both honest) strategy are become dominated and no further changed. The simulation implies that cooperative (both honest) strategies will be adopted by buyers and sellers in the ERN Game.

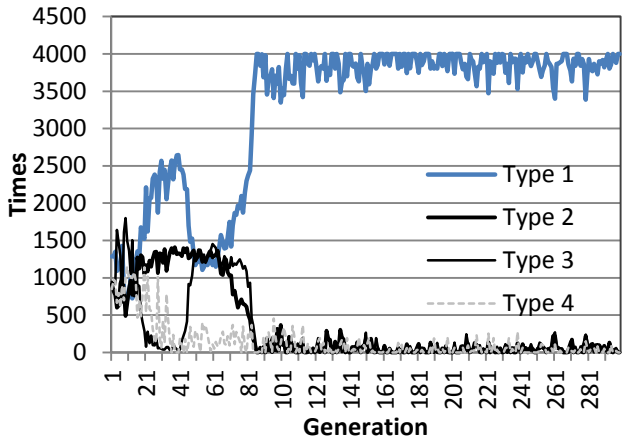

Fig. 5. Evaluation of strategies adopt of buyers and sellers.

CONCLUSION

In this paper, we study the problem about the behaviors of negotiation plans carried by mobile agents are easily to be eavesdropped on the malicious cloud platforms. Two research questions in buyers' resistance to resist the sellers' cheating are studied: (1) What is an analytic behavior model of buyers and sellers? (2) What are the strategies co-evolved by buyers and sellers? Aiming at the Question (1), we model above situations between buyers and sellers as Eavesdropping and Resistance of Negotiation Game (ERN Game). Aiming at the Question (2), we develop a simulator to simulate an artificial market consisting of buyers and sellers on the ERN Game, based on the Trade Network Game model. The simulation results show the buyers' resistances will deter from sellers' cheating behaviors and the cooperative strategies will be adopted by buyers and sellers.

Most of researches in studying behaviors of negotiation mainly focus on human based negotiations; however, our focus is the computer assisted based negotiation. With growth of integration of cloud computing and mobile commerce, automatic negotiations with the intelligent technologies, such as mobile agent technology, will be getting popular in the modern mobile commences; They will, however, result in a variety of new behavior models, different from the traditional human based negotiations. In the future, we will further study a variety of behaviors caused by adopting new technologies.

REFERENCES

1. Adane, D., Adane, P., & Sathe, S. (2007). Data privacy in mobile agent communication. In *Proceeding of 2007 IEEE/IFIP International Conference in Central Asia*,1-5.
2. An, B., Lesser, V., Irwin, D., & Zink, M. (2010). Automated negotiation with decommitment for dynamic resource allocation in cloud computing. In *Proceedings of the 9th International Conference on Autonomous Agents and Multiagent Systems*, 981-988.
3. Aversa, R.; Martino, B. D.; Rak, M. & Venticinque, S. (2010). Cloud Agency: A Mobile Agent Based Cloud System Complex, *IEEE Intelligent and Software Intensive Systems, International Conference*, 132-137.
4. Bartolini, C., Preist, C., & Jennings, N. (2005). A software framework for automated negotiation. *Software Engineering for Multi-Agent Systems III*, 213-235.
5. Bierman, E., & Cloete, E. (2002). Classication of malicious host threats in mobile agent computing. In *Proceedings of the 2002 annual research conference of the South African*, 141-148.
6. Branzei, R., Dimitrov, D., & Tijs, S. (2008). *Models in cooperative game theory*, Berlin, Springer-Verlag.
7. Cavalcante, R. C., Bittencourt, I. I., da Silva, A. P., Silva, M., Costa, E., & Santos, R. (2012). A survey of security in multi-agent systems. *Expert Systems with Applications, 39*, 4835 - 4846.
8. Crasso, M., Mateos, C., Zunino, A., & Campo, M. (2011). Swam: A logic-based mobile agent programming language for the semantic web. *Expert Systems with Applications*, *38*, 1723-1737.
9. David McFadzean, Deron Stewart, and Leigh Tesfatsion, "A Computational Laboratory for Evolutionary Trade Networks", IEEE Transactions on Evolutionary Computation, Volume 5, Number 5, October 2001.
10. Dadhich, P., Dutta, K., & Govil, D. (2010). Security issues in mobile agents. *International Journal of Computer Applications*, *11*, 24-28.
11. Fasli, M. (2007). *Agent technology for e-commerce*. John Wiley & Sons.
12. Kim, Y. (2007). Maximizing sellers' welfare in online auction by simulating bidders' proxy bidding agents. *Expert Systems with Applications, 32*, 289-298.
13. Laib, F., & Radjef, M. (2011). Automated traders in commodities markets: Case of producer-consumer institution. *Expert Systems with Applications*, *38*, 15134 -15142.
14. Leigh Testfatsion and Kenneth L. Judd , Agent-Based Computational Economics: A Constructive Approach to Economic Theory of Handbook of Computational Economics, Vol 2: Agent-Based Computational Economics, North-Holland, 2006.
15. Oberheide, J., Veeraraghavan, K., Cooke, E., Flinn, J., & Jahanian, F.(2008). Virtualized in-cloud security services for mobile devices. In *Proceedings of the First Workshop on Virtualization in Mobile Computing*, 31-35.
16. Overeinder, B., & Brazier, F. (2006). Scalable middleware environment for agent-based internet applications. *Applied Parallel Computing. State of the Art in Scenic Computing*, 675-679.
17. Sander, T., & Tschudin, C. (1998). Protecting mobile agents against malicious hosts, *Lecture Notes in Computer Science* (Vol.1419, pp. 44-60). Berlin, Heidelberg: Springer-Verlag.
18. Shih, D., Lin, B., & Huang, S. (2007). Morvam: A reverse vickrey auction system for mobile commerce. *Expert Systems with Applications*, *32*, 1113-1123.
19. Tsaur, W.J., (2012). Secure communication for electronic business applications in mobile agent networks. *Expert Systems with Applications, 39(1),* 1046 -1054.