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The evaluation of intelligent agent performance — An example of B2C e-commerce negotiation

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ABSTRACT

Increasing demand for sophisticated software capable to collaborate, control, and organize all distributed activities has encouraged researchers in various disciplines to utilize and implement Intelligent Agent (IA). This paper develops a methodology to appraise performance of the IA and demonstrate the use in the B2C e-commerce negotiation process. An experiment was conducted to acquire empirical data and a survey was implemented to confirm advantage of the use of the IA. The computational results indicate that the proposed approach successfully evaluates IA performance and significantly distinguishes groups of using (vs. not using) the negotiation mechanism in B2C e-commerce.

1. Introduction

Increasing demand for sophisticated software capable to collaborate, control, and organize all distributed activities has encouraged researchers in various disciplines to utilize and implement IA. IA can help users perform actions involving inquiries, negotiation, and tradeoffs to improve effectiveness. Among them, negotiation is an inseparable component of many e-commerce activities, such as auctions, scheduling, and contracting, and is one area that can benefit markedly from automation [38]. However, negotiation in B2C is time-consuming due to all parties anticipate to maximize their profit and likely they may have opposing consequences. When some parties do not compromise, reaching an agreement is impossible [10]. The IA is a new approach for e-negotiations. Using IA to represent negotiating parties can greatly decrease the effort and time needed to complete negotiations [17].

Recent research in IA has primarily focused on developing technologies in the agent systems. For example, Morge and Beaune [32] developed an agent-based negotiation support system that has the following functionalities: information sharing among stakeholders; auto-negotiation between agents; and, group decision-making modeling. Moreover, Louta et al. [30] proposed a dynamic multi-lateral negotiation model and constructed an efficient negotiation strategy based on a ranking mechanism. Recently, Lee et al. [27] analyzed the data with an agent-based procurement system (APS) to re-engineer and improve the existing procurement process while Huang et al. [17] present a multiple-attributes negotiation model for B2C ecommerce. This model deploys intelligent agents to facilitate autonomous and automatic on-line buying and selling by intelligent agents while quickly responding to consumers. Using IA in e-commerce negotiation applications are enormous [14]. However, very little research has appraised performance of the IA to validate contribution and an active role of the IA, especially in the area of B2C e-commerce.

This study develops a methodology to appraise performance of the IA and demonstrate the use in the B2C e-commerce negotiation process. An experiment was conducted to acquire empirical data and a survey was implemented to confirm advantage of the use of the IA. This paper is organized as follows: In Section 2, the literature review of B2C e-commerce and intelligent agent performance evaluation is illustrated. The research method used in this paper is proposed in Section 3. Then, data analysis is described in Section 4. Section 5 concludes the paper.

2. Literature review

2.1. B2C e-commerce

Business-to-consumer (B2C) is similar in concept to the traditional method of retailing, the main difference being the medium used to carry out business — the Internet [1]. By directly to customers and reducing the middlemen rake, the company could lower prices and

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then in consultation with customers to obtain greater benefits [15]. Besides, [16] developed a goal-driven methodology for eliciting and modeling the requirements of a B2C application, it enables business managers and system developers to develop high-level strategies that improve value activities and obtain competitive advantage, and thereby determine the specifications of the core eservices. Recently, several approaches and applications have been proposed to exploit B2C. For example, Weltevrede [43] proposed mobility effects of B2C and C2C e-commerce in the Netherlands while Ramanathan [36] proposed the moderating roles of risk and efficiency on the relationship between logistics performance and customer loyalty in e-commerce. Using data from online customer ratings, it explores how the relationships between logistics performance and customer loyalty are affected by risk characteristics of products and efficiencies of the websites. In Asia, Ngai [34] described an e-commerce teamwork-based project designed and implemented at the Hong Kong Polytechnic University (PolyU) for undergraduate business and management students.

Negotiation is a very extensive subject spanning from pre-negotiation to post-negotiation analysis, both at the local and social level [42]. In B2C, negotiation capabilities are essential for the B2C e-commerce systems [17]. Beam and Segev [4] defined negotiation in electronic commerce as the process by which two or more parties multilaterally bargain resources for mutual intended gain, using the tools and techniques of electronic commerce. Negotiation in B2C commerce is also a time-consuming process because all parties desire to maximize their own payoff while they may have opposite consequences. If some of the parties do not concede, it could take forever to reach an agreement [10]. Therefore, the IA is a new approach and remedy for e-negotiations. Intelligent agent is promising for supporting business negotiations in e-marketplaces due to its capabilities [26]. Using IA to represent negotiating parties can greatly decrease the effort and time required to complete negotiations [17].

2.2. The performance evaluation of intelligent agent

The performance evaluation of intelligent agent can be categorized into case study and statistical analysis. Schetter et al. [37] compared the centralized and hierarchical organizations on "CPU workload," "CPU time" and "communication data." Agent-based simulations of mission case studies illustrate the autonomous operation of the multi-agent architecture, which can be used to build, evaluate and compare autonomous software architectures for multiple satellite systems. Ben-Ami and Shehory [5] evaluated agents in the open multi-agent systems (MAS) on "response time" and "hit rate." Moreover, Huang and Lin [19] proposed an intelligent sales-agent, ISA, equipped with persuasion and negotiation mechanisms to execute persuasion and bargaining strategies to interact with various buyers. Finally, a questionnaire is used to evaluate the system. Recent literatures on the performance of Intelligent Agent are summarized in Table 1.

To date, little research has evaluated the performance of intelligent agent in the area of B2C e-commerce. Therefore, a research method is proposed next to validate function, contribution and an active role of the IA.

3. Research method

The principal aim of the study is to verify the effectiveness of intelligent agent systems in B2C e-commerce. This study uses an experimental desig1n to compare differences in using and not using the intelligent agent system. Additionally, a questionnaire is used to assess the effectiveness of the intelligent agent system via participant responses.

Table 1
The recent literatures on the performance of intelligent agent.

Literature	Description
Lin and Lin [28]	Used satisfaction algorithms to analyze the 10 companies' the order fulfillment rate, cycle time, WIP (Work-In-Process) inventory cost, and final product inventory cost.
Beydoun [6]	The paper proposed e-learning community to construct a semantic web (SW), an undergraduate class over two semesters. It's improving its performance by exploring the relationship between "kinds" of research assignments and the e-learning semantic web development.
Kahramanli and Allahverdi [20]	In this study, a method that uses Artificial Immune Systems (AIS) algorithm has been presented to extract rules from trained hybrid neural network. It has been observed that these results are one of the best results comparing with results obtained from related previous studies.
Manzoor and Nefti [31]	This paper proposed an agent based system for activity monitoring on network (ABSAMN) for the monitoring of resources over a network, suitable for network of networks.

3.1. Research model and hypotheses

The research model was shown in Fig. 1. Delone and Mclean propose a model to measure the success of information systems, which system quality, suggests that information quality, user satisfaction, IS usage, individual impact and organization impact [11]. Boudreaux et al. [7] uses the DARSSA consisted of end-user satisfaction ratings, completion times for the assessment module, and the proportion of patients with risky substance use that chose to receive a dynamic referral. It has the potential to improve identification of substance abuse in medical settings and to provide referrals that would not routinely be provided [7]. One study surveyed judges, attorneys, child welfare workers, and parents regarding their satisfaction with CASA (Court Appointed Special Advocate) volunteers [29]. Udo et al. [39] develop web service quality constructs, and analyze their relationships with customer satisfaction and behavioral intentions in an e-business environment [39]. Herein, our first hypothesis:

H1. The use of buyer negotiation agent increases e-commerce customer satisfaction.

Kwon et al. proposes a reservation price reporting mechanism (RPR) and its extended version (ERPR), the lab experiments are conducted to compare the performance of RPR, ERPR and the traditional direct bargaining (TDB), each negotiation session have total number of sessions, successful sessions, average number of rounds, average total profit [25]. Moulet and Rouchier use the time buyers can spend on the market and the frequency of update in learning by

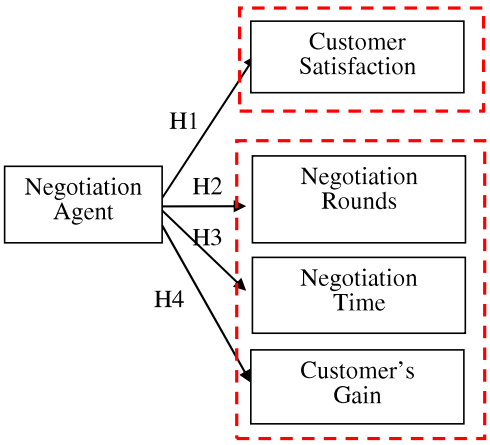

Fig. 1. Research model.

Table 2
Questionnaire of customer satisfaction.

1. The shopping system provides individual customer service.
2. The shopping system provides a convenient acquisition process.
3. The shopping system helps me making a better shopping decision.
4. I am satisfied with the consultation process.

sellers, and have to validate the model, features produced by the simulated market are compared to the stylized facts gathered for negotiation about four goods [33]. Huang and Lin [18] design a lab prototype of a sales agent with persuasion and negotiation capabilities and to evaluate its effectiveness as a virtual clerk in an e-store. The experimental results reveal that an e-store embedded within such a sales agent can improve a seller's surplus and increase a buyer's product valuation, willingness-to-pay, and satisfaction with the e-store [18]. Faratin et al. [12] present a formal model of negotiation between autonomous agents [12]. The paper concentrate on many-parties, many-issues, single-encounter negotiations with an environment of limited resources (time among them). The negotiation may be iterative in that several rounds of offers and counter offers will occur before an agreement is reached or the negotiation is terminated [12]. Maherthiran reports the results of a laboratory experiment concerning the effects of communication medium on the process and outcomes of negotiations in a transfer pricing situation. Cheung et al. proposed negotiation of contracts also involves two or more parties multilaterally bargaining for mutual gain in order to achieve a mutual beneficial agreement [9]. Argoneto and Renna [2] proposed an innovative approach, based on multi-gent system and a concerning simulation test-bed conducted to demonstrate. As the results show, both supplier and customer gain benefits from the coalition strategies adoption [2]. According to the above, this study will use Number of Negotiating Rounds, Length of Negotiating Time and Customer's Negotiating Gain as indexes to assess the negotiation agent system, three hypotheses were tested:

H2. The use of buyer negotiation agent decreases e-commerce negotiation rounds.

H3. The use of buyer negotiation agent decreases e-commerce negotiation time.

H4. The use of buyer negotiation agent increases e-commerce customer's gain.

3.2. Definition of variables

The independent variable is "Agent negotiation mechanism," the experiment whether to use intelligent agents for consultations. Dependent variables are customer satisfaction and three index adapted from Chan et al. [8] and Lau et al. [26]: (1) Number of Negotiating Rounds: It means to finish the negotiating time as once, the sum of price times of buyer and seller; (2) Length of Negotiating Time: It means experiment participants press "Negotiation" to negotiation finish need times; (3) Customer's Gain: It means in the negotiation, the ratio of customer's gain, the negotiating gain of a customer is defined as:

$$\text{Customer's gain} = \frac{\text{Market Price} - \text{Agreed price}}{\text{Market Price}} * 100\% \quad (1)$$

The questionnaire (Table 2) of customer satisfaction is adapted from Chan et al. [8]. Chan et al.'s questions were designed for a shopping mall survey. In this experiment, participants were also asked to perform the shopping process with additional negotiation function. Therefore, the questionnaire will be useful to evaluate the intelligent agent performance (personalized service, convenient, helpful and consulting). Each item is graded with a five-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = uncertain, 4 = agree, and 5 = strongly agree.

3.3. Experiment design

This study uses the case example of purchasing a desktop computer. Sixty graduated students from a university in Taiwan were randomly divided equally into Group A and Group B. Group A used the buyer negotiation agent and Group B did not. Previous studies have shown

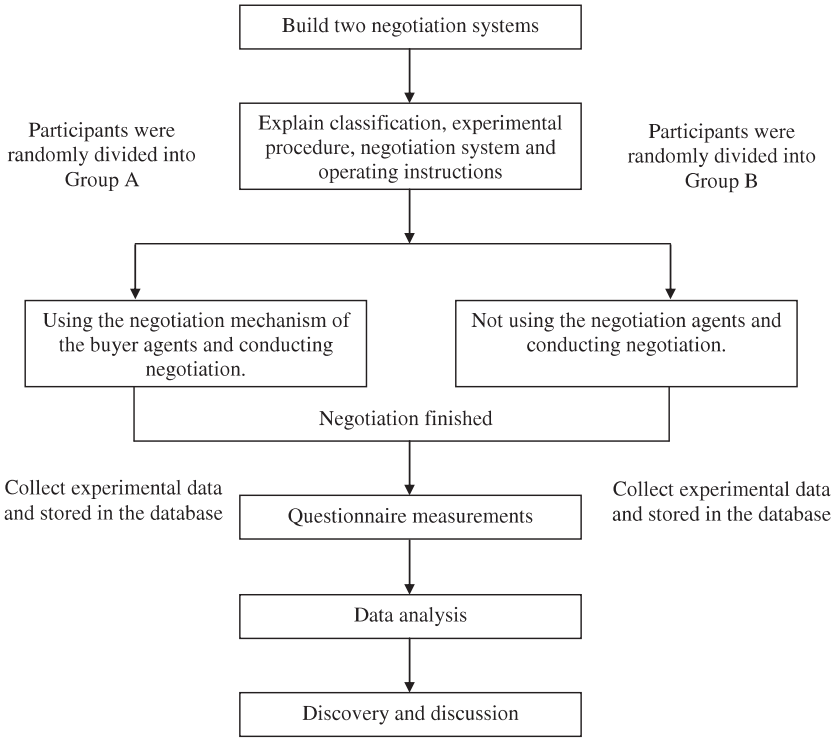

Fig. 2. Experiment processes.

that purchase intention is affected by product brand [22,3]. Thus, both groups were offered the same desktop PCs to negotiate to ensure that both groups had the same conditions. However, the participants' preferences (the floor prices and incremental bids) cannot be constrained due to the experiential nature. By randomly assigning the participants to two groups, this research tried to make sure the superiority of the IA is not affected by extraneous factors. The experiential process is shown in Fig. 2.

3.4. Design of the negotiating system

In this paper, a prototyping intelligent agent system is created in java for Group A. Group A is to use buyer negotiation agent to negotiate with the seller. The major functions are: Login, setting membership function, shown the products and negotiation.

Fuzzy theory was introduced by Zadeh [44] as a means to model the uncertainty of natural language [44]. Fuzzy logic is a superset of conventional logic extended to handle the concept of partial truth values between "completely true" and "completely false." A fuzzy set is a class of objects with a continuum of grades of the Membership Function. In this paper, the fuzzy theory is applied to define product membership function to obtain the utility value.

In this paper, both buyer agents and seller agents own their negotiation strategy. Buyer strategy refers to the offer method of buyer agents and the stop conditions. The new offer is calculated according to the total utility of products and the offering function [41]. The new offering function is defined as follows:

$$offer_{new} = utility \times 100\% \times u + offer_{old} \tag{2}$$

Where $offer_{new}$ refers to new price, utility to product utility, u to the unit increase value, $offer_{old}$ to the last offer.

Besides the current offer, the buyer agent must know when to stop the negotiation. In this paper, we present two conditions where both of them must be reached and then agents can decide to trade or not. The first condition is the product price which the seller agent presents must be within the buyer offer range. The second condition is the ratio of buyer offer and seller offer must be larger than a threshold defined by the buyer in the initial negotiation stage.

Seller strategy decides the seller agent current offer and the stop condition. This paper calculates the next offer as follows [13].

$$x[i]_{new} = x[i]_{old} + (-1)^{w} F\left|RV_i - x[i]_{old}\right| \tag{3}$$

$x[i]_{new}$ is the new offer and $x[i]_{old}$ is the last offer. F is the factor which between 0-1, w is the factor to control the increase or decrease. RV refers to the max or min limit value, setting value or buyer offer. For a seller agent, the condition to stop negotiating is when the buyer offer is at the seller's acceptable price. The screen of Group A is shown as follow: The interface of system login (Fig. 3); the interface of setting membership function (Fig. 4); the interface of setting user's preference (Fig. 5); the process of negotiation (Fig. 6).

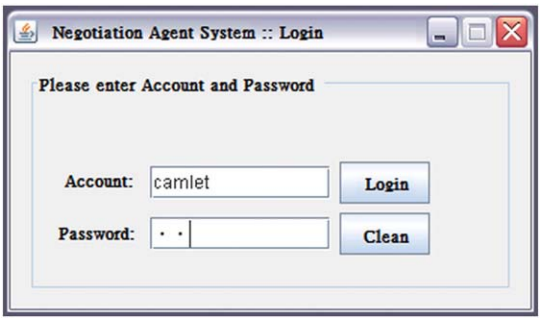

Fig. 3. The interface of system login (Group A).

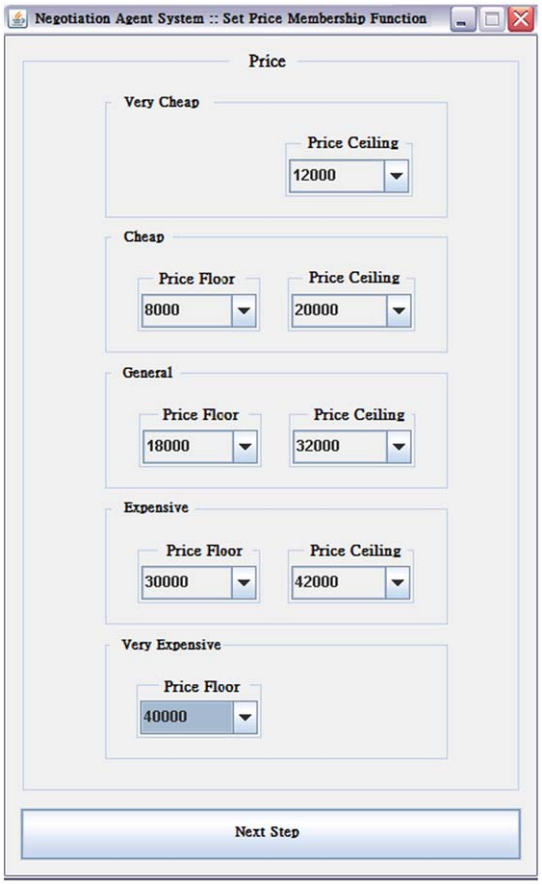

Fig. 4. The interface of setting membership function (Group A).

A prototyping system is also created in java for Group B. Group B in the B2C e-commerce did not use the negotiation agent to negotiate. The buyers can set up their new offer according to their instincts while seller agent negotiation strategy is the same with Group A. The screen of Group B is shown as follow: The interface of product setting in Fig. 7 and the interface of negotiation in Fig. 8.

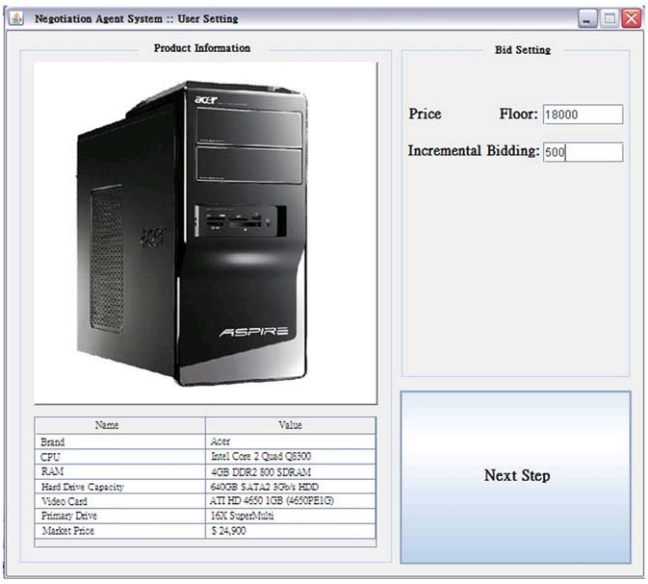

Fig. 5. The interface of setting user's preference (Group A).

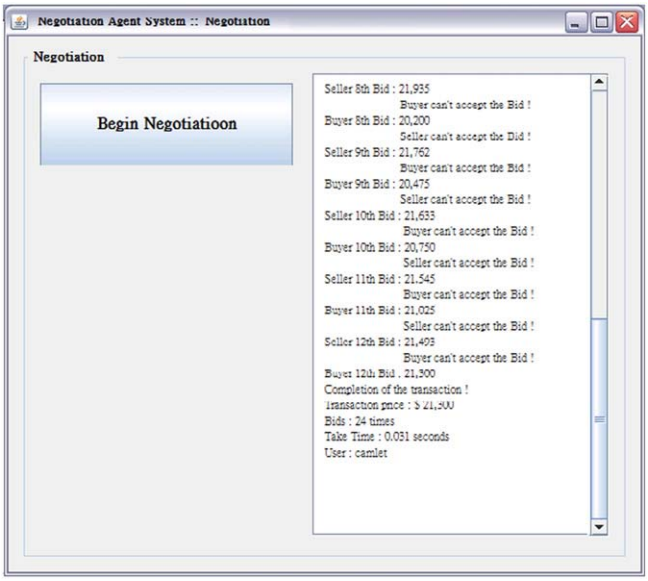

Fig. 6. The interface of negotiation (Group A).

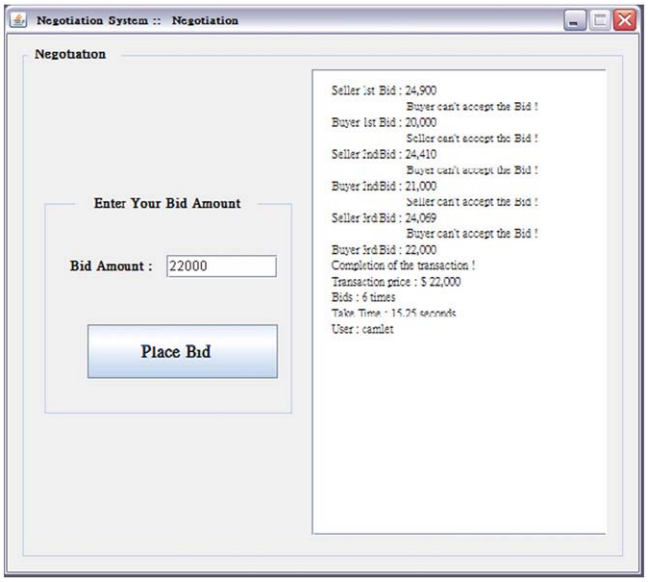

Fig. 8. The interface of negotiation (Group B).

4. Data analysis

Data were analyzed using SPSS version 12.0. Statistical methods used for questionnaire of the customer satisfaction analysis were the Kolmogorov–Smirnov test, reliability analysis, validity analysis and T-tests. This study used T-tests to implement test hypotheses.

4.1. The questionnaire of customer satisfaction analysis

4.1.1. Kolmogorov–Smirnov test

The Kolmogorov–Smirnov test is often employed for testing the null hypothesis that a dataset has a distribution described by a fully determined (theoretical) distribution function. The testing statistic is a maximum difference between the empirical and theoretical distribution functions [40]. Since participants in this experiment were randomly selected into Group A and Group B. K-S test was used to verify that the Group A and Group B come from the same distribution population. The K-S test was conducted in SPSS with default parameters and the result was shown in Table 3. It is not significant of difference with p-value <0.05. The two samples (Group A and Group B) are drawn from the same distribution.

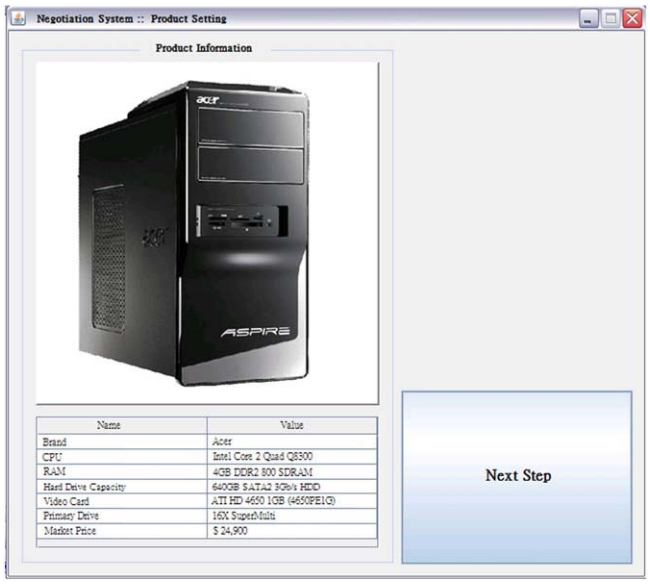

Fig. 7. The interface of product setting (Group B).

4.1.2. Reliability analysis

These questionnaires are considered to be reliable because their Cronbach coefficient, a Cronbach's alpha value of 0.719, was above the 0.70 threshold, indicating that the scales had high reliabilities [35].

4.1.3. Validity analysis

The questionnaire is based on the literatures and then amended by three experts, who teach e-commerce related classes in universities, so it has content validity. Regarding the criterion validity, this study uses the measuring dimension which most of them are recognized by scholars according to the past similar research, so there should be a high validity in the criterion validity. Finally, this paper uses factor analysis to assess construct validity.

KMO (Kaiser-Meyer-Olkin Measure) and the Bartlett ball-type test were used to determine if it is suitable for factor analysis. The result has showed that KMO value is 0.744, higher than 0.7, the suggested ideal value by Kaiser [21]. The P value of Bartlett ball test was 0.000 ($\alpha <= 0.05$) and reached the significant level. These indicate there are relevant among questionnaire [21].

Table 4 shows all the factors extractable from the analysis along with their eigenvalues, the percent of variance attributable to each factor, and the cumulative variance of the factor. Notice that the first factor accounts for 54.726% and the remaining factors are not significant. All dimensional factor loading are greater than 0.6 (Table 5). Zaltman and Burger [45] have suggested if the factor loading values are greater than 0.3 and the cumulative variance are greater of 40%, then the results obtained are very reliable [45]. Therefore, these questionnaire results are considered to be reliable.

Table 3
Kolmogorov–Smirnov test.

	Kolmogorov–Smirnov test
Z	1.033
P	0.236

$p<0.05$.

Table 4
Total variance explained.

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of variance	Cumulative%	Total	% of variance	Cumulative%
1	2.189	54.726	54.726	2.189	54.726	54.726
2	.738	18.438	73.164			
3	.591	14.777	87.942			
4	.482	12.058	100.000			

Extraction method: principal component analysis.

4.1.4. T-tests

The study uses two single sample T-tests to exam if offering the buyer negotiation agent has higher customer satisfaction. The basic statistics of the collected questionnaire data are shown in Table 6 and the analysis of SPSS is shown in Table 7. All correlations were significant with p-value<0.05, the research model was able to explain: t-value = 2.534, p = 0.014, it was significant of difference, the Group A (using the negotiation mechanism of the buyer agents) has higher customer satisfaction than the Group B (not using an agent negotiation mechanism for the buyer).

Item 1 — "The shopping system to provide personalized service (t = 2.048, p = 0.046)" and Item 3 — "The shopping system to help me do better shopping decision (t = 2.766, p = 0.008)" both achieve the level of significance. Moreover, Group A (using the negotiation mechanism of the buyer agent) offered by the system of personal service and shopping decision are superior to Group B (without using an agent negotiation mechanism for the buyer). However, Item 2 — "The shopping system provides a convenient shopping (t = 1.316, p = 0.193)" and Item 4 — "I am satisfied with the consultation process (t = 1.173,p = 0.245)" do not reach the level of significance.

4.2. Quantitative analysis of negotiation agents

In the study, two independent sample T-tests detected whether there are significant differences in Number of Negotiating Rounds, Length of Negotiating Time and Customer's Negotiating Gain. SPSS analysis results in Table 8.

When p-value<0.05 was level of significance, Number of Negotiating Rounds showed: t = 0.952, p = 0.354, not reach level of significance, indicating that the Group A (using the negotiation mechanism of the buyer agents) in the number of negotiation rounds and Group B did not reach level of significance. At p<0.05 level of significance, the Length of Negotiating Time showed: t = −6.389 and p = 0.000, that significantly, indicating that the Group A (using the negotiation mechanism of the buyer agents) in the number of negotiation rounds are better than Group B (not using an agent negotiation mechanism the buyer). Finally, in p<0.05 level of significance, customer's gain analysis showed: t = 1.736, p = 0.044, reach level of significance, indicating that the Group A (using the negotiation mechanism of the buyer agents) in the customer's gain are better than Group B (not using an agent negotiation mechanism the buyer).

Table 5
Factor loadings.

	Component
	1
1	0.630
2	0.769
3	0.754
4	0.796

Extraction method: principal component analysis.

Table 6
The basic statistics of the collected questionnaire data.

	Groups	Maximum	Minimum	Average	Standard deviation
The shopping system provides individual customer service.	A	5	3	4.00	0.525
	B	5	2	3.60	0.932
2. The shopping system provides a convenient acquisition process.	A	5	2	3.90	0.548
	B	5	2	3.67	0.802
3. The shopping system helps me making a better shopping decision.	A	5	3	4.13	0.571
	B	5	2	3.53	1.042
4. I am satisfied with the consultation process.	A	5	2	4.13	0.776
	B	5	1	3.87	0.973
Satisfaction with the overall dimensions of test	A			4.0417	0.42081
	B			3.6667	0.69274

4.3. Discussion

In this study, both the effectiveness (in terms of customer satisfaction and customer's gain) and the efficiency (in terms of negotiation rounds and negotiation time) of the negotiation processes were evaluated.

In the questionnaire of customer satisfaction analysis, the research model was able to explain and Group A (using the agent negotiation mechanism) had higher customer satisfaction than Group B (not using the agent negotiation mechanism). Customer satisfaction is positively affected by the convenience of an online marketplace [24]. Although, item 2 — "The shopping system provides a convenient acquisition process" and item 4 — "I am satisfied with the consultation process" did not reach the significance level. We infer that both groups were satisfied with the negotiation function (by the agent or manually) provided by the system as few e-commerce websites have this function. Although, there is no significance between Group A and Group B in convenience (item 2) and consultation (item 4). The average of convenient perception in group A (3.90) is still superior to group B (3.67). The average of consulting perception in group A (4.13) is also superior to group B (3.87).

In quantitative analysis, the research model was able to explain and Group A (using the agent negotiation mechanism) spent less time negotiating and gets more customer's gain than Group B (not using the agent negotiation mechanism). No significance difference existed between Group A and Group B in number of negotiation rounds. A previous study pointed out that B2C e-commerce negotiation is often time-consuming. When some parties do not concede, reaching an agreement is impossible [10]. We infer that some Group B participants increased the new offer quickly to complete the transaction while Group A had to follow the preset unit increase value to increase the new offer.

Quality information related to the product positively affects its value. Consumers believe that products acquired from the website

Table 7
T-tests — the questionnaire of customer satisfaction analysis.

	Groups	t-value	p-value
1. The shopping system provides individual customer service.	Group A Group B	2.048	0.023*
2. The shopping system provides a convenient acquisition process.	Group A Group B	1.316	0.097
3. The shopping system helps me making a better shopping decision.	Group A Group B	2.766	0.004*
4. I am satisfied with the consultation process.	Group A Group B	1.173	0.122
Satisfaction with the overall dimensions of test	Group A Group B	2.534	0.007*

* p<0.05.

Table 8
T tests — quantitative analysis.

	Groups	Average	Standard deviation	t-value	p-value
Number of negotiating rounds	Group A	20.60	22.807	0.952	0.177
	Group B	15.87	14.887		
Length of negotiating time (s)	Group A	0.013	0.014779	−6.389	0.000*
	Group B	95.29263	81.676791		
Customer's negotiating gain (%)	Group A	0.13072	0.033992	1.736	0.044*
	Group B	0.11241	0.046706		

* $p<0.05$.

contain better value due to their perception of cyber goods [23]. In this paper, computational results show that the intelligent agent is capable to provide updated and timely information and improve performance of the negotiation process. Consequently, intelligent agent is promising to support business negotiations in e-marketplaces.

5. Conclusion

Per literature review in agent based study, numerous references can be found in designing agents for automated negotiation. However, few studies have evaluated performance of the intelligent agent and validate contribution of the IA. This research applies intelligent agent to B2C e-Commerce negotiation. An experiment was used to conduct the evaluation. Results show that intelligent agent do improve performance of the negotiation process. The questionnaire of customer satisfaction analysis indicates that using buyer agents increased customer satisfaction. The results of quantitative analysis also illustrate that the negotiation mechanism with IA support reduces negotiation time and obtains more customers' satisfaction.

Acknowledgments

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