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지능형 전자 상거래 시스템 구축을 위한 친밀도 기반 신뢰도 추론방법

An Intimacy-based Trust Reasoning Method for Intelligent Ecommerce Systems

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초 록

전자상거래에서 신뢰도는 전자상거래 서비스 제공업체의 비가시성이나 그들의 평판으로 인한 소비자의 우려를 완화시켜주기 때문에 사용자의 신뢰수준을 추정하는 것은 전자상거래의 지속적 사용에 있어 중요한 기술이다. 기존의 신뢰도 측정법은 주로 전자상거래 시스템에서 사용된 정책과 평판기반의 추론에 근거한 사용자들의 초기 경험에 중심을 두었다. 그러나, 보다 성숙된 단계의 전자상거래 시스템 지속사용 가능성 추정을 위한 신뢰도 측정에 대해서는 별다른 대안이 없었다. 따라서 본 연구에서는 성숙단계에서의 전자상거래 시스템에 알맞은 신뢰도 추론방법을 제안한다. 특히, 친밀도는 평판뿐 아니라 신뢰도와도 깊이 관계하고 있기 때문에 사용자의 입력을 강제하지 않는 친밀도 측정 방법을 새롭게 개발하였다. 성과 측정을 위한 실험에서는 제안된 방법이 유효하고, 평판기반의 신뢰도 추론과 함께 사용할 수 있는 것으로 나타났다.

ABSTRACT

Estimating levels of user trust is important for maintaining continuous use of e-commerce systems because trust alleviates user concerns about the invisibility of service providers or their reputation. Conventional trust estimation approaches such as policy-and reputation-based reasoning have focused on the experience of e-commerce systems at an early stage. However, only a few trust reasoning methods have considered the mature stage, which is more related to continuance intention. We propose a trust reasoning method dedicated to the mature stage of using e-commerce systems. In particular, a new method of unobtrusively estimating the degree of user intimacy is developed, because intimacy has been highly associated with trust as well as reputation. Our experiments show that the proposed method is valid and can be used in conjunction with reputation-based trust reasoning.

키워드 : 신뢰도 추론, 친밀도, 상황인지 시스템, 친밀도 기술, 전자 상거래
Trust Reasoning, Intimacy, Context-Aware System, Intimacy Technology, E-Commerce

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1. Introduction

Trust (or trustworthiness) is a central facilitator of e-commerce success [6]. Trustworthy systems help realize more efficient e-commerce by alleviating perceived risks, eliminating the cost associated with avoiding vulnerability during transactions due to the invisibility of the providers to the customers. Moreover, trust is important to transaction completion, ex-post partner satisfaction, and ultimately, e-commerce sustainability [21]. In addition, trust positively affects the intention to revisit a system. Trust has been regarded as an important aspect of users' acceptance of e-business systems such as web-based services [11], online transactions [9], and systems of multi-agent architecture [4].

Researchers have agreed that e-commerce systems running on websites can be objects of trust [6], simply because technology itself, including Internet technology, has come to be perceived as an object of trust [37]. In fact, some empirical studies of computer systems have included e-commerce systems as objects of trust and have shown that errors in e-commerce systems strongly affect trust violation. The magnitude of a system error is an important factor in loss of trust [19, 26].

Determining trust reasoning levels is a way of realizing and evaluating trust-based ecommerce. Trust reasoning refers to automated and relevant estimation of human trust in an e-commerce system or service. Trust reasoning research in computer science encompasses two major areas: policy-based and reputation-based trust reasoning. Policy-based trust is established simply by obtaining a sufficient number of credentials pertaining to a specific party. The amount of trust is mainly determined by trust in a third party that gives credibility to the e-commerce systems. Hence, the amount of trust in a certain e-commerce system highly depends on trust in those third parties and the results of evaluating them. Reputation based trust reasoning refers to past interactions and performance that enable the trustee (the e-commerce provider) to estimate its customer's future trustworthiness of the object of trust. Reputation refers to the history of an e-commerce system's action or behavior. In the absence of history data, referral-based trust acquired from others is used as default knowledge.

Intimacy is one of the most important ingredients that influence people to trust an ecommerce system. Intimacy plays an integral role in improving and maintaining the trustor-trustee relationship [36]. It is characterized by feelings of closeness and emotional bonding, involving intense liking, moral support, and the ability to tolerate flaws in the significant other [40]. The concept of intimacy is not new to e-commerce research [46]. E-commerce researchers have found that people do in fact enter into intimate relationships with computers, websites, and other new media [35]. They have argued that people handle computer

systems in the same intimate manner they treat other people, being polite or rude, timid or helpful, and that they also have physical responses to computer systems.

Intimacy-based trust reasoning refers to an estimation of trust based on an individual's level of intimacy with a certain e-commerce system. Intimacy-based trust reasoning is different from previous reasoning methods [17, 18, 21, 42]. First, intimacy-based trust reasoning mainly stems from the individual her or himself, and does not depend on others. The policy- and reputation based approaches to identifying the level of trust are related to the interesting assumption that what one person trusts will also be trusted by others. However, this may not be the case for all persons or situations. For example, people who are introverted tend to make decisions more independently of others' opinions than those who are extroverted. According to Enneagram's nine personality types, the individualist or challenger who wants to be independent does not prefer to follow others' thoughts [30]. Indeed, referring to others may not be appropriate when a person's preferences are unique, or he/she prefers to use the same service repeatedly when the same or at least very similar situations recur. Intimacy is a more intrapersonal and quite persistent concept that is seldom affected by others [28]. Hence, customer's trust level on an e-commerce system based on intimacy is more stable than one based on other people's evaluations.

Second, intimacy-based trust reasoning needs no institutional infrastructure which is costly to operate and maintain. Intimacy is estimated and managed by personal resources, not by third parties or recommendations from others. Actually, the reputation-based approach may suffer from the cold-start problem when history data are not accessible due to privacy concern or data inconsistency. In this case, the e-commerce systems have an insufficient set of historical data from which to build a reputation. This problem is more severe if the e-commerce system is too small and local to generate a large volume of historical data.

Relevant estimations of intimacy can be very useful for personalizing trust-based ecommerce. However, to the best of our knowledge, studies on automated estimation of intimacy have been very few. Traditionally, intimacy has been estimated by survey. Offline or online, completing questionnaire items manually is very obtrusive and time-consuming. Thus, an artificial reasoning method of estimating intimacy must be developed, a way of automatically collecting user context data via sensors and readily available personal information.

The purpose of this paper is to propose a method of trust reasoning in the mature stage of ecommerce usage. Intimacy is estimated with context data and an ensemble intimacy reasoning method. The proposed method shows an automated estimate of the user's current intimacy level based on context data. The

paper is organized as follows: literature on trust reasoning is reviewed in section 2. Intimacy and the proposed trust estimation method are discussed in section 3. To show the performance and feasibility of the proposed method, implementation and experimentation are conducted and described in section 4. Finally, theoretical and practical implications of this method are discussed along with future research issues in section 5.

2. Theoretical Background: Trust Reasoning

Trust is crucial to sustainable e-commerce systems. It is a main element of the user's internal utility function based on past transactions and future expectations. This function reflects people's opinions and experience about the possibility of having successful interactions with others, which is called trust.

Conventionally, customer's trust level on e-commerce systems has been estimated both directly and indirectly. The direct method uses rating systems. For example, trust has been directly measured by professional or general raters such as Fortune. Raters rate companies on attributes such as the following: quality of management, quality of products or services, long-term investment value, innovativeness, financial soundness, ability to attract talented people, community and environmental responsibility, and use of corporate assets. Trust on e-commerce system has also been computed indirectly based on available data about reputation. In eBay's reputation system, for example, buyers and sellers can rate each other after each transaction, and the overall reputation of a participant is the sum of these ratings over the last 6 months. This arrangement relies on a centralized system to store and manage ratings. Trust value on e-commerce system is computed using evaluations of the results of transactions. Perhaps the most recognized reputation-based trust reasoning algorithm is EigenTrust. The EigenTrust algorithm computes a global reputation value (using PageRank) for each entity [18]. The algorithm provides each peer in the peer-to-peer network with a unique global trust value based on the peer's history of uploads.

Trust reasoning can be supported by sophisticated analysis models. The semantics of trust are better understood using visualization techniques. For example, trust network analysis with subjective logic (TNA-SL) simplifies complex trust graphs into series-parallel graphs by removing the most uncertain paths to obtain a canonical graph. TNA-SL requires trust relationships to be expressed as beliefs [18]. A trust computation model provides a more elaborate way of trust reasoning, rather than using a simple determinant such as reputation. Vassileva et al. [42] computed trust as a function of evaluated experience and inflation rate, which is used

to model the fact that older experiences become less important as time goes on. The evaluation value of positive experience ranges from 0 to 1, whereas negative experience ranges from -1 to 0.

Another example of model-based trust reasoning is a process-oriented multidimensional trust formation model [21]. The model consists of six dimensions (information, product, transaction, behavior, institution, and technology) and three layers (seller, buyer and third party, and technology). The investigators did not intend to estimate trust with only a three-dimensional view, so the subdimensional items play the role of independent variables in the trust derivation model of Kim et al. [21]. Statistical models such as regression models can estimate trust level from a variety of factors which have been known to affect trust. For example, trust is affected by individual attitudes or internal evaluation about using a certain system or service. Attitude is represented as a variety of psychological constructs either temporarily developed, such as reputation and stereotypes of systems or services, or accumulated over time, such as disposition to trust [22], familiarity [10, 27], feelings of dependence, and reliability [8].

So far, however, trust reasoning methods have seldom considered the mature stage of usage when a user is not relying on a third party. Research in this area is partially related to the research stream about trust in marketing and information systems. Although numerous studies have established the link between trust and initial purchase [16], efforts to examine the relationship between customer retention and trust still remain limited [33]. Moreover, trust is very dynamic in nature; hence, information about ongoing implicit reasoning is very much needed. Moods and emotions influence the experience of trust. This means that the trustee's level of trust depends on the trustor's condition, which is subject to change and temporal boundaries. Consequently, estimating the trustor's emotions of intimacy or perceived closeness over time is important for trust reasoning in the mature stage.

3. Methodology

3.1 Intimacy and trust

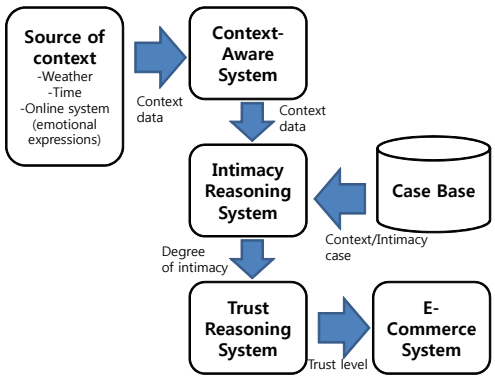
Intimacy with an e-commerce service is a feeling of closeness and emotional bonding, involving intense liking, moral support, and the ability to tolerate flaws in the service [28]. It is a factor for system success in terms of continuance intention and satisfaction.

In the literature, there are two perspectives on the causal relationship between intimacy and trust. First, some researchers argued that trust and intimacy are reciprocally related [34]. Establishing an intimate and trustworthy relationship with clients assures ven-

dors more transactions and retention of customers in the long run [42]. Second, when intimacy is seen as a positive understanding of the current actions of the object of trust, it is a sufficient condition of trust in future actions; if there is intimacy between two parties, then they surely feel trust [10]. However, trust does not necessarily indicate that the trustor and object of trust have an intimate relationship. In other words, trust is the backbone of intimacy; trust provides the safe climate necessary for intimacy to develop. In an online environment, trust is built through intimacy and familiarity in a positive sense [10, 11].

However, these two perspectives are contradictory in the way they conceptualize trust. Pavlou and associates classify trust into institutional trust and interorganizational trust [31]. In their model, institutional trust and intimacy determine interorganizational trust. Especially at the earlier stages of relationship building, institutional trust plays a more important role, whilst intimacy informs interorganizational trust at the mature stage. In other words, intimacy is a determinant of interorganizational trust, and at the same time, it is reciprocally related to institutional trust. This information carries the very important implication that the conventional trust reasoning methods, the policy- and reputation-based methods, are more useful for estimating trust at the earlier stage of system usage. In the mature stage, however, these two methods may not work so well.

In this paper, we adopt the second viewpoint: intimacy is a sufficient condition of trust, because we focus on interorganizational trust rather than institutional trust, and trust reasoning at the mature stage. The overall framework of the proposed method is shown in <Figure 1>.



〈Figure 1〉 Overall Framework

3.2 Context-aware Reasoning of Degree of Intimacy

Although “everybody knows” what an intimate relationship means, there is little agreement as to what “it” is [5]. However, intimacy is generally conceived as knowing and being known by another, which incorporates mutual and reciprocal liking and vulnerability. Most social psychological researchers define intimacy as a quality of interaction and relationships between people [1, 25], or as enduring motivation to experience closeness, warmth, and communication [39]. Degree of intimacy

refers to the depth of intimacy that an individual has with another. How to measure the degree of intimacy in a context-aware manner is a main focus of this paper.

In the literature of psychology, scholars have agreed that offline intimacy is a multidimensional concept consisting of several specific components. Among the most widely used questionnaires for measuring intimacy, Walker's explores several dimensions: attachment, visiting (i.e., frequency of contact), and proximity [44]. Hook et al. proposed a few other dimensions such as love and affection, personal validation, and self-disclosure [14]. In addition, Vetere et al. found that people express intimacy to a certain person with the following five multidimensional sources [43] : emotion, reciprocity, expression, proximity, and openness. In this paper, we integrate the multidimensional views of Walker [44], Hook et al. [14], and Vetere et al. [43] to conceptualize intimacy as shown in <Table 1>.

Emotional positivity is strongly related to intimacy. People in a positive mood tend to disclose more intimate details about themselves. Intimate people share good messages, rather than dwelling on destructive or gloomy topics. They spend more time in conversation late at night, which is good for creating a positive mood. As for reciprocity, preparation and expectation are elements of reciprocity in an intimate relationship. Reciprocity indicates that parties are engaged in a common cause, awaiting incoming messages, co-presenting and maintaining mutual conversation rather than mass communication. Intimate people are highly expressive with each other. They want to express their feelings explicitly to confirm their degree of intimacy. Proximity encompasses physical and logical proximity. Physically, people who are intimate with each other can be found at the same time in the same vicinity because they want to get along with each other. In terms of logical proximity, two people are in proximity if they are similar to each other or share traits, characteristics, or interests. Proximity enables higher expression, enforces reciprocity, and makes it easier to show emotion more explicitly.

Items for each dimension of this five-di-

〈Table 1〉 Multidimensional Views of Intimacy

Walker	Hook et al. [14]	Vetere et al. [43]	Ours
Attachment	Love and affection	Emotion	Emotion
Visiting	-	Reciprocity	Reciprocity
Proximity	-	Proximity	Proximity
-	Personal validation	-	Personal validation
-	Self-disclosure	Openness	Openness
-	-	Expression	Expression

〈Table 2〉 Human-to-Online Marketplace Intimacy

Dimension	Context	Source of context
Emotion	Emotional positivity	Online survey
	Rating	Raters
Reciprocity	Degree of agreement	Messengers
	Positivity on event alert	Online survey
	Remaining in favorites	Web browser
	Return of responses	E-mail
Expression	Amount of communication	Web browser
	Purchase with no ads and promotions	Online survey
Proximity	Device proximity	Using device
Openness	Number of private data used	Website
	Number of private words used	Website

mensional view of intimacy, the source of the items' context, and raw context data from the literature survey are listed in <Table 2>. "Source of context" indicates the data or program source from which each item was collected without manual input. For example, the level of goodness of a message can be calculated through the raters' rating statistics.

<Table 3> shows the website characteristics that express online intimacy. For example, an intimate website uses more emoticons in the interface, provides tailored content, and is worded in warm and polite language, and features sounds or scenes which stimulate an intimate mood. Such websites are more familiar to the user, considering the user's current context such as location, time, weather, cultural differences (e.g., language, colors of the website), and any emotional expressions (e.g., exclamation marks).

〈Table 3〉 Intimacy-Reinforcing Actions

	General interface	Intimate interface	References
Emoticon	No emoticons	Uses emoticons	Kato [20]
Exclusivity	Regular service	Exclusive service	Lamming and Flynn [24]
Mental state	Plain language	Warm language	Bell et al. [3]
Media	No music, images	Intimate music, images	Bell et al. [3]
Physical closeness	Using their computer	Using my computer	Silva and Ball [38]
Context awareness	Not contextual	Context-aware	Lamming and Flynn [24]
Cultural differences	Ignore	Consider	Bell et al. [3]
Emotion	Cognitive	Emotional	Dodge [7]

3.3 Parsimonious Vertical Boosting Applied to Intimacy Reasoning

To estimate the degree of intimacy, we applied the parsimonious model of the vertical boosting method [23]. Original vertical boosting generates classifiers for each attribute in a training set. Then each classifier generates individual patterns, with the assistance of sensitive multipliers, to find the desirable state. If there is more than or equal to one attribute which is inferred correctly, the pattern is identified as right, while if there no attribute which is inferred correctly, the pattern is identified as wrong. The generated patterns are identified as pattern matrix with adjustment by the multiplier, and then used in the ensemble method to generate combined rules. In this paper, we exclude multiplier functionality from the vertical boosting method because we do not need to deal with the so-called "gold mining problem." A gold min-

Function name: Get conclusion

Input: (right/wrong) pattern matrix

Output: output

```
Patterns = Generate patterns ();
for (attr = N; attr> = 0; attr--) // N is the number of input items
{
while ((NOT end_of_patterns) AND (NOT pattern found))
        {
                if (identified as right patterns)
                {
                        output = conclusion of this pattern;
                        Pattern found;
                }
Go to next pattern;
        }
}
Return output;
```

〈Figure 2〉 Procedure of "Get Conclusion"

Function name: Generate patterns

Input: training cases

Output: (right/wrong) patterns

```
while (NOT end_of_cases)
{
        if NOT (at least one attribute hit the result) // false pattern found
        {
                if (false pattern already exists in false pattern set) Append new false pattern;
        }
        Else // right pattern found
        {
                If the attribute returns wrong answer, set value of the attribute as -99;
                Else set value of the attribute as the answer;
Put answer to the result of the pattern;
        }
}
Return patterns;
```

〈Figure 3〉 Procedure of "Generate Patterns"

ing problem is any problem which satisfies the following condition: it has a low frequency of an occurring desirable state, considerably lower than that of an occurring undesirable state. In the context of this study, however, since we do not need to classify desirable and undesirable states, giving multiplier is meaningless and hence omitted to make the reasoning more parsimonious. The pseudo-code of the parsimonious algorithm consists of two parts: the "Get conclusion" procedure <Figure 2> and the "Generate patterns" procedure <Figure 3>. Detailed description, which is available in an earlier paper [23], is omitted in this paper.

3.4 Trust Reasoning with Intimacy

Once the estimated degree of intimacy between the k-th user and the l-th e-commerce system ($\hat{n}_{kl}$) is identified, the k-th user's trust on the l-th e-commerce system (T_{kl}) is estimated as a weighted average of reputation value and estimated degree of intimacy according to (1):

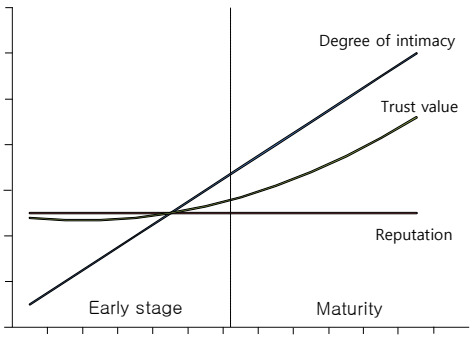
$$T_{kl} = (1-\beta_t) \times r_l + \beta_t \times \hat{n}_{kl} \qquad (1)$$

The reputation value of the l-th e-commerce system, r_l, can be acquired from a third-party organization or any other reputation rating system. r_l ranges from -1 to 1: -1 and 1 indicate that the reputation is ultimately negative or positive, respectively. Consequently, β_t, which is a function of usage pattern and time, is a sort of weight factor indicating to what extent the trust value relies on intimacy. Next, we have (2):

$$\beta_t = \alpha \times \phi_{kl} \times \rho_{kl} \times \pi_k \qquad (2)$$

where α is a normalization factor to make β_t ranges [0, 1], ϕ_{kl} and ρ_{kl} are the k-th user's frequency of visiting and elapsed time from the initial visit to the l-th e-commerce system, respectively. In addition, π_k indicates the k-th user's relative preference to rely on intimacy factors rather than reputation. Hence, the value of β_t tends to increase for the time being. This makes the trust value, which is a weighted average of the degree of intimacy and reputation, like the curve shown in <Figure 4>. Reputation is evaluated and used when an e-commerce system is being considered. Once evaluated, the reputation value is persistent unless there are any noteworthy incidents which significantly increase or decrease the reputation level. This implies that the expected degree of reputation will remain the same for the time being. At the early stage, where reputation is more critical than intimacy, trust value on e-commerce system is more affected by reputation. In other words, the trust value curve changes as the influence of reputation increases or decreases. This makes the trust value curve sting to reputation. However, in the later stages of system use, the degree of intimacy mediates trust value because the

weight of that factor becomes higher than that of reputation.



〈Figure 4〉 Computation of Trust Value on e-commerce System

4. Experiment

4.1 Implementation

To show the feasibility of the method proposed in this paper, a prototype system has been developed and implemented. Case base is first constructed using Microsoft Access and then is accessed by a Java application program via a JDBC/ODBC connection. Finally, the trust reasoning method is implemented using Java SE.

4.2 Procedure

To show the feasibility of the intimacy-based trust reasoning algorithm proposed in this paper, we performed experimental studies with actual participants who were recruited via e-mail and a sign-up sheet. A survey technique was used to collect experience sets and profile data. The population sample was selected from among community members of universities in Asia who were very well acquainted with web-based programs and had no problems using web browsers. In total, 12 people participated in the experiment.

A survey technique was used to collect experience sets and profile data. Participants were asked to complete the questionnaire items. First, they are exposed to visit specific websites (Auction, eBay, Amazon.com, Facebook, Google Search, LinkedIn, Twitter, Travelocity, etc.), which are randomly chosen. Then they outlined their history of usage of that website. Questions about user profile (P = {gender, age, income}), user context (C = {emoticon, personalization service, polite expression, emotional music, ease of access, cultural expression}), usage profile (U) = {usage frequency, interarrival time}, and result set (R = {degree of intimacy, trust level}) were asked. In addition, to evaluate performance, the questionnaire also included intimacy metrics for five items; Tomasi's questionnaire was adopted and modified to the context of web-based systems [28, 41]. For testing how the system characteristics relate to intimacy, we considered intimacy-reinforcing actions suggested by research from the computing community, as shown in <Tables 2> and <Table 3>. Items about reputation were also included [15]. The participants were asked to evaluate the system

characteristics subjectively. In this way, we obtained evaluations from the participants for 10~20 websites (including Auction, eBay, Amazon.com, Facebook, Google Search, LinkedIn, Naver, Twitter and Travelocity), resulting in 100 cases. Among these, 10 cases were discarded due to incompleteness. Finally, 90 cases were stored in the case base for later experimentation.

4.3 Validation of Survey Data

To determine the validity of the collected survey data, we performed several statistical analyses to test the relationships among website usage history, intimacy, reputation, and trust. We regarded website usage history (elapsed time from the first visit to a website, frequency of visits, number of visits, *etc.*) as a measure of continuance intention. As mentioned earlier, the basic assumption of this paper is that intimacy becomes a more critical indicator of trust as usage accumulates, whereas reputation affects the level of trust at the beginning stages of website use. If this is correct, then the relative weight of intimacy as an indicator will be positively associated with website usage history. Hence, we asked the participants to rate the validity of the following statement based on a 7-point Likert scale: "It is my level of intimacy with the website, rather than its reputation, that motivates my visits now". They also answered a question about website usage history in terms of number of years (mean = 2.44 yrs, standard deviation = 1.89, maximum = 8 yrs, minimum = 1 yr). Causal relationships were examined via regression analysis, the results of which are shown in <Table 4>. As expected, the relative weight of intimacy becomes significantly higher ($p < 0.001$) than that of reputation as usage accumulates.

Competition models were established to determine if trust, reputation, and intimacy affect continuance intention. In a comparison of F-values and R-square values, the collected

〈Table 4〉 Causal Relationship between Usage History and Relative Weight of Intimacy

	dof	Sum of square	Mean square	F-value	Significant F
Regression	1	42.4985	42.4985	19.7249	0.0000
Residual	88	189.6015	2.15456		
Total	89	232.1			

	coefficient	Standard deviation	t-value
Y intersection	3.198	0.255	12.521*
Usage history (yr)	0.364	0.082	4.441*

* $p < 0.001$.

〈Table 5〉 Regression Models of Continuance Intention

	Model 1	Model 2	Model 3	Model 4	Model 5
Dependent variable	Continuance intention	Continuance intention	Continuance intention	Continuance intention	Continuance Intention
Y intersection	0.3000 (0.5547)	-0.3618** (0.4745)	1.2315 (0.7408)	0.6837** (0.3085)	-1.3364** (0.5822)
Trust	0.7500*** (0.1089)	0.5159*** (0.1715)	0.2672 (0.3023)		0.5172*** (0.1466)
Reputation		-0.2085 (0.1651)			
Intimacy		0.6999*** (0.0967)			0.3177** (0.1332)
Trust×Reputation			-0.0479 (0.0314)		
Trust×Intimacy			0.1272*** (0.0167)	0.0845*** (0.0123)	
F-value	47.4443***	42.5998***	45.3739***	46.7719***	24.2287***
R-square	0.5918	0.7731	0.7828	0.5891	0.5981

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

cases show that intention to continue using a website is affected by trust and intimacy, in accordance with statements in the conventional literature (See <Table 5>). Finally, to ascertain if trust is associated with reputation, and hence indirectly affects continuance intention, we performed another regression analysis, the results of which are shown in <Table 6>. As expected, reputation strongly influences trust. These results indicate that from the data set used in this study, we obtained the same results as those reported in the literature on

〈Table 6〉 Causal Relationships among Trust, Reputation, and Intimacy

	dof	Sum of square	Mean square	F-value	Significant F
Regression	2	136.5373	68.2686	122.8372	0.0000
Residual	87	48.3515	0.5557		
Total	89	184.8888			

	coefficient	Standard deviation	t-value
Y intersection	0.5580	0.2873	1.9422*
Reputation	0.7514	0.0713	10.5343***
Intimacy	0.1355	0.0651	2.0799**

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

continuance intention and trust. Hence, the data set is validated.

4.4 Validation of the Proposed Method for Intimacy Reasoning

Using the validated cases acquired in the survey, K training datasets and K test datasets were generated using a K-fold random subsampling method. For each simulation run, a new training and test data set were selected. As a result, 2,955 runs were performed in total.

We compared the proposed method with three different trust reasoning methods: reasoning with survey items, reasoning with reputation, and the multiple regression method. Furthermore, we applied the proposed trust reasoning method with three different data sets: reasoning with a static context, reasoning with a dynamic context, and reasoning with both contexts, to examine if the dynamic context data make a significant contribution to increasing the accuracy of trust reasoning. Moreover, using the intimacy-based trust reasoning method with the dynamic context only and then comparing the method with reasoning in both contexts, we attempted to identify if the method is durable without the static context. If the outputs of the two methods did not differ statistically, then we concluded that privacy-preserving trust reasoning is possible.

Method 1: Reasoning with survey items

For each simulation run, Tomasi's five items indicating intimacy (INT) were used to estimate intimacy level [41]. For each estimation, we averaged the values of the following five items ranging from 1 to 7:

INT1. I enjoy the online shopping mall and am at ease while using it.
INT2. I think of the online shopping mall as a friend of mine.
INT3. I choose the online shopping mall without any hesitation when purchasing goods on the net.
INT4. I feel intimacy with the online shopping mall.
INT5. I feel that visiting the online shopping mall is a very important part of my consumption life.

Method 2: Reasoning with multiple regression

To derive a statistically relevant regression model, the insignificant intimacy-related variables in <Tables 2> and <Table 3> were deleted. The remaining variables were "My language", "Willing to get e-mails or messages", "Favorites", "Reciprocity", and "Proximity" (see <Table 7>). Hence, a multiple regression model was formulated using these four variables, and the model was then used in estimating intimacy level.

Method 3: Case-based reasoning with all properties

With all properties in the case base, the

〈Table 7〉 Regression Analysis of Intimacy-Related Variables

	Coefficient	Standard deviation	t-value
Individualization	-0.0495	0.1379	-0.3590
Warm, friendly language	-0.0040	0.1615	-0.0250
Using my computer	-0.0006	0.1554	-0.0039
My language	0.3163	0.1543	2.0494**
Good feeling	0.0282	0.1799	0.1568
Willing to get e-mails or messages	0.3141	0.1397	2.2482**
Favorites	0.3881	0.1159	3.3484***
Computers nearby	0.1153	0.1136	1.0151
Emotion	0.1816	0.1130	1.6073
Reciprocity	0.1959	0.0991	1.9755*
Proximity	0.3668	0.1216	3.0153**
Openness	0.1220	0.0777	1.5708
Validation	-0.0648	0.1075	-0.6031

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

case-based reasoning method was used to estimate intimacy level. The rationale as to why case-based reasoning was applied is as follows. First, since intimacy is psychological in nature, intimacy reasoning rules cannot be acquired structurally. This makes it difficult to extract the rules explicitly from scratch. Thus, the reasoning rules are derived heuristically. Second, since intimacy reasoning is appropriate to the mature stage, rather than the earlier stage of usage, in the proposed method, the cold-start problem is not an issue. This refers to the problem that case-based reasoning cannot provide any inferences for users about which it has not yet gathered sufficient information. That is to say, the weak point of case-based reasoning is hindered in the method proposed here. The case base (CB) consists of a user profile (P), user context (C), and intimacy (Y).

$$CB = < P,\ C,\ Y > \tag{3}$$

P = {gender, age, income, etc.}

C = {emotional positivity, rating, degree of agreement, positivity of event alert, remaining in favorites, return of responses, amount of communication, purchase without no ads and promotions, device proximity, number of private data given, number of private words given}

Y = {degree of intimacy}

Suppose a similarity between a current context (CC) and the i-th case (CB_i) is com-

puted as (4):

$$S_i = \frac{1}{\sum_{\forall j} f(CB_{ij},\ CC_j)} \tag{4}$$

Where f indicates a function of concept distance between CC and CB_i. The j indicates j-th property of each case. In general, Euclidean distance is defined as f. Then, the estimated degree of intimacy between the k-th user and the l-th e-commerce system, $(\hat{n}_{kl})$, ranging from -1 (highly hostile) to 1 (highly intimate), is derived as (5):

$$\hat{n}_{kl} = y_{i^*},\ where\ s_{i^*} = \min_{\forall i}(S_i) \tag{5}$$

where y_{i^*} indicates the degree of intimacy of the i^*-th case in CB.

In this paper, we used Tversky's Euclidean distance method as an instance of (4). In the simulation for performance evaluation, the $\boldsymbol{p}$-value is randomly determined in {2, 4, 6, 8, 10} because $\boldsymbol{p}$ should be an even number.

$$d(1) = (\sum_{\forall i}(y_i - \hat{y}_i)^P / N)^{1/P} \tag{6}$$

Method 4: Case-based reasoning with partial properties selected by Method 2

Method 4 is different from Method 3 in that we considered only the statistically proven variables in performing the case-based reasoning. However, as in Method 3, we also used Tversky's weighted Euclidean distance method.

$$d(2) = (\sum_{\forall i} w_i (y_i - \hat{y}_i)^P / N)^{1/P} \tag{7}$$

We adopted the t-value of the variables derived from multiple regression analysis as weight value.

Method 5: Ensemble method 1 (averaging Methods 2, 3, and 4)

Ensemble methods are among the most promising of the methods available to improve the performance of classifiers such as learning and decision-tree algorithms [45]. An ensemble consists of a set of individually-trained classifiers, such as neural networks or decision trees, whose predictions are combined when classifying novel instances. In ensemble methods, each base learner is trained on a resampled version of an original training sample of the same size. As in Method 5, averaging is used as a voting strategy of the bagging ensemble method.

Method 6: Ensemble method 2 (vertical boosting with Methods 2, 3, and 4)

As in Method 5, we used Kwon's vertical boosting method [23], which generates classifiers for each attribute in a sample. Then each classifier generates individual rules, with the assistance of sensitive multipliers, to find the desirable state. The individual rule sets are

generated with adjustment by the multiplier, and then used in the ensemble method to generate combined rules. In this paper, the whole algorithm excluding multipliers is considered. The detailed algorithm is omitted in this paper.

The metrics used in the simulation were overall precision (accuracy) and response time. First was overall precision, the traditional accuracy measurement. In the literature, overall accuracy has been computed using a global metric, namely the Mean Absolute Deviation (MAD) or Root Mean Squared Error (RMSE), which can be computed as (8) and (9):

$$MAD = \frac{1}{N} \times \sum_{\forall i} |y_i - \hat{y}_i| \qquad (8)$$

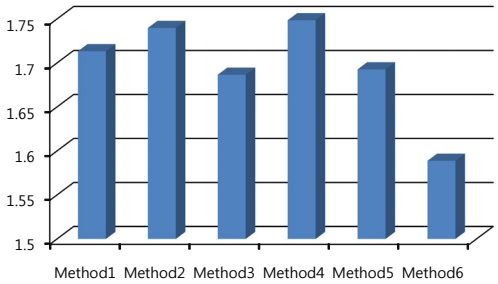
and

$$RMSE = \sqrt{\sum_{\forall i} (y_i - \hat{y}_i)^2 / N} \qquad (9)$$

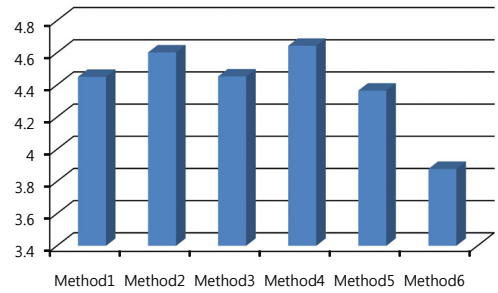
where N indicates the total number of examples in the test data set.

Performances of all Six Methods

The performances of all six methods are now described. The performances in terms of MAD and RMSE are shown as <Figures 5> and <Figure 6>, where it is evident that Method 6 seems to be the best in terms of accuracy. To validate its superiority statistically, the MAD values of Method 1 and Method 6 were compared by t-test. As shown in <Table 8>, the result clearly indicates that Method 6 outperforms Method 1. The comparison with respect to RMSE is omitted, simply because the result is trivial.



〈Figure 5〉 Performance Evaluation with MAD (the lower the better)



〈Figure 6〉 Performance Evaluation with RMSE (the lower the better)

〈Table 8〉 Comparison of Methods 1 and 6 by t-test (MAD)

	Method 1	Method 6
Average (MAD)	1.7133	1.5888
Variation	1.5153	1.3539
Observations	2955	
Pooled variation	1.4346	
t-value	3.9968*	

* $p < 0.001$.

〈Table 9〉 Causal Relationship between Method 6 and Intimacy

	dof	Sum of square	Mean square	F-value	Significant F
Regression	1	48668.31	48668.31	12547.57	0.0000
Residual	2954	11457.69	3.878703		
Total	2955	60126.00			

	coefficient	t
Method 6	0.9948	112.016*

* $p < 0.001$.

〈Table 10〉 Causal Relationship between Method 6 and Trust

	dof	Sum of square	Mean square	F-value	Significant F
Regression	1	1798.248	1798.248	1211.827	0.0000
Residual	2953	4382.001	1.483915		
Total	2954	6180.249			

	coefficient	t
Y intersection	2.5025	34.7237*
Method 6	0.6150	34.8113*

* $p < 0.001$.

The R-square value of Method 6 on intimacy is 0.809, which is higher than that of Method 1 (0.786). This implies that we do not need to consider acquiring intimacy values manually with a questionnaire. The manual questionnaire is very obtrusive and hence to be discouraged in developing ubiquitous or context-aware systems. Rather, Method 6 relies on an ensemble of the methods of acquiring user-related data. Moreover, when it comes to privacy issues, Method 6 is very flexible: if the user has privacy concerns about some items, then the method simply marks those values as "unavailable."

To confirm if Method 6 is usable as an intimacy-based trust reasoning algorithm, the causal relationship between the result from Method 5 and intimacy is derived by regression analysis. <Table 9> clearly shows a significant causal relationship between them ($p < 0.001$). Moreover, the R-square value of Method 6 on trust is 0.539 ($p < 0.001$) (see <Table 10>). Thus, we can conclude that without using survey data, Method 6 can be used to estimate intimacy, and hence trust.

5. Discussion

5.1 Main findings

In this paper, we have shown that intimacy

reasoning using context data is very useful for estimating the level of trust on websites or e-commerce systems. To begin with, we investigated information about all possible methods of gathering intimacy-related information or intimacy-fostering techniques and how they work to estimate the level of intimacy in an automated manner. Applying parsimonious vertical boosting, the proposed intimacy reasoning method outperforms other competing methods, including the conventional questionnaire approach, multiple regression method, and simple ensemble method.

Another major finding is that an intimate fostering policy can be a way to increase trust level rather than getting a third party's opinion about credibility and reputation. When the results of website assessments based on credibility and reputation are almost the same as those of competing websites, the level of intimacy can have a huge impact on website evaluation, especially if the website has a long history of operation.

Because trust is a form of social capital that is enhanced by intimacy, maintaining user intimacy is a crucial organizational practice for website success. Since social capital refers to the quantity and quality of social interactions in the community [32], the concept is still valid in terms of communication in cyberspace. However, estimating the amount of social capital is not easy unless the system incorporates an efficient trust estimation method. The proposed intimacy-based trust reasoning method provides an efficient means of social capital valuation.

5.2 Intimacy-based Website Management: Why Include Intimacy?

The result of this study also shows that intimacy is a powerful predictor of user trust, which was previously recognized as one of the most influential cognitive factors from the adoption stage to the post-adoption stage. Existing e-commerce providers have made great efforts to produce good content and services. However, customers' trust levels do not depend simply on the functionality or usability of the e-commerce sites. Customers are interested in the service moving their hearts with the story of the product, or stimulating their emotions, not only in rational suggestions. Revisiting consumers move from the function pursuit to the combining function and feeling pursuit.

Consumers today see few major differences in site quality or function, because existing popular e-commerce systems and websites are highly competitive and nearly perfect. Therefore new differentiated features are needed for business success. One possibility is to focus on the feelings of intimacy visitors experience while engaged in using the website. Intimacy must be evaluated directly from the post-adoption perspective. Ongoing customer loyalty cannot be retained by relying only on a service's

functional quality. Purchases can be guaranteed only by maintaining constant relationships with customers. The proposed intimacy reasoning method can change a service-focused strategy into a relationship-focused one. These days, sites must consider what customers really want. One answer to this question is evident from the results of this study: customers prefer true and intimate relationships, rather than just usefulness [28]. They want a closer relationship with their web-based services. Indeed, it is a great achievement when intimacy results from a customer-service provider relationship.

Fostering customer-to-customer intimacy has become a crucial trigger for continuance intention in social media, where this kind of intimacy really does matter. By using social media, companies can increase their level of intimacy with customers. If a user becomes closer to others through social media such as Facebook or Twitter, the social media becomes a must-have service to the customer no matter what the quality. This status clearly increases the intention to continue to use social media.

Intimacy is indeed important to corporate success because it contributes significantly to customer retention. For example, the iTunes store is an online media sales service through iTunes of Apple. The sense of closeness that customers feel for Apple is a result of much more than the company's leveraging of customer data. They cultivated a warm and fuzzy feeling in their customers using top-down branding. Apple lovers continue to feel intimacy with Apple, and barriers to exit are higher than ever. Efforts to enhance intimacy between Apple, its services, and its customers have ultimately brought great loyalty to the company, which is the driving force behind Apple's legendary success.

Intimacy is a familiar though not always well handled factor, especially when it comes to web-based services, in terms of service quality and relationship management. In developing customer retention strategies, managers need to consider customer intimacy because it affects customers as much as more objective factors such as quality. Managers can run traditional customer relationship management (CRM) programs on customers' basic profiles to analyze past transaction data, but should also prepare highly-developed CRM strategies that take into consideration customers' emotions. Moreover, since customer intimacy can be increased by individual care, not just by attention on the group or market level, future CRM should be personalized. Moreover, customer satisfaction evaluation systems, which are key to any customer-related performance evaluation, must be supplemented with new evaluation items and measurement methods that can measure beyond satisfaction levels to include affective factors.

5.3 Incorporating Intimate Technology with e-Commerce System

As a substitute for policy-and reputa-

tion-based methods, intimacy-based trust reasoning is useful. A research re-emphasis on intimate technology for developing sustainable e-commerce systems is therefore warranted. An intimate technology is any technology that focuses on individual identity or self-expression, and projection of this identity as a discrete entity into the system. Intimate technologies address human needs and desires, as opposed to traditional technologies, which meet functional task specifications exclusively. For example, SynchroMate is a relationship-enhancing technology designed to mediate intimacy by affording serendipitous synchronous exchanges [13]. SynchroMate supports serendipitous synchronous communication by conveying not only the message itself, but also the fact that a message is being composed. One example is Hug Over a Distance: an intimate interface for remote couples [29], which is able to initiate a hug, causing a remote partner's jacket to emulate, in some fashion, the feeling of a hug. inTouch creates the illusion that two people separated by distance are interacting with a shared physical object.

Social media based e-commerce such as Facebook can benefit from intimate technology in the struggle to obtain consumer trust, which they are lacking in comparison with corporate websites. More often than not, knowledge embedded in social media is mixed with emotion or moods. For example, when people send e-mails or text messages, write blogs, and use social networking sites (SNS) such as MySpace and Twitter to share personal information with others, they often incorporate their emotional expressions to show or sustain intimacy with others. Social media *per se* consists of websites which require trust from users. Due to the global popularity of SNS sites [2], it is more important than ever to address users' vulnerability and privacy concerns. Based on the results of this paper, one possible strategy to demonstrate website credibility is to manage user intimacy. Social media sites can adopt the method proposed here to assess the degree of intimacy using context data such as emotional expressions and language support in a privacy-preserving and automated manner. Automatically monitored intimacy-related data, combined with reputation, is then used to estimate trust level. Trust level is useful in predicting continuance intention, which is a core ingredient in developing marketing strategy.

In this study, conventional constructs such as product quality and price level are not considered because we focus on enhancing reputation-based trust reasoning mechanism, not just empowering every part of the competitive advantages of e-commerce systems. However, the usage of e-commerce system in the mature stage will also be influenced by price level of the products it provides when the intimacy level, rather than reputation *per se*, and assorted products are same with its competitors.

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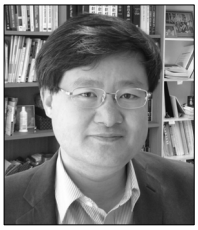

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