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Mobile Agent Based Trust Management Framework using Fuzzy Logic in B2C E-Business Environment

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***Abstract*— Trust is a major factor for the success of any business. The need for trust is no longer an option but a necessity when it comes to e-business environment since there are no direct person to person interactions. One way to evaluate the trustworthiness of a vendor is through feedbacks. As each customer interacting in an e-business environment has different perceptions and choice, the general feedback systems fail to meet their requirements. The general systems are more prone to attacks by malicious vendors, who provide fake feedbacks and use other tactics to build a high reputation and continue to be dishonest. Here we propose an architecture where customers can collect feedback through the system using agents. Trust calculation is done using three methods, one using direct method and the second using the fuzzy logic and the third implementing feedback mechanisms using agents. Thus, these methods ensure customers with more freedom and trust to carry out their transactions.**

***Index Terms*—Direct method, E-Business, Feedback, Fuzzy logic, Indirect method, Trustworthiness.**

I. Introduction

The aim of this system is to help customers evaluate the quality of a product supplied by an online vendor. The ecommerce environment must be able to ensure trust values to customers by any means to put forth a strong trust management system. Since the customers don't get see the products and also the absence of human interaction, makes ecommerce more deprived to reach its maximum capacity. Since these two elements are absent in an online environment, vendors tend to provide low quality products for a higher price. This system uses a 'word of mouth' which is otherwise known as indirect trust. Indirect trust is implemented using agents. Agent technology has been the subject of extensive discussion and investigation within the scientific community for several years, but it is perhaps only recently that it has seen any significant degree of exploitation in commercial applications. Multi-agent systems are being used in an increasingly wide variety of applications, ranging from comparatively small systems for personal assistance to open, complex, mission-critical systems for industrial applications. Evaluation of trustworthiness (overall trust) is done from previous interactions with the vendor (Direct Trust) and feedback provided by other customers (Indirect Trust). Overall trust is calculated for several attributes of the concerned product. From these results and using the fuzzy logic, customers can check or evaluate whether the concerned vendor is trustworthy.

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II. Related Work

Bin Yu [2,3] developed a distributed reputation management model based on Dempster shafer theory of evidence. This system solves some of the problems in e –bay's reputation model. It also takes deceptive ratings into account. FIRE[6], a trust model developed for multi-agent systems(MAS) takes into consideration the information provided from several sources(Interaction trust, witness reputation, role based trust and certified reputation). FIRE^{+} [1] is an extension to the FIRE trust model which uses Dempster Shafer theory of evidence. This model introduces a concept of information content which is total amount of information used to calculate the trust values. Ling Liu, Li Xiong [4] gives a generalized trust metric for e-commerce communities. They have identified various factors like credibility of feedback, transaction context etc. for a reputation based system. They show how various trust models can be developed by neutralizing each factor. Zhang Lin, Wang Ruchuan [7] has developed a system for making trusted decision in open networks. Trust value for a node and risk propagation paths and calculated and using fuzzy logic a trusted decision is made regarding a node.

III. Methodology

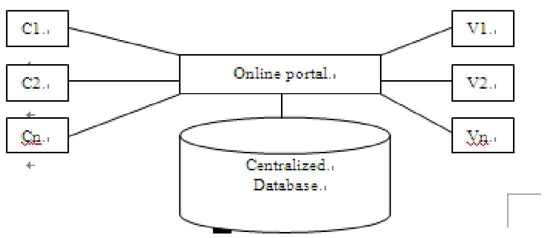

Fig 1 Direct trust model

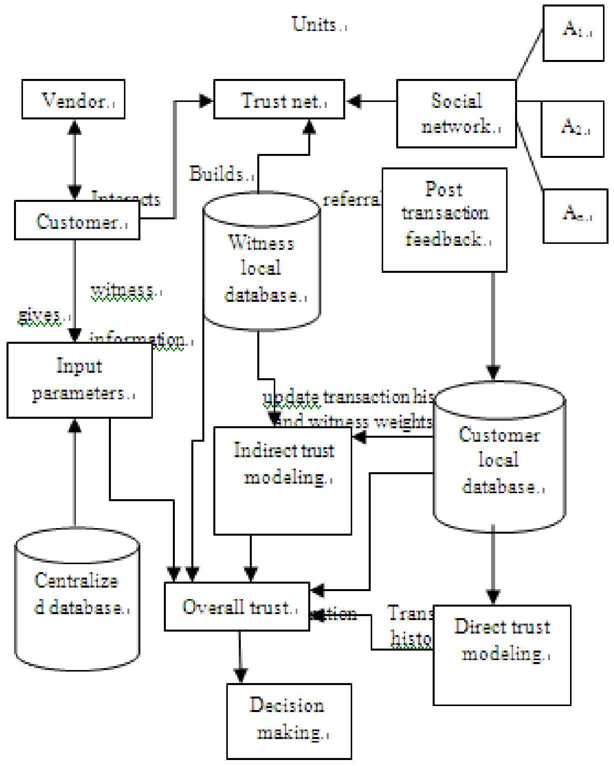

Fig 2 Process flow

A. Components

C_1, C_2…C_n: Customers
V_1, V_2…V_n: Vendors
A_1, A_2...A_n: Agents

Online portal: A portal on which vendors can sell items and customers can buy items.

B. Indirect Trust

1) Trust is calculated from the information provided by the other customers who have interacted with the same vendor in past.
2) All other customers are known as witnesses.
3) The detail of every vendor is automatically updated in between all customers where all these customers are used as agents.

C. Multi Agent System

1) Customers can collect feedbacks about a particular vendor through social network.
2) Social network is established by the use of Agents.
3) Agent communication is done automatically and database is also maintained without the interaction of user. Hence we can say these agents work on behalf of users.
4) Agent communication takes place through internal message transfer protocol.

D. Trust calculation

Two methods have been proposed for calculating trust. The first one is based on the demster-shafer evidential theory, while the second incorporates the fuzzy logic into the trust model.

i. Data representation

Rating of x_j denoted by $case_{ij}$ is thus triple in the following form: $case_{ij} = < e_j, e_j', t >$ where i is the ith rating. In this triple, $e_j = (a, b, x_j, v_j)$ denotes that agent a expects x_j 's value is v_j when assigning the where $v_j' \in [0,1]$. t is time when the rating is recorded.

ii. Interaction History

A matrix I = H × n where H represents transactions while n represents attributes. I is a queue of the past H interactions. Each column (for each attribute $x_j \in X$) in the matrix I is represented as

$$CB_j = \{case_{1j}, case_{2j} \ldots\ldots case_{nj}\}$$

D. Model 1 (Fuzzy logic based)

Direct Trust: Let R($case_{ij}$) be the rating given by the customer for the j[th] interaction and the i[th] attribute, w_{ij} be the weight and $f(case_{ij})$ be the effective rating.

$$f(case_{ij}) = w_{ij} * R(case_{ij})$$

The value of w_{ij} is assigned depending on the transaction's age and the relative cost of the transaction. The assignment of w_{ij} is done using fuzzy logic as explained below. Membership functions are assigned for age and cost of the transactions.

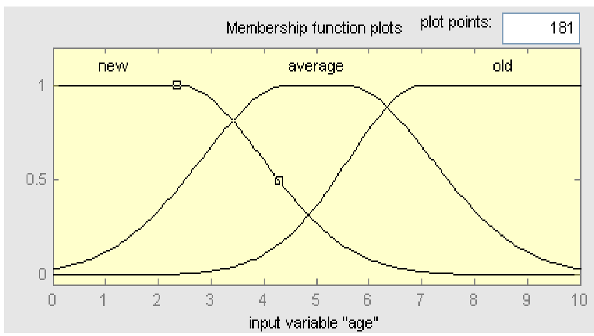

Fig 3 Membership function for age

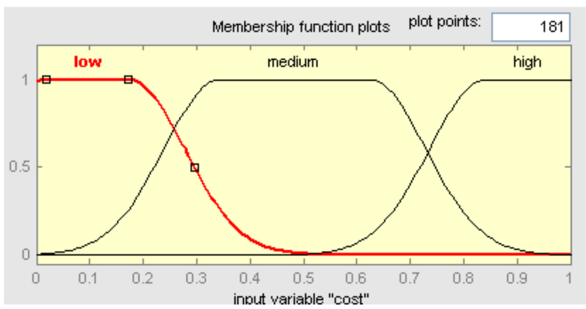

Fig 4. Membership function for cost

The fuzzy rules are designed as follows:

- If (age is old) and (cost is low) then (weight is low)(1)

- If (age is old) and (cost is medium) then (weight is low)(1)
- If (age is old) and (cost is high) then (weight is medium)(1)
- If (age is average) and (cost is low) then (weight is low)(1)
- If (age is average) and (cost is medium) then (weight is medium)(1)
- If (age is average) and (cost is high) then (weight is high)(1)
- If (age is new) and (cost is low) then (weight is medium)
- If (age is new) and (cost is medium) then (weight is high)(1)
- If (age is new) and (cost is high) then (weight is high)(1)

Min () function is used for "and" operation.

$$T_i(age, cost) = \min\{\mu(age), \mu(cost)\} \quad -(5)$$

Where, $\mu(age)$ is the membership degree of age of transaction *age* and $\mu(cost)$ is the membership degree of cost of transaction *cost*.

T_i(*Age*, *cost*) is calculated for each of the above rule *i* and the output in each case be V where, V is the rating and $\mu_i(V)$ be the membership degree of V calculated for a rule *i* (i ε the 9 rules given above).

Max () function is applied for each output V. With the 9 rules the final membership degree $T(V)$ will be as follows

$$T(V) = \max\{\mu_1(V), \mu_2(V), \ldots, \mu_9(V)\}$$

Defuzzification is done using centroid method. The defuzzified value is taken as w_{ij} .The value of direct trust (DT) is calculated similar to model1 using Dempster Shafer Theory of evidence. However here we use fuzzy sets to model the local belief ratings as explained below.

Suppose a customer C_i has evaluated a vendor V_j for a particular attribute (issue) for the past H interactions. Let $S_{ij} = \{s_{ij}^1, s_{ij}^2, \ldots s_{ij}^H\}$, where s_{ij}^k is the adjusted ratings given by (1) . For each customer C_i there are there are two thresholds defined Ω_i and ω_i where $0 \leq \omega_i \leq \Omega_i \leq 1$.

Let $S_{ij}(\{T\})$ be a fuzzy set denoting the trustworthy transactions, $S_{ij}(\{-T\})$ be a fuzzy set denoting the transactions that are untrustworthy while $S_{ij}(\{T,-T\})$ be a fuzzy set of transactions that are uncertain. Membership functions are selected such that the sum of the membership values for any rating over all the above sets is 1. Then

$m(\{T\})$ = sum of membership values of $S_{ij}(\{T\})/H$

$m(\{-T\})$ = sum of membership values of $S_{ij}(\{-T\})/H$

$m(\{T,-T\})$ = sum of membership values of $S_{ij}(\{T,-T\})/H$

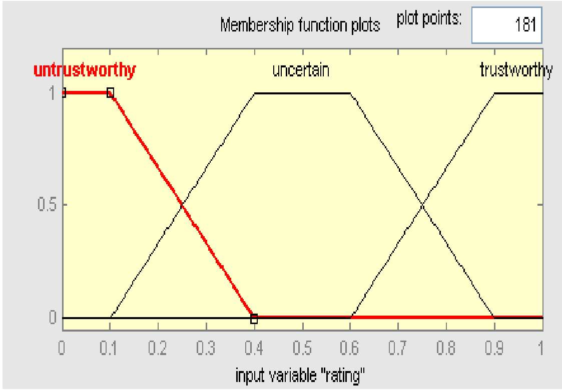

Fig 5 Membership function for rating

Indirect Trust: Indirect trust is calculated in the same way as model 1. Weights for witnesses are updated as follows:

Let DT_i be the direct trust given by W_i, and let DT be the new direct trust of the customer for vendor Vg. The weight for W_i is updated as follows $D_{if} = (|DT_i - DT|)$

Based on the depth of the witness in the social network and the difference D_{if} the adjustment for the weights is calculated using fuzzy logic as follows:

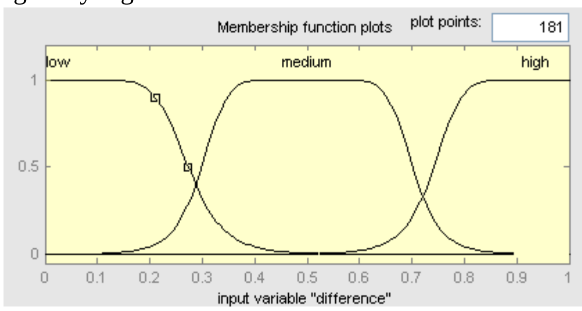

Fig 6. Membership function for difference

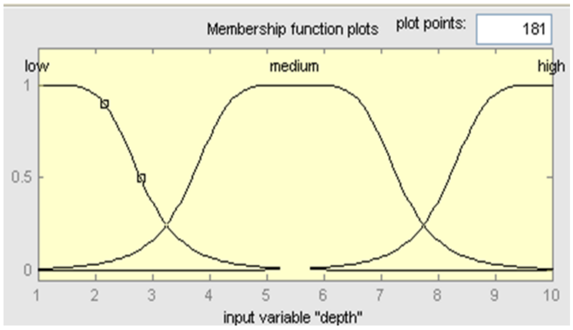

Fig 7. Membership function for depth

The Fuzzy rules are designed as follows:

- If (difference is low) and (depth is low) then (weight_adjustment is positive)
- If (difference is low) and (depth is medium) then (weight_adjustment is positive)
- If (difference is low) and (depth is high) then (weight_adjustment is positive)
- If (difference is medium) and (depth is low) then (weight_adjustment is neutral)
- If (difference is medium) and (depth is medium) then (weight_adjustment is neutral)

- If (difference is medium) and (depth is high) then (weight_adjustment is positive)
- If (difference is high) and (depth is low) then (weight_adjustment is negative)
- If (difference is high) and (depth is medium) then (weight_adjustment is negative)
- If (difference is high) and (depth is high) then (weight_adjustment is negative)

Min () function is used for "and" operation.

T_i*difference, depth)*=min $\{\mu(difference), \mu(depth)\}$

Where, $\mu(difference)$ is the membership degree of difference between the user's direct trust and the witness's direct trust *difference* and $\mu(depth)$ is the membership degree of depth of the witness in the network *depth.*

T_i(*difference,depth*) is calculated for each of the above rule *i* and the output in each case be V and $\mu_i(V)$ be the membership degree of V calculated for a rule *i* (i ε (1,9)) .

Max() function is applied for each output V. With the 9 rules the final membership degree $T(V)$ will be as follows

$$T(V) = \max\{\mu_1(V), \mu_2(V), \dots \dots \dots, \mu_9(V)\}$$

Defuzzification is done using centroid method. Let the defuzzified value be adj_i

Then the weight is updated as follows,

if(adj_i is –ve) then $w_i = \max(0, w_i + adj_i)$
if (adj_i is +ve) then $w_i = \min(1, w_i + adj_i)$

IV. System Implementation

The system implementation requires development of three modules i.e. direct trust, indirect trust and model based on fuzzy rules. In this model trustworthiness is calculated based on customer's direct experience and feedback through agents.

It includes three major steps namely: estimate trust level based on direct experience, calculate the level obtained feedbacks through agents and determine the final trust.

A. Feedback Mechanism Design

Here the feedback through agents is calculated and given a range of values. Once a customer is performing a transaction with a vendor, the corresponding feedback is received which is provided through agents. This corresponding trust value indicates to the customers about the trustworthiness of that particular vendor.

V. Experimental Results

The simulation environment has been developed in JAVA JDK5.0, using the Java Agent Development (JADE). JADE simplifies the implementation of multi-agent systems through a predefined middleware concept. It provides a common agent base class for creating user-defined agents, by extending the standard functionality of JADE and by implementing custom behaviour. JADE also provides features for interacting with the yellow pages and the standard platform. For each agent, custom behaviors can be defined and triggered by internal or external events. All users share the same ontology to be able to interpret messages from other agents. The messaging format in JADE complies with the FIPA specifications, which delivers a well-formed basis for a structured communication process. One further advantage of JADE is the support for distributed processing of agents in a network, which allows for scaling of the simulation environment and also agents reduce the overall over head on the system. Also, since fully based on JAVA, agent objects are portable to other environments such as JAVA-enabled mobile devices.

Fig 8.1 shows the snapshot of the JADE agents which shows the communication between buyer agent and the seller agent.

We have developed an online shopping application using the framework mentioned in this paper. This application is developed with and without agents. In fig 8.1 we show the sniffer agent sequence diagram which shows the interaction between the agents and the message passing between them. The agents register themselves first and the buyer agent checks with the yellow pages for the available services. After the services have been notified, the buyer agent communicates with the seller agent and the best and trustworthy seller is chosen implementing the models described in this paper. Immediately after the transaction is purchased, the buyer agent terminates it automatically and the concerned product is removed from the catalogue thus making the process more efficient. Based on the models, the graph shown in fig 8.3 shows the trust values based on the ratings calculated by fuzzy rules.

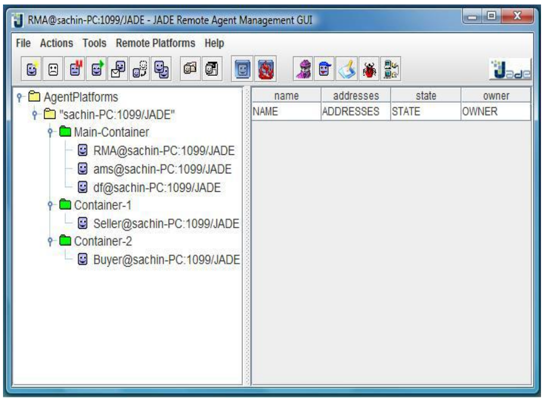

Fig 8.1 JADE Remote Management Agent Gui showing the Buyer and Seller Agents

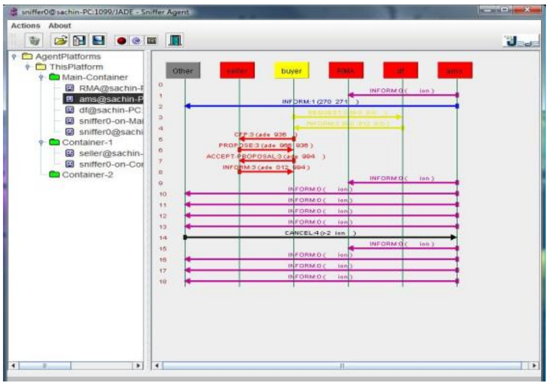

Fig 8.2 Message passing between the agents using the sniffer agent

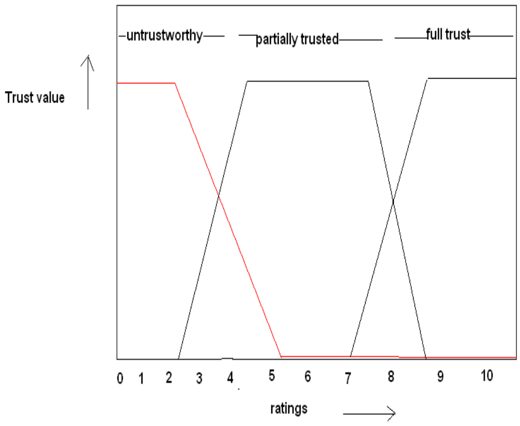

Fig 8.3 graph between ratings and Trust values

VI. Conclusion And Future Work

A framework is designed that facilitates E-business transactions to be conducted in a trust-worthy manner for today's e-business environment that spans across the globe. E–commerce has been successful in the B2B sector; the B2C sector has not achieved its expected growth potential. One of the main reasons for low growth is because of lack of consumer trust. In this paper a reputation management system has been proposed using direct interactions and feedback from other customers in a social network using agents, where each customer models trustworthiness of a vendor. The modeling of trustworthiness is done using dempster – shafer evidential theory, fuzzy logic. The concept of information content is used to give priority to direct and indirect trust. Thus the customer can decide the trustworthiness of the vendor. Our future work will be based on the extension of this model to the mobile environment since agent's objects are portable to JAVA-enabled mobile devices.

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