REPUTATION SYSTEM FOR AN E-COMMERCE SYSTEM USING FUZZY LOGIC

LIANG ZEON POEE

BACHELOR OF COMPUTER SCIENCE
(SOFTWARE ENGINEERING)
UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

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Alamat Tetap:
25, Kampung Baru,
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(TANDATANGAN PENYELIA)

Nama Penyelia:
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REPUTATION SYSTEM FOR AN E-COMMERCE SYSTEM USING FUZZY LOGIC

LIANG ZEON POEE

A report submitted in partial fulfillment of the requirements
for the award of the degree of
Bachelor of Computer Science (Software Engineering)

Faculty of Computer Systems & Software Engineering
UNIVERSITY MALAYSIA PAHANG

JUNE, 2012

STUDENT'S DECLARATION

"I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. This project has not been accepted for any degree and is not concurrently submitted for award of other degree."

Signature : …….....
Name : Liang Zeon Poee
ID Number : CB09090
Date : June 13th, 2012.

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Computer Science (Software Engineering).

Signature : ……..…….....
Supervisor : Dr. Adzhar bin Kamaludin
Position : Deputy Dean of Faculty of Computer Systems & Software Engineering
Date : June 13th, 2012.

DEDICATION

Dedicated to my parents.

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ABSTRACT

E-commerce system is one of the most rapid-growing systems online. E-commerce system is the medium for buying and selling goods on the internet. However, on internet all the online users cannot recognize each other the way they do in real life. In E-commerce system where transaction is made and money is involved, the reliability of a seller holds a substantial amount of importance. Hence, there are many trust and reputation systems are introduced for e-commerce system. However, many of the existing systems are based on the simple calculation which is vulnerable to user manipulations. This may increase the chances of dishonest rating and reduce the reliability of the reputation system. This project aims to overcome this problem by applying fuzzy logic in the reputation system. By using fuzzy logic to compute a weight based on the user's information, each rating is multiplied with different weight. This can increase the difficulty of manipulation by dishonest users and increase the reliability of the system. The result of applying fuzzy logic shows that it can indeed prevent certain scenarios of dishonest manipulation in user rating.

ABSTRAK

Sistem e-commerce merupakan salah satu system yang semakin kerap diguna dalam internet. Sistem e-commerce telah menjadi pengantara aktiviti penjualan dan pembelian barangan di internet. Namun, pengguna internet tidak dapat mengecam sesama diri sebagaimana mereka mengenali orang lain di dunia nyata. Dalam sistem e-commerce di mana transaksi berlaku dan wang dilibatkan, kebolehpercayaan seorang penjual memainkan peranan yang amat penting. Justeru itu, sistem amanah dan sistem reputasi telah diperkenalkan dalam sistem e-commerce. Meskipun begitu, banyak sistem reputasi yang ada menggunakan cara kiraan berdasarkan pengiraan mudah yang terdedah kepada manipulasi pengguna. Ini akan meningkatkan kebarangkalian berlakunya rating tak jujur dan seterusnya menurunkan kebolehpercayaan sistem reputasi tersebut. Projek ini bertujuan untuk mengatasi masalah tersebut dengan mengaplikasikan logik fuzzy dalam sistem reputasi. Dengan menggunakan logik fuzzy untuk menghasilkan satu pemberat berdasarkan maklumat pengguna, setiap rating didarabkan dengan pemberat. Ini boleh meningkatkan tahap kesukaran manipulasi oleh pengguna tak jujur dan meningkatkan kebolehpercayaan sistem reputasi. Keputusan aplikasi logik fuzzy menunjukkan sesetengah senario manipulasi tidak jujur dalam rating pengguna boleh dicegah.

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CHAPTER 1

INTRODUCTION

This chapter describes the Reputation System for an e-commerce system using fuzzy logic. This chapter comprises five sections: The first section describes the background of the project. The second section describes the problem statement and motivation of the project. The third section describes the objectives for the project. The fourth section describes the scopes for the project. Finally the thesis organization is described in section five.

1.1 Background

With the explosive growth of the Internet, electronic commerce system is an increasingly important segment of commercial activities on the web. In traditional way, people often do business via face-to-face communication with their personal experience and judgments; while electronic trade cannot support immediate communication. Buyers can only browser some photos and the descriptions from web sites that are provided by sellers. It is hard to decide whether to buy or not. When most of these activities can be made using credit card or other online banking solutions, buyers and sellers do not usually get to meet each other, much less know each other. Now the lacking of trust becomes the bottleneck of E-commerce. In this case, trustworthiness of a seller is the main concern.

Trust can help people make decisions, while reputation is an expression of trust in social groups. In network community, as the virtual identity of the participants, the traditional trust and reputation systems are unable to build. However, computer network allows users to collects information widely, timely and process information accurately, providing trust and reputation conclusions to users to assist decision making. Reputation system evolves as a mechanism to build trust in virtual world.

In short, reputation system is an important block for achieving trust within large distributed communities, especially when mutually unknown agents engage in transactions.

1.2 Problem Statement

E-commerce system is one of the most widely employed web application in the world nowadays.

However, when a trade involves two people without background information, the issue of sellers' reliability is a main concern. The possibility of fraudulent attempts and scams is a big drawback that challenges an e-commerce system. The number of criticisms about net cheating or mistrust behaviors in electronic trade from customers is increasing, especially in recent years, such as the delivery delay; the quality of commodities that customers brought are bad or is not the same as merchants said in the Internet; many merchants refuse to take the responsibility of the commodities after selling, the after-service is unable to be guaranteed. More and more disharmony phenomenon appears when doing business in the Internet. The main reason is the trust problem.

To cope this problem, there are many reputation is build and apply in e-commerce systems. At present, many C2C E-commerce web sites such as Taobao and eBay have built their own online reputation systems. Unfortunately, these online

systems often just accumulate the number of three kinds of evaluation feedback, good, medium and bad. These credit evaluation methods are not very reliable and exact.

To improve the simple method of accumulating the number of good, medium and bad, we can reference more reliable and rational methodology to trust evaluation in C2C E-commerce. And more factors associated with trust should be paid attention.

This paper analyzes the criteria of a good reputation system and the existing system. And according to that, a new method is established based on fuzzy logic to provide reliable reputation score. The method involves with the factors that were often ignored before.

1.3 Objectives

The objectives of this project are as below:

i. To create a user reputation system
ii. To apply fuzzy logic in the computation algorithm for the reputation system
iii. To implement the reputation system in an e-commerce system

1.4 Scope

The target users of the Reputation System for an e-commerce system using fuzzy the reputation system is including all registered users with recorded trade history.

1.5 Thesis Organization

This thesis consists of 6 chapters. Chapter one, introduction gives an overview about the system. It consists of five sub topics which are introduction, problem statement, objective, scope, and thesis organization. Chapter two is explaining about the reviews for the system. Other related researches that had been conducted by other will

be reviewed and explained. Technique or technology that can be used will also be discussed in this chapter. The approach, method used and their justification will be discussed in chapter 3, methodology. There are 4 elements in this chapter, which are introduction, project planning, model usage/ approach and also project requirement. Chapter 4 will discuss detail about implementation. The result and the discussion will be described briefly in chapter 5. This thesis will be ended by the chapter 6, which is conclusion of the whole system.

CHAPTER 2

LITERATURE REVIEW

This chapter briefly describes the review on existing techniques related with reputation system for e-commerce system. This chapter comprises of two sections: the first section describes the comprehensive review on existing related systems; the second section describes the review on method, equipment, and technology previously used in the same domain.

2.1 Reputation System

2.1.1 What is a Reputation System

On internet, everyone is anonymous to each other and online service provision commonly takes place between parties who have never transacted with each other before, in an environment where the service consumer often has insufficient information about the service provider and about the goods and services offered. This forces the consumer to accept the risk of prior performance. In this case, reputation systems represent a significant trend in decision support for Internet mediated service provision.

According to Wikipedia (2011), a reputation system computes and publishes reputation scores for a set of objects (e.g. service providers, services, goods or entities) within a community or domain, based on a collection of opinions that other entities hold about the objects. The opinions are typically passed as ratings to a reputation center

which uses a specific reputation algorithm to dynamically compute the reputation scores based on the received ratings.

The basic idea of reputation system is that to solve information asymmetry of provider and consumer. Even if the consumer cannot try the product or service in advance, he can be confident that it will be what he expects as long as he trusts the seller. A trusted seller therefore has a significant advantage in case the product quality cannot be verified in advance (AudunJøsang et.al, 2006).

From the above definition of reputation system, we can conclude that there are two vital elements for a reputation system which are the criteria and the reputation algorithm used to compute the reputation score.

2.1.2 Criteria for a Good Reputation System

This section will discuss about the set of objects mentioned before or in other words, service quality factor. To identify the best set and design a reliable reputation system, criteria for a good reputation system will also be discussed. A few researchers have researched on the critical criteria and their findings are discussed below.

Wang and Huarng (2002) identified nine service quality factors including:

(i) general feedback of the website design,
(ii) competitive price of product,
(iii) merchandise availability,
(iv) merchandise condition,
(v) on time delivery,
(vi) merchandise return policy,
(vii) customer support,
(viii) e-mail confirmation on customer order, and
(ix) promotion activities.

Besides, e-service quality is also defined as seven dimensions that form two scales: a care e-SQ scale and a recovery scale (Zeithaml, 2002). Core e-SQ consists of four dimensions which are efficiency, reliability, fulfillment and privacy.

Efficiency refers to the ability of the customer to get to the web site, find their desired product and information associates with it and to check it out with minimal effort. Fulfillment incorporates accuracy of the service promises, having products in stock and delivering the product within the promised time. Reliability is associated with the technical functioning of the site, particularly the extent to which it is available and functioning properly. The privacy dimension includes assurances that shopping behaviour data are not shared and the credit card information is securely held.

The recovery- SQ scales includes responsiveness, compensation and contact. Responsiveness measures the ability of a company to provide appropriate information to customers when a problem occurs, a mechanism for handling returns, and an arrangement for online guarantees. Compensation is the dimension that involves receiving money back, return shipping and handling. Contact points to the need of customers to be speak to a live customer service agent online or through the phone.

On the other hand, Allen and Appelcline investigated several reputation systems and summarized six main criteria for a good reputation system.

Firstly, the rating system should be granular. Statistics show that people tend to ignore the lower part of the scale of rating systems. Consequently, the decimal places of mean feedback scores are of decisive importance. The rounding of mean scores or the simplification of ratings to a “thumbs up” or “thumbs down” would be the wrong strategy. For example, a 5-scale rating that allows half-points (e.g. 0.5, 1.0, 1.5, ..., 5.0) gives the user more options for expressing their ratings compared to the one without half-points (e.g. 1, 2, 3, 4, and 5) (Dominikus, Rafael, Fabian, Eelco, Jan, 2011).

Secondly, the consistent rating performed by the user. If a user expresses the same opinion in two different rating processes with two distinct ratings, the feedback statistic is influenced. For example, we cannot look at two items, see that one is a "2" and another is an "4", and truly believe that the user likes the "4" more than the "2" (Dominikus, Rafael, Fabian, Eelco, Jan, 2011). Therefore, the criteria of the ratings have to be distinct in order to help the users to stay consistent and give more meaningful ratings. The following is an example of distinct rating systems with 5-scale rating for a game (Dominikus, Rafael, Fabian, Eelco, Jan, 2011).

5 – Excellent game. Always want to play.

4 – Good game. I like to play.

3 – Average game, slightly boring, take it or leave it.

2 – Bad game, likely won't play this again although could be convinced.

1 – Extremely annoying game, won't play this ever again

Thirdly, rating systems must be statistically reliable. The best way to realize this is to collect a large number of ratings. If there are only a few unique ratings for an object, the risk of an unreliable overall rating increases. The more ratings are performed for an object, the smaller the effect of outliers (extreme values) is.

Allen and Appelcline also stated that rating systems also should not be bilateral (involving both sides). If users rate each other, there is a high risk that there are almost only positive ratings. The reason for this effect is that users are afraid of getting a negative rating in revenge for a negative feedback.

Fifthly, user ratings should have a concrete usage within a web site. A possible way to achieve this is to display rankings, in which the best and the worst rated users can be investigated.

The last criteria is that a clear user interface is essential for a rating system because badly designed and confusing graphical user interfaces (GUI) discourage users and have a negative effect on the quality of the ratings.

2.1.3 Computation Technique of Reputation System

As mentioned, a reputation system computes and publishes reputation scores. A computation technique is needed to compute the score. After receiving rating from a rater, the user's current rating score is calculated using certain mathematical formula. Currently, the widely used method is simple summation method. The simplest form of computing reputation scores is simply to sum the number of positive ratings and negative ratings separately, and to keep a total score as the positive score minus the negative score (AudunJøsang, Roslan Ismail, Colin Boyd, 2006). This method is practiced by two major C2C e-commerce site, eBay.com and taobao.com which will be explained in section 2.2.

2.2 Existing Systems

2.2.1 eBay's Feedback System

eBay is a popular auction site that allows sellers to list items for sale, and buyers to bid for those items. The current feedback system used by eBay was created in February 1996 by eBay founder Pierre Omidyar. The Feedback Forum is on open forum for both complaint and praise of members that others have dealt with. When someone purchases or sells an item they can leave feedback for the member they traded with (Joseph, Marie, 2007).

The three ratings that can be left are positive, neutral, and negative. These ratings are then translated into a score for each member. eBay collects all the ratings and computes the scores. The running total reputation score of each participant is the sum of positive ratings (from unique users) minus the sum of negative ratings (from unique users). In order to provide information about a participant's more recent behavior, the total of positive, negative and neutral ratings for the three different time windows i) past

six months, ii) past month, and iii) past 7 days are also displayed (AudunJosang, Roslan Ismail and Colin Boyd).

Before 2007, eBay's reputation system had a lot of weaknesses. It only supports the three choices of positive, neutral and negative feedback as shown in Figure 2.1 below. There were no clear guidelines to what kind of user behavior should result in which rating and the rating system basically have no use because there is no way to exclude users with a low rating score from auctions (Dominikus Heckmann, Rafael Math, Fabian Abel, Eelco Herder, Jan Hidders, 2011).

There were many empirical studies of eBay's reputation system indicating shortcomings in the old system. In general, the observed ratings on eBay were surprisingly positive. Buyers provide ratings about sellers 51.7% of the time, and sellers provide ratings about buyers 60.6% of the time. Of all ratings provided, less than 1% is negative, less than 0.5% is neutral and about 99% is positive. It was also found that there is a high correlation between buyer and seller ratings, suggesting that there is a degree of reciprocation of positive ratings and retaliation of negative ratings (P. Resnick and R. Zeckhauser). In other words, buyers and sellers tend to help each other by giving positive ratings regardless of quality of the trade.

According to Dominikus, Rafael, Fabian, Eelco, Jan (2011) in May 2007, eBay introduced a new version of rating system. The rating system makes it possible to rate additional aspects of a transaction rather than only providing the three categories positive, neutral and negative. There are now four components in the new rating system which has highly increased the transparency of the auction platform. The four components are:

(i) Was the item delivered as described?
(ii) How was the communication with the seller?
(iii) How long was the shipping time?
(iv) Were the shipping and handling charges satisfactory?

Using the new five-star rating system, users can give detailed statements within these additional rating dimensions. The mean value of these rating categories is shown in the user profile, among the standard feedback score.

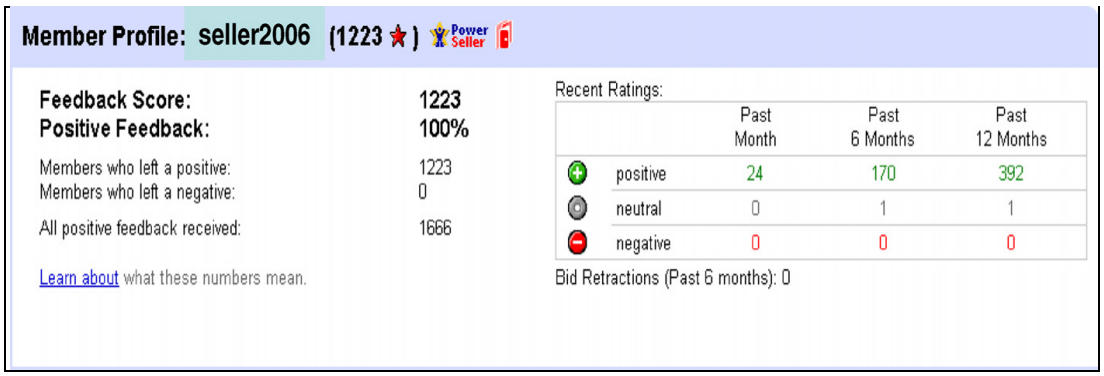


Figure 2.1: eBay's Reputation Forum

(eBay, 1/1/2004)

Figure 2.2: eBay's Member Profile

(eBay, 11/2/2011)

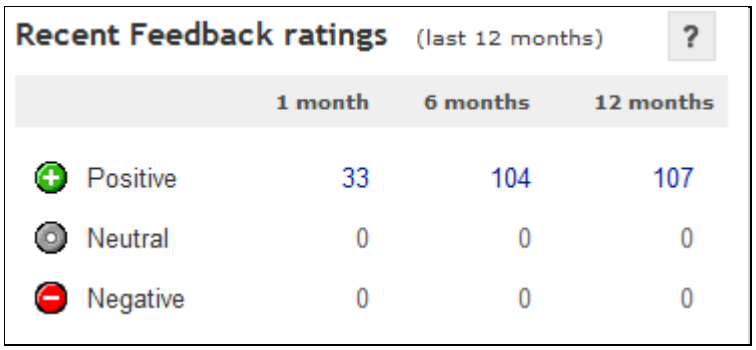
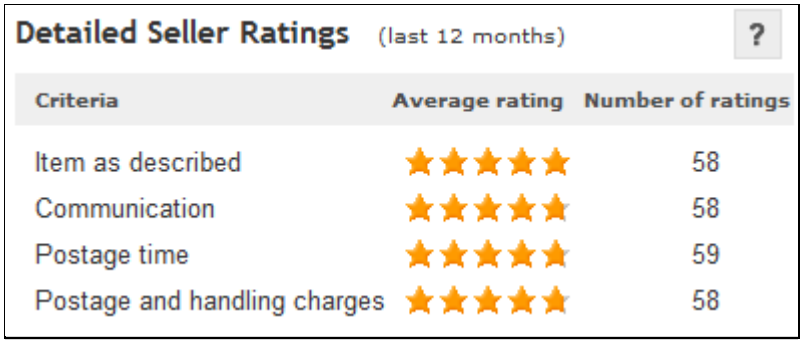


Figure 2.3: Recent Feedback Ratings (eBay, 2011)



Detailed Seller Ratings (last 12 months) ?

Criteria	Average rating	Number of ratings
Item as described	★★★★★	58
Communication	★★★★★	58
Postage time	★★★★★	59
Postage and handling charges	★★★★★	58

Figure 2.4: Detailed Seller Ratings (eBay, 2011)

Here's what the different stars mean:

Yellow star ( ) = 10 to 49 ratings

Blue star ( ) = 50 to 99 ratings

Turquoise star ( ) = 100 to 499 ratings

Purple star ( ) = 500 to 999 ratings

Red star ( ) = 1,000 to 4,999 ratings

Green star ( ) = 5,000 to 9,999 ratings

Yellow shooting star ( ) = 10,000 to 24,999 ratings

Turquoise shooting star ( ) = 25,000 to 49,999 ratings

Purple shooting star ( ) = 50,000 to 99,999 ratings

Red shooting star ( ) = 100,000 to 499,000 ratings

Green shooting star ( ) = 500,000 to 999,999 ratings

Silver shooting star ( ) = 1,000,000 ratings or more

Figure 2.5: Explanation of Ratings (eBay, 2011)

Figure	Explanation
Figure 2.1:	Shows the old rating system with only three types of rating, without additional supporting rating aspects.
Figure 2.2: Member Profile	Shows the percentage of positive ratings received in the last 12 months. 1 point is raised or lowered depending on the overall rating from the same buyer within one week. (E.g. Buyer A buy 2 items in same week, Feedback on seller B is raised by 1)
Figure 2.3: Recent Feedback Ratings	Shows the total number of positive, neutral and negative feedback ratings received in the last 1, 6, and 12 month(s).
Figure 2.4: Detailed Seller Ratings	Shows additional rating for this member's performance as a seller. Five stars is the highest rating, and one star is the lowest. These ratings do not count toward the overall Feedback score and they are anonymous. That means that sellers can't trace detailed seller ratings back to the buyer who left them. Detailed seller ratings from the same buyer are counted in the same way as Feedback. Only one every week is included in the seller's score.
Figure 2.5: Explanation of Ratings	Explains the meaning of different 'stars' beside the username on Member's Profile page.

Table 2.1: Explanations of eBay User Rating Pages

2.2.2 Taobao's Buyer & Seller Creditability System

Taobao.com is one of the largest online shopping websites in China (http://www.taobao.com/about/intro.php). Two major retailing mechanisms exist in Taobao, including Taobao Mall listing brand owners and authorized distributors(Business-to-Consumer, B2C) and Taobao Marketplace where users posts new or used goods for sale. Its online feedback system is similar to the online feedback systems of Amazon and eBay.

Before participating in e-commerce at Taobao, a user's registration needs to pass the Identity Authentication System by providing identity information, including name and contact information. Sellers are required to provide their personal information such as identify number, bank account to the Taobao for approval. Valid email address and payment method are required for buyers. Service Center of national citizen's ID number querying, a department of The Ministry of Public Security, assists Taobaoto check members' registration information, in order to keep away from internet deception.

Buyers and sellers can leave comments about each other after transactions,but this is optional.Each comment consists of one line of text, plus a numeric rating of +1 (positive), 0 (neutral), or -1 (negative). All feedback had to be tied to a transaction: i.e., only the seller and buyer can leave feedback about each otherafter one transaction. Moreover, if some of the buyers forget to give feedbacks, the system will automatically choose "Good". The same way works on sellers.

When posting reviews for a transaction at Taobao, consumers are asked to write a paragraph describing their experiences and rationale for their ratings. Based on the different consumer postings, Taobao gives an average customer rating for each shop. The customer overall ratings of item description, service attitude and delivery speed are averaged and reported in each seller's profile.

Figure 2.6: Seller's Information (Taobao, 2012)

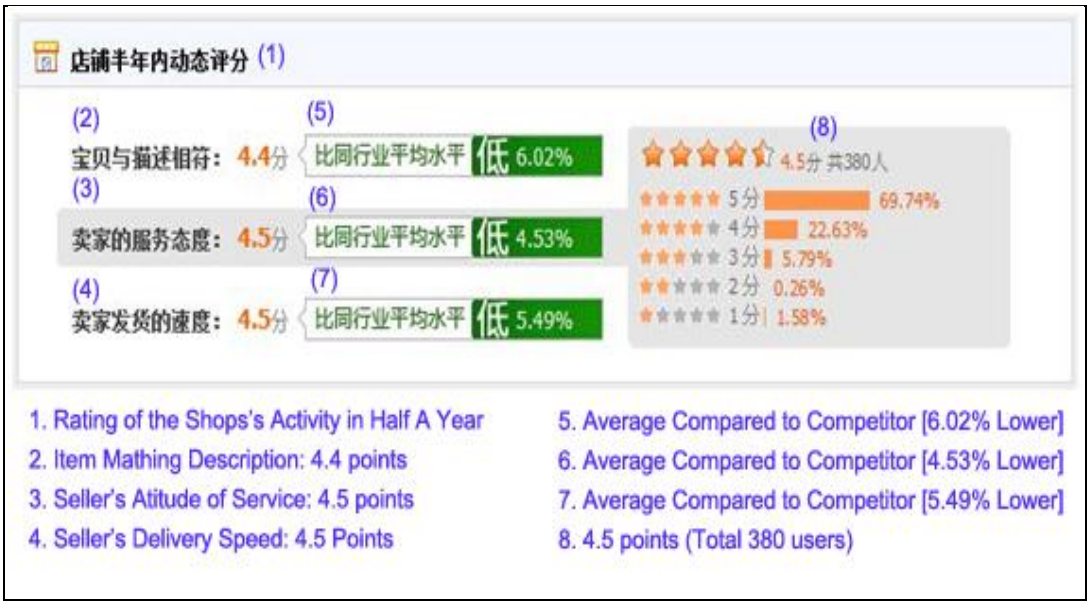


Figure 2.7: Performance of Shop in 6 Months (Taobao, 2012)

Figure 2.7 shows the performance of the shop based on 1. Was the item delivered as described? 2. How would you rate the communication with the seller? 3. How long took the shipping time?

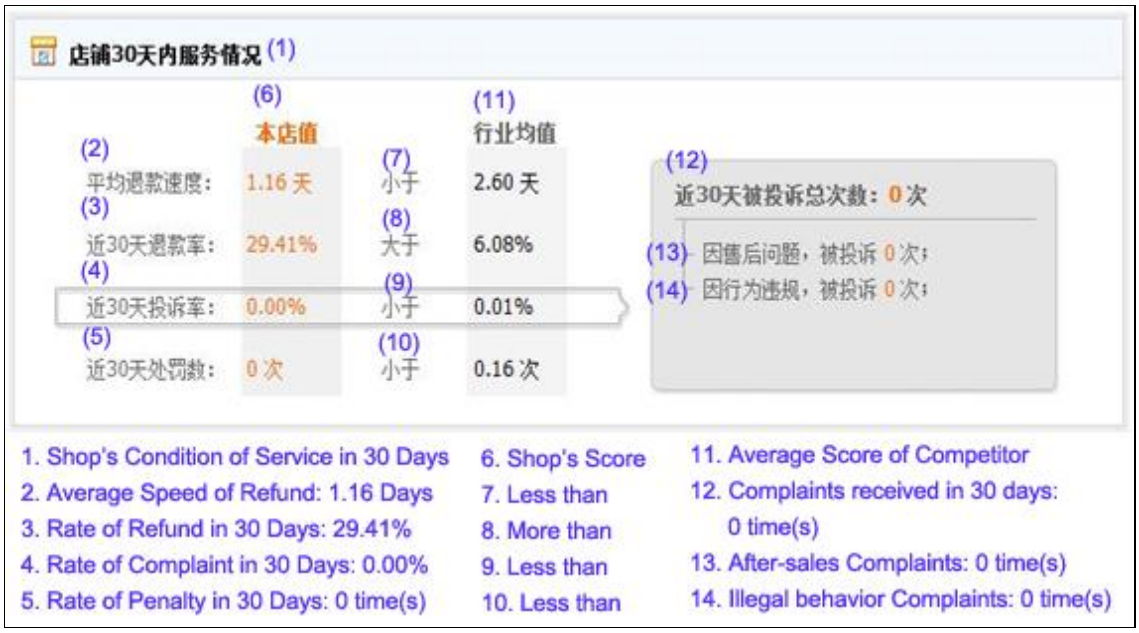


Figure 2.8: Service Condition of Shop in 30 Days (Taobao, 2012)

Figure 2.8 shows the situation of the shop based on 1. Speed of refund 2. Recent 30 days refund rate 3. Recent 30 days complain rate 4. Recent 30 days compound unit.

Figure 2.9: Seller Reputation Table (Taobao, 2012)

Figure 2.10: Seller's Reputation Computation (Taobao, 2012)

Number of Transactions	Rating	Description
4-10		Junior vendor very risky deprecated
11-40		
41-90		
91-150		
151-250		
251-500		Advanced vendor risky
501-1000		
1001-2000		Advanced vendor recommended
2001-5000		
5001-10000		
10001-20000		Senior vendor reliable
20001-50000		
50001-100000		Large vendor top 1000 of 2 million highly reliable
100001-200000		
200001-500000		
500001-1000000		Very Large vendor top 100 of 2 millions highly reliable
1000001-2000000		
2000001-5000000		
5000001-10000000		No vendor reaches this level until now
>10000000		

Figure 2.11: Scheme of Sellers' Ratings (Taobao.com, 2010)

2.2.3 Comparison Between eBay & Taobao

	eBay	Taobao
Rating Criteria	1. Was the item delivered as described? 2. How would you rate the communication with the seller? 3. How long took the shipping time? 4. Were the shipping and handling charges adequate?	1. Was the item delivered as described? 2. How would you rate the communication with the seller? 3. How long took the shipping time?
Reputation degree	One degree	Two degree – display one's reputation profile as a seller and as a buyer respectively.
Computation technique	Simple summation - sum of positive ratings minus the sum of negative ratings.	Simple summation – sum of positive ratings / sum of ratings * 100

Table 2.2: Comparison between eBay and TaoBao's Reputation System

2.3 Techniques/Methods

2.3.1 Fuzzy Logic

The application of fuzzy logic is expected to increase the reliability of rating and it is useful in manipulating imprecise of uncertain information. It does so by considering multiple factors to calculate the feedback in this user reputation system. Besides, it may solve the problem like unfair rating in current reputation system. Fuzzy logic consists of four steps: Fuzzification, Rule evaluation, Aggregation, and Defuzzification.

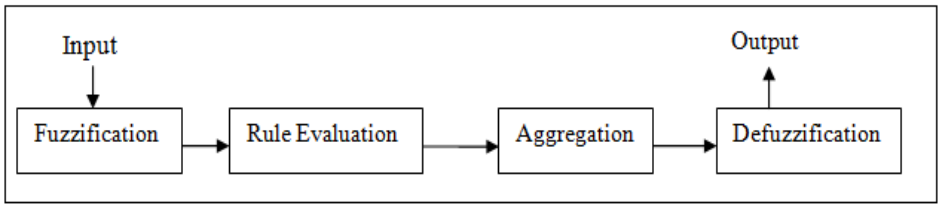


Figure 2.12: Fuzzy Inference Model

i. Fuzzification

Fuzzification is the first step in which the inputs are taken and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions. The input variables are first fuzzified by using membership functions. We determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions.

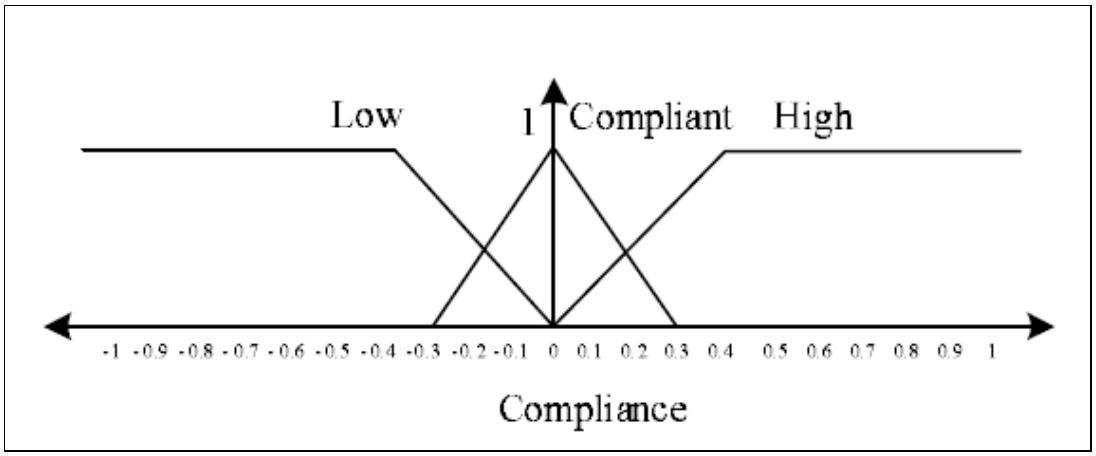


Figure 2.13: Input Membership Function

ii. Rule Evaluation

Once the inputs are fuzzified, we apply the fuzzy rule base to arrive at the fuzzy output. Fuzzy Inference Rule Base comprises many Fuzzy Rules (AnsumanMahapatra, NachiketaTarasia,Anuja Ajay and Soumya Ray, 2011).

Fuzzy inference rules are defined for relating inputs to the outputs. In this case, fuzzy inference rules relate the compliance values in different attributes to an estimated rating value. Rules are defined on the notion that if a service/ provider perform well in all or most of the attributes, it should be given a high rating and vice-versa. Figure 2.3 presents unbiased fuzzy inference rules for 3 level “compliance” inputs and 4 level “rating” outputs.

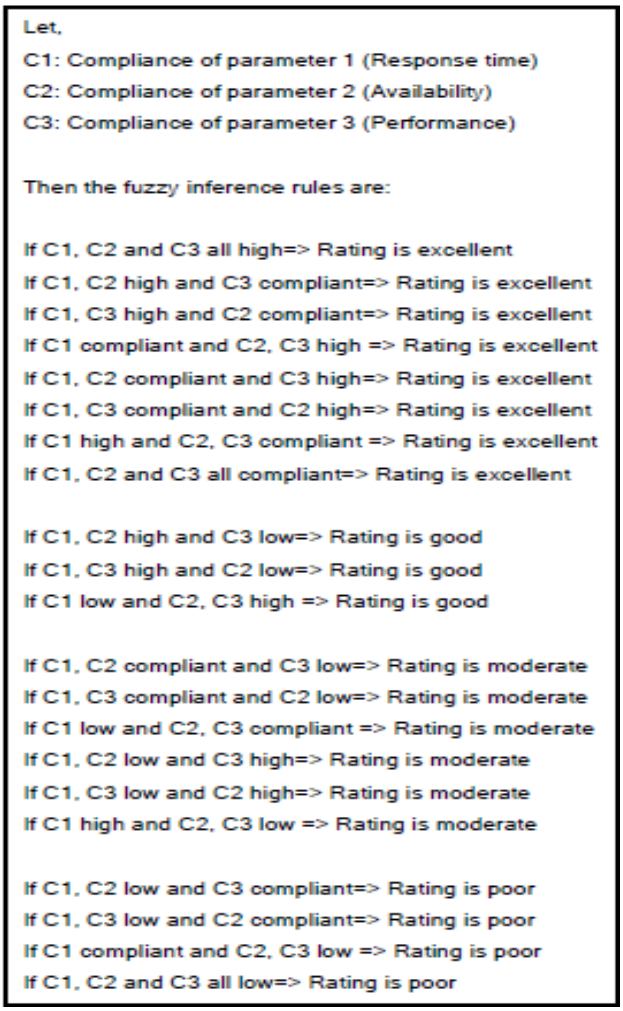


Figure 2.14: Fuzzy Inference Rules

iii. *Aggregation*

Fuzzy Inference Engine is Mamdani-type fuzzy inference system. This method is the most commonly seen fuzzy methodology. Mamdani's method was among the first control systems built using fuzzy set theory. Mamdani-type inference, expects the output membership functions to be fuzzy sets. After the aggregation process, there is a fuzzy set for each output variable that needs defuzzification.

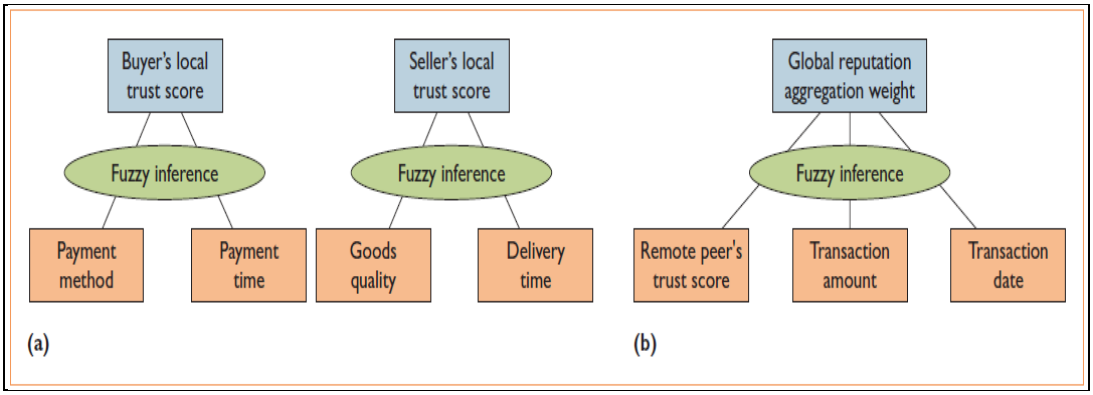


Figure 2.15: Local Trust Inference versus Global Reputation Aggregation

The FuzzyTrust system (a) performs fuzzy logic inferences to determine the local trust scores and (b) uses accumulated local scores for weight inference in global reputation aggregation (Trusted P2P Transactions with Fuzzy Reputation Aggregation, 2006)

The global reputation is calculated using the following formula:

$$R_i = \sum_{j \in S} \left(\frac{w_j}{\sum_{j \in S} w_j} t_{ji} \right) = \frac{\sum_{j \in S} w_j t_{ji}}{\sum_{j \in S} w_j},$$

Where R_i is the global reputation of peer i, S is the set of peers with whom peer i has conducted transactions, t_{ji} is the local trust score of peer i rated by peer j, and w_j is the aggregation weight of t_{ji}. The global aggregation process runs multiple iterations until each R_i converges to a stable global reputation rating for peer i.

iv. *Defuzzification*

From the fuzzy output, we use center of gravity defuzzification to arrive at the crisp output which is our required reputation value. Defuzzification is the reverse process of fuzzification.

Trust and Reputation we have gotten above is a "fuzzy" result, that is, the result is described in terms of membership in fuzzy sets. Defuzzification would transform this result into a single number indicating the trust level of an entity. A variety of methods are available for this. Two of the most widely used are:

Center of Gravity (CoG): The weighted average of the output membership function.

Mean of Maximum (MoM): The mean of the highest points of the output membership function.

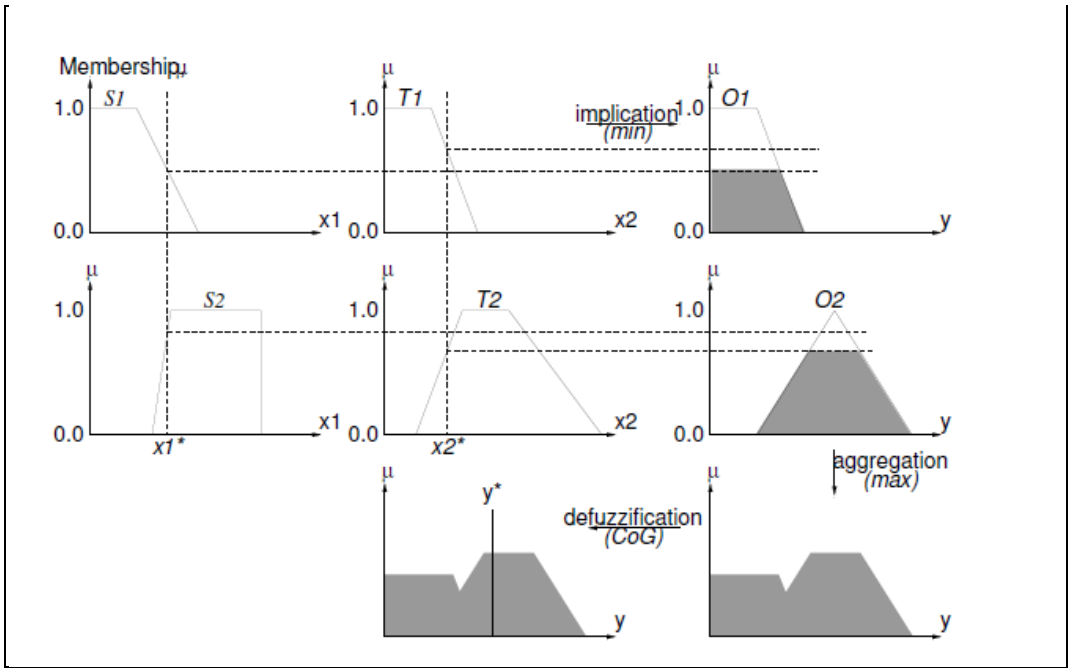


Figure 2.16: Fuzzy Inference and Defuzzification

2.3.2 Bayesian System

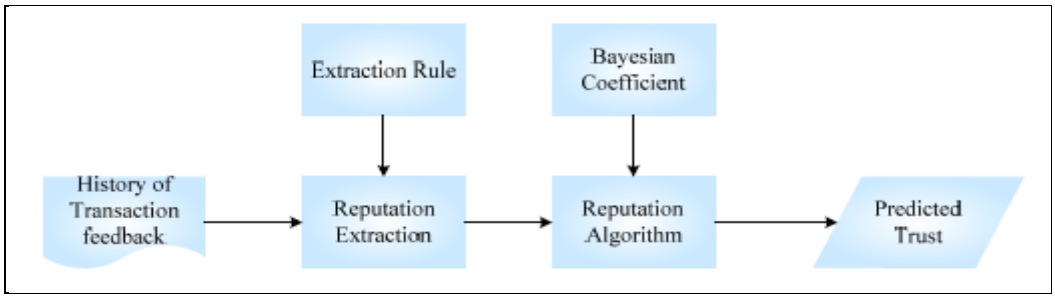


Figure 2.17: Proposed Bayesian Reputation Management System

The proposed reputation system uses Bayesian theory to analyze the probability distribution of the predicted valued given by RMS and makes suitable adjustment. It is one of the most successful mechanisms in terms of accuracy. This model gets a posteriori (i.e. the updated) reputation from the computing of combining the priori (i.e. previous) reputation with the new ratings. To use the Bayesian reputation systems, we need to get enough training data to get the prior knowledge.

This system applies a nearest neighbor-like scheme to predict a user's ratings based on the ratings given by like-mined users. We use $r_{i,j}$ to represent user i 's rating on service provider j . SP_i is used to represent the set of service providers on which user i has given ratings. The mean rating for user i is defined as:

$$\bar{r}_i = \frac{1}{|SP_i|} \sum_{j \in SP_i} r_{i,j} \qquad (1)$$

We use p_a, j to represent the predicted rating value given by the active user (indicated with a subscript a) on service provider j . Using RMS, $p_{a,j}$ is calculated as:

$$p_{a,j} = \bar{r}_a + k \sum_{i=1}^{n} w(a,i)(r_{i,j} - \bar{r}_i) \qquad (2)$$

Where $w(a, i)$ is the weight which reflect distance, correlation, or similarity between each user i and the active user a ; n is number of users who gave rating on service provider j ; k is the normalizing factor such that the absolute values of $w(a, i)$ sum to

unity. Pearson Correlation Coefficient is one of the most effective methods to calculate $w(a, i)$. Using Pearson Correlation Coefficient:

$$w(a,i) = \frac{\sum_q (r_{a,q} - \overline{r_a})(r_{i,q} - \overline{r_i})}{\sqrt{\sum_q (r_{a,q} - \overline{r_a})^2 \sum_q (r_{i,q} - \overline{r_i})^2}} \quad (3)$$

Where $q = SP_a \cap SP_i$.

Example:

In this example, we randomly choose 100 ratings to act as test dataset, the left ratings on 318 different movies are used as training dataset. That is, for training dataset, SP_i =318; for test dataset SP_i =100. Thus we get two vectors, training dataset *TR* and test dataset *TS* , with length of 100 and 318 respectively.

In this experiment, we calculate $P_{a,j}$ for *TR*, and compare $P_{a,j}$ with the real rating values in *TR* given by active user. The comparison results are used as the prior probability. Formula (4) gives the well-known Bayesian theorem:

$$P(H|E) = \frac{P(E|H)P(H)}{P(E)} \quad (4)$$

where $P(H\ E)$ is the posteriori probability, which is a measure of belief about a hypothesis H updated in response to evidence E ; $P(E\ H)$ is the conditional probability, which is the probability of E given H ; $P(H)$ is the prior probability, which is the belief about H in absence of evidence; $P(E)$ is the probability of E .

By using the Bayesian theorem, we give the prediction mechanism of BMRS based on the conventional MRS as follows:

1. Calculate $p_{a,j}$ for *TR* and compare with *TR* to get the prior knowledge.
   (1) Calculate *PR* , which is used to represent the vector of *pa, j* for *TR* , use formula (2).
   (2) Analyze *PR* and divide the interval of *pa, j* into *m* suitable categories.

$$Cat_{a,j} = f(p_{a,j}) \qquad (5)$$

where $Cat_{a,j}$ is the category of $P_{a,j}$. $Cat_{a,j}$ is a function of $P_{a,j}$, and there are totally m categories for PR. $P_{a,j} \in PR$. The function f is decided by the analysis of the probability distribution of $p_{a,j}$

(3) Calculate the probability of each divided category (i.e. $P(Cat_{a,j})$) by analyzing PR based on formula (5).

(4) Calculate the probability of each possible rating value i.e. $P(TrueValue = i)$. For EachMovie Dataset, $i \in [0, 0.2, 0.4, 0.6, 0.8, 1]$. Since we amplify the ratings as shown in Tab.1, $i \in [1, 2, 3, 4, 5, 6]$ in our paper.

(5) Calculate the conditional probability $P(Cat_{a,j} \mid TrueValue = i)$, i.e. the probability of each category given the real predicted value equals to i. This is based on the comparison of PR, TR and the calculation of formula (5).

2. For TS, calculate posteriori probability for each $p_{a,j} \in P$.

(1) Calculate P using formula (2).

(2) Map each $p_{a,j} \in P$ into a category using formula (5).

(3) Using formula (6), calculate the posteriori probability $P(TrueValue = i \mid Cat_{a,j})$.

$$P(TrueValue = i \mid Cat_{a,j}) \qquad (6)$$
$$= \frac{P(Cat_{a,j} \mid TrueValue = i) P(TrueValue = i)}{P(Cat_{a,j})}$$

The calculation of the right side of formula (6) is based on the prior knowledge gotten in step 1.

3. Give the predicted value for each item $j \hat{I} TS$ using formula (7).

$$p^{B}_{a,j} = \sum_{i=1}^{n} P(TrueValue = i \mid Cat_{a,j}) * i \qquad (7)$$

where $P^{B}_{a,j}$ is the predicted value for active user a on item j ; i is the possible real rating value; n is total number of i .

2.3.3 Comparison Between Fuzzy and Bayesian

Fuzzy Approach	Bayesian Approach
Define fuzzy sets of expected results of a web service from different criteria.	Bayesian Theorem : $p(H\|E) = \frac{p(H\&E)}{P(E)}$
Use a web service's historical performance statistic	Use a web service's historical performance to predict the future performance
For each record of the history, compare it from each aspect with the defined result sets	Use the historical trust value of web service as the condition: a) A positive historical experience has a value of 1 b) A negative historical experience has a value of 0
Represented as linguistically fuzzy concepts, where membership functions describe to what degree an agent can be described as e.g trustworthy or not trustworthy.	Based on computing reputation scores by statistical updating of beta probability density functions (PDF).
Easy to understand by everyone, so they can confident with the reputation system when rate the seller.	Too complex for average persons to understand, users might have less confident to the reputation system.

Table 2.3: Comparison between Fuzzy and Bayesian

CHAPTER 3

METHODOLOGY

This chapter discusses about the implementation of fuzzy logic in the Reputation System.

3.1 Fuzzy Logic

Fuzzy logic is a kind of logic based on multiple values, it reasons approximately instead of exactly. It has been used to deal with the concept of partial truth, where the truth value may take any value between true and false. Moreover, when using linguistic variables, these degrees may be dealt with by certain functions.

This reasoning is designed to imitate human reasoning by allowing rough values and inferences, including incomplete or inexact data (fuzzy data) as compared to using purely crisp data (binary yes/no choices). It has the ability to deal with incomplete data and provide approximate solutions to problems that other methods may not be able to solve. Some examples of words used in fuzzy logic which are not found in other methods include: very tall, plummeting, somewhat lower, good enough and very low.

Fuzzy systems as a trust metrics can link natural language expressions with a meaningful numerical analysis. Application of fuzzy logic to trust has been studied in the context of peer to peer networks to improve peer rating. Also for grid computing, it has been demonstrated that fuzzy logic allows us to solve security issues in reliable and efficient manner.

3.2 Justification of the Chosen Method

E-commerce markets can increase their efficiency through the usage of intelligent agents which negotiate and execute contracts on behalf of their owners. The measurement and computation of trust to secure interactions between autonomous agents is crucial for the success of automated e-commerce markets.

The calculation and measurement of trust in unsupervised virtual communities like multi-agent environments involves complex aspects such as credibility rating for opinions delivered by peer agents, or the assessment of past experiences with the peer node one wishes to interact with. The deployment of suitable algorithms and models imitating human reasoning can help to solve these problems.

Fuzzy logic provides a natural framework to deal with uncertainty and the tolerance of imprecise data inputs to fuzzy-based systems makes fuzzy reasoning especially attractive for the subjective tasks of trust evaluation and credibility adjustment.

3.3 Steps of Fuzzy Logic

Firstly, we need to understand about the key concept of this system:

Calculation of Rating

Rater's Raw Rating Score (1-5) * Weight of Rating (0-1) = Rater's Final Rating Score (0-5)	Seller's Current Rating Score = (Old rating$_1$+ Old rating$_2$ + … + Rater's Final Rating Score)/ Number of Rating

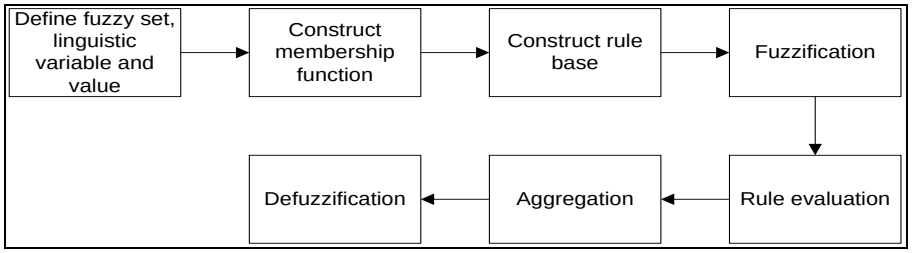


Figure 3.1: Fuzzy Inference Model

Step 1: Define fuzzy set, linguistic variable and value

Linguistic Variables:

i. Rater's Rating (r)

ii. Amount of Transaction (t)

iii. Interval Between Trades of Same Users (i)

Linguistic Variable	Linguistic Value	Notation	Numerical Range (unit)
Rater's Own Rating, r	Low	L	[0, 2]
	Average	A	[1, 4]
	High	H	[3, 5]

Table 3.1: Linguistic Variables of Rater's Own Rating

Linguistic Variable	Linguistic Value	Notation	Numerical Range (RM)
Amount of Transaction, t	Low	L	[1, 10]
	Average	A	[5, 50]
	High	H	[>40]

Table 3.2: Linguistic Variables of Amount of Transaction

Linguistic Variable	Linguistic Value	Notation	Numerical Range (Day)
Interval Between Trades of Same Users, i	Low	L	[0, 14]
	Average	A	[7, 21]
	High	H	[>14]

Table 3.3: Linguistic Variables of Interval between Trades of Same Users

Linguistic Variable	Linguistic Value	Notation	Numerical Range (Day)
Weight of Rating, w	Low	L	[0, 0.5]
	Average	A	[0.2, 0.8]
	High	H	[0.5, 1.0]

Table 3.4: Linguistic Variables of Weight of Rating

Step 2: Construct Membership Function

Membership function graphs are used to obtain the degree of membership in a particular linguistic variable from the crisp input. For example, it plots 100KG to 0.92 Heavy, meaning 100 kilogram is considered heavy.

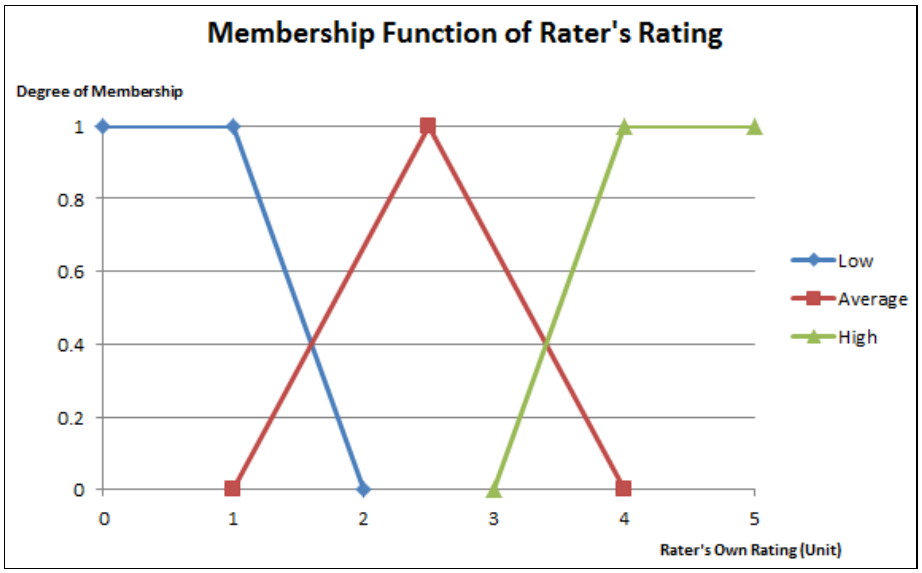


Figure 3.2: Membership Function of Rater's Rating

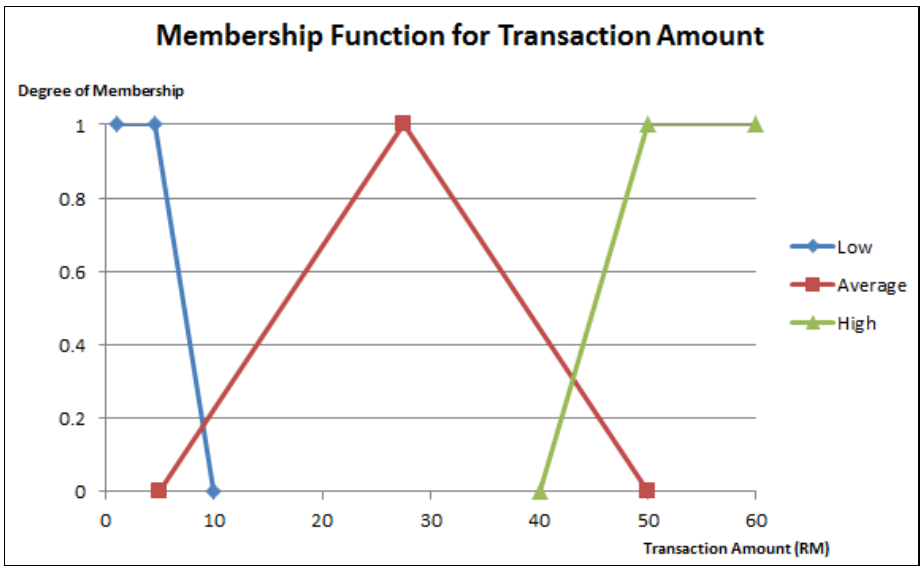


Figure 3.3: Membership Function of Transaction Amount

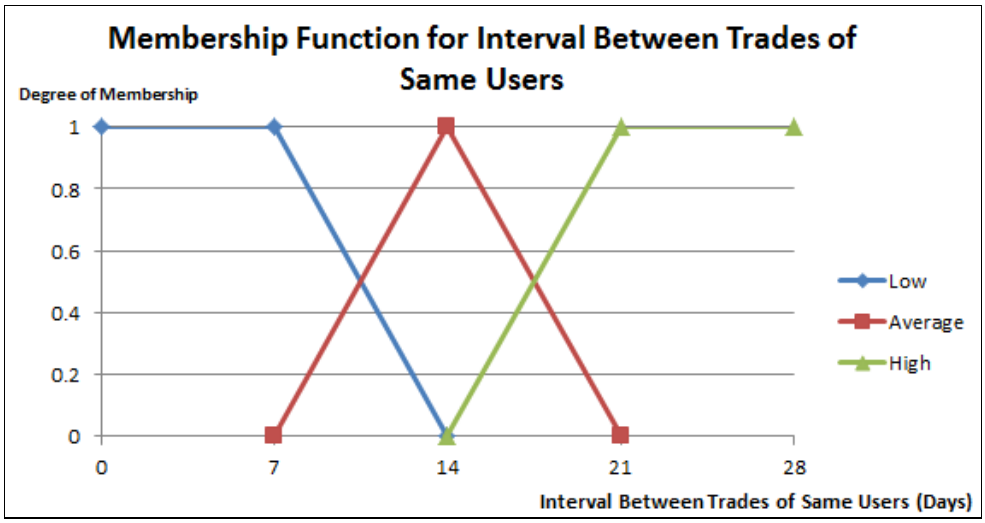


Figure 3.4: Membership Function for Interval between Trades of the Same Users

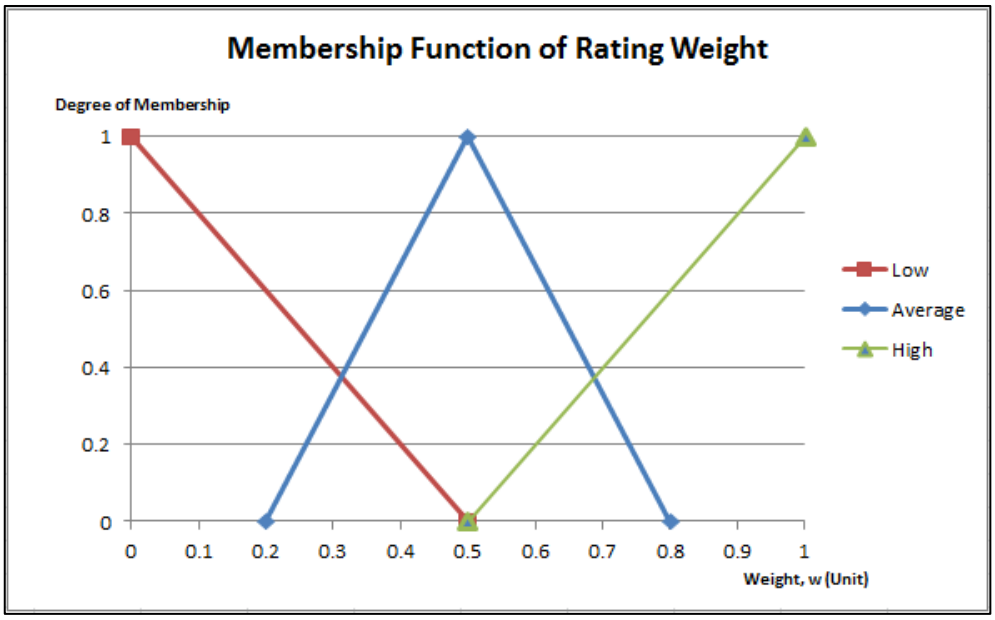


Figure 3.5: Membership Function of Rating Weight

Step 3: Construct fuzzy rule base

When the transaction factors in the transaction factor set have different transaction evaluation grades, we can set many different rules, so as to establish fuzzy logic inference rules library.

Let

r = Rater's Own Rating

t = Amount of Transaction

i = Interval between Trades of Same Users

w = Weight of Rating

L = Low, A = Average, H = High

For example,

1. If *r* is low OR *t* is low OR *i* is low, then *w* is low.
2. If *r* is average OR *t* is low OR *i* is low, then *w* is low.

Rule	*r*	*t*	*i*	*w*
1	L	L	L	L
2	A	L	L	L
3	H	L	L	L
4	L	A	L	L
5	A	A	L	A
6	H	A	L	A
7	L	H	L	A
8	A	H	L	H
9	H	H	L	H
10	L	L	A	L
11	A	L	A	L
12	H	L	A	A

13	L	A	A	A
14	A	A	A	A
15	H	A	A	A
16	L	H	A	A
17	A	H	A	H
18	H	H	A	H
19	L	L	H	L
20	A	L	H	L
21	H	L	H	A
22	L	A	H	A
23	A	A	H	A
24	H	A	H	H
25	L	H	H	H
26	A	H	H	H
27	H	H	H	H

Table 3.5: Fuzzy Rule Base

Step 4: Fuzzification

Fuzzification comprises the process of transforming crisp values into grades of membership for linguistic terms of fuzzy sets. The membership function is used to associate a grade to each linguistic term. The membership value can be got through the graph in step 2.

For example,

Rater's Own Rating, $r = 2$

(Degree of Membership for Average = 0.62)

Amount of Transaction, t = RM27.5

(Degree of Membership for Average = 1)

Interval between Trades of Same Users, i = 28 days
(Degree of Membership for High = 1)

Step 5: Rule Evaluation

This fuzzy model uses the fuzzy set operation "OR". The operator "OR" takes the higher value out of the variables. By using the example in step 4 and with the help of the graph,

max[r, t, i]
= max[0.62, 1, 1]
= 1

We find that r = Average, t= Average and i = High,
Rule 23 is fired,
Weight of Rating, w is average
(with Degree of Membership = 1)

Step 6: Aggregation

Because decisions are based on the testing of all of the rules, the rules must be combined in some manner in order to make a decision. Aggregation is the process by which the fuzzy sets that represent the outputs of each rule are combined into a single fuzzy set. Aggregation only occurs once for each output variable, just prior to the final step, defuzzification.

Step 7: Defuzziffication

After the aggregation step, the overall result is fuzzy value. So, we need to transform the fuzzy value we obtained in step 6 into a single numerical value. One of the most popular defuzzification methods is the centroid, which returns the center of the area under the fuzzy set obtained in step 6.

3.4 Design

Figure 3.6 shows the flowchart of the system. This system requires an e-commerce system as the pre-requisite. User can only rate the seller after the transaction is success. User need to login to use the reputation system. They shall input the transaction ID to verify the valid transaction. They will later prompt to input the ratings based on the criteria chosen and give some comments about the transaction. The new ratings will be computed using computation technique and then stored into database. New updated ratings and reports will be displayed in the profile of ratee.

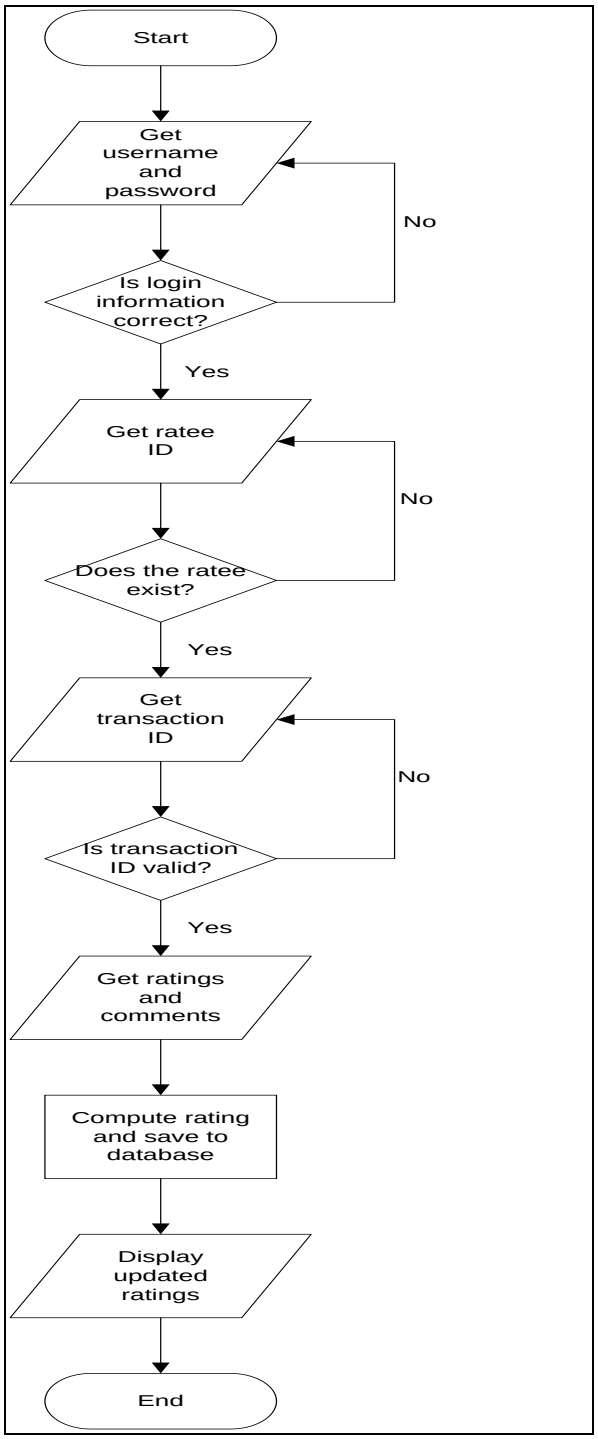


Figure 3.6: Flowchart of the System

CHAPTER 4

IMPLEMENTATION

This chapter discusses about the implementation of the project.

4.1 E-commerce System

One of the main deliverables of this project is the e-commerce system (Delphi) where users can register, sell and buy items. The main functions are shown below.

i. Registration

```
$registerQuery="INSERT INTO $table_name VALUES ('', '$username', '$cust_pwd',
'$first_name', '$last_name', CURDATE(), '$email' ,'$phone_no' ,'0' , '$address_main',
'$address_city' ,'$address_postcode' ,'$address_state')";
$result=mysql_query($registerQuery) or die("Registration failed.");
```

Figure 4.1: Coding to Register User into Database

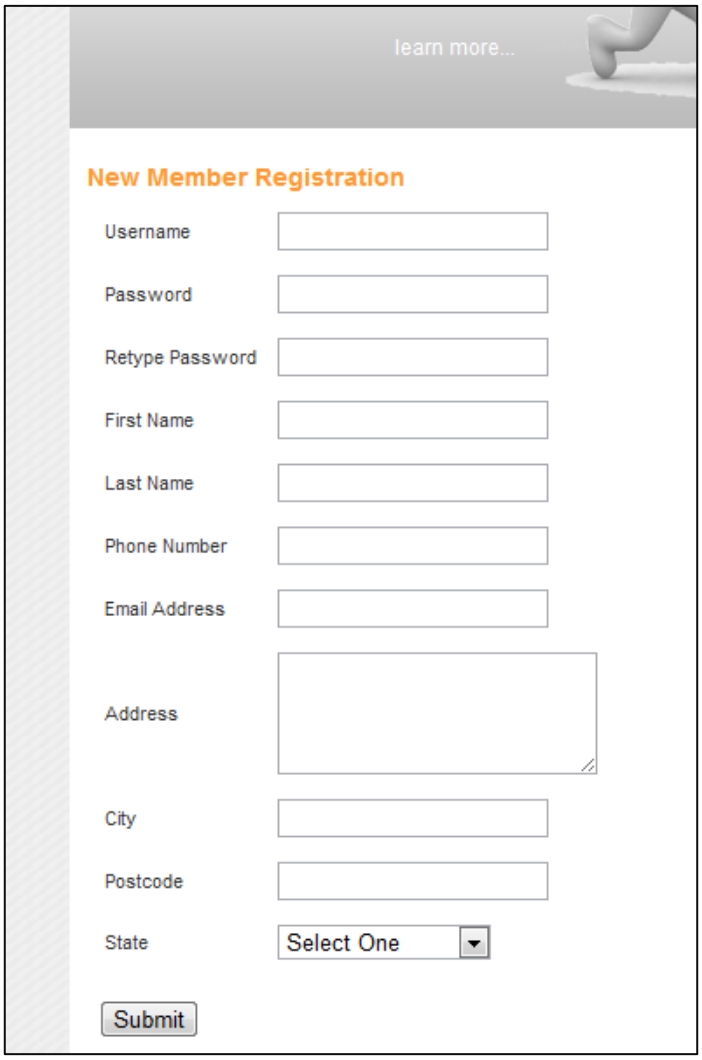


Figure 4.2: Interface of Registration

Once registered, the users may then login the account using the login box in any pages as shown below:

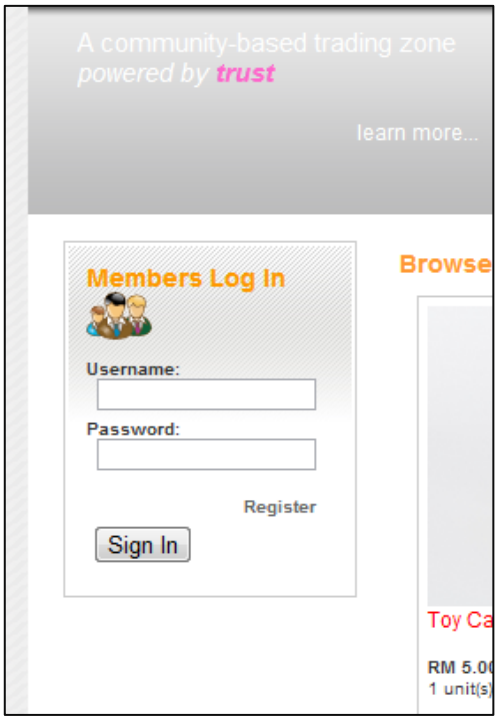


Figure 4.3: Login Box

Without logging in, user cannot sell or buy items. The item selling and buying module is shown as below.

ii. Selling Item

```
$sellItemQuery="INSERT INTO $table_name VALUES ('', '$itemname', '$ownerid', '$description',
'$quantity', '$quantity', '$price', '$categoryid', NOW(), '0',  '$itempicture1')";
$result=mysql_query($sellItemQuery) or die("Request failed.");
```

Figure 4.4: SQL Query to Save Items into Database

This will be the main source of input required by Delphi where users will list the items they wish to sell.

Figure 4.5: User Interface to Sell Item

iii. Buying

```
$itemname=$rowItem['itemname'];
if(strlen($itemname)>25){
    echo substr($itemname, 0, 25).'...</a>';
}else{
    echo $itemname.'</a>';
}

echo '<br /><br /><strong>RM '.$rowItem['price'].'</strong>';
echo '<br />'.$rowItem['quantityleft'].' unit(s) Available';
echo '</span>';

echo '<span class="picture_text_right">Added on <em>'.date_format(date_create($rowItem['timeadded']),

$categoryid=$rowItem['categoryid'];

$query2="SELECT sub_categoryname FROM $table_name2 WHERE sub_categoryid='$categoryid' LIMIT 1";
$result2=mysql_query($query2) or die(mysql_error());
$rowItem2=mysql_fetch_array($result2);
```

Figure 4.6: PHP Coding & SQL Query to Show All Item List

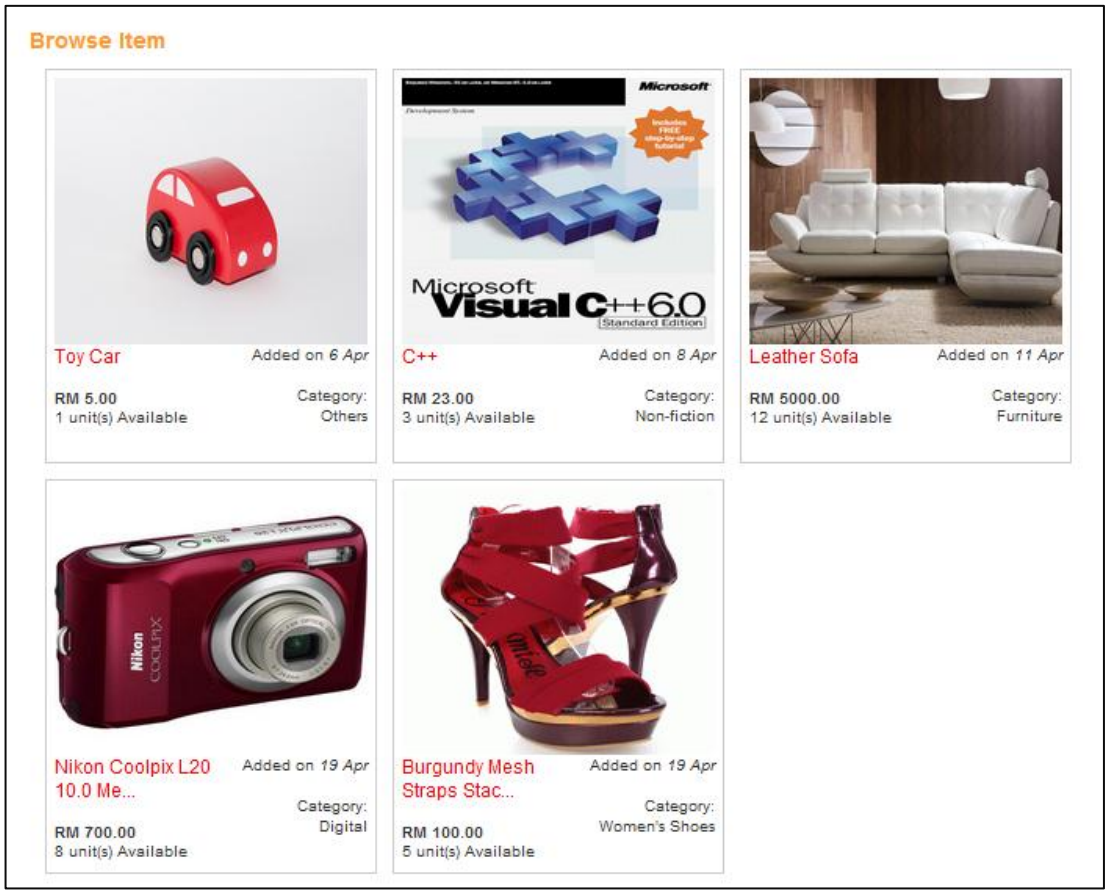


Figure 4.7: User Interface of Item List

In this interface, user can navigate to each item listed here by clicking on the image or item name. Then user will be directed to the individual page of that item as shown below.

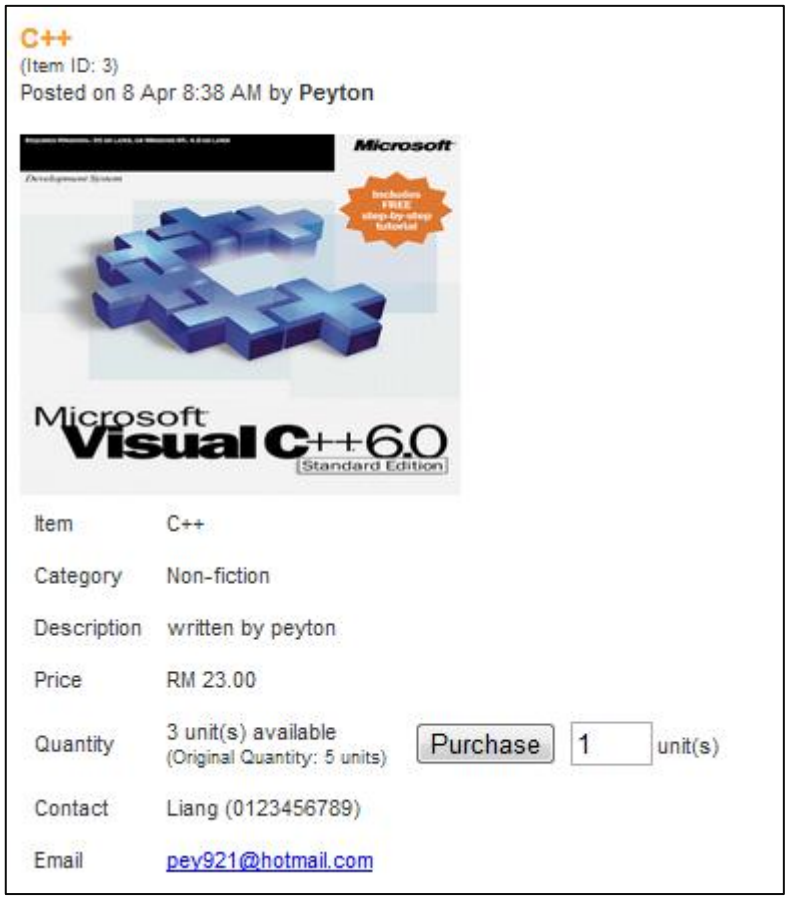


Figure 4.8: Single Item Page

This page can only be accessed by logged in users. By clicking on “Purchase” button and specifying a quantity no larger than the available units, user will be proceeding with the purchase of the item. Purchased item will no longer appear on the item list.

iv. Rate User

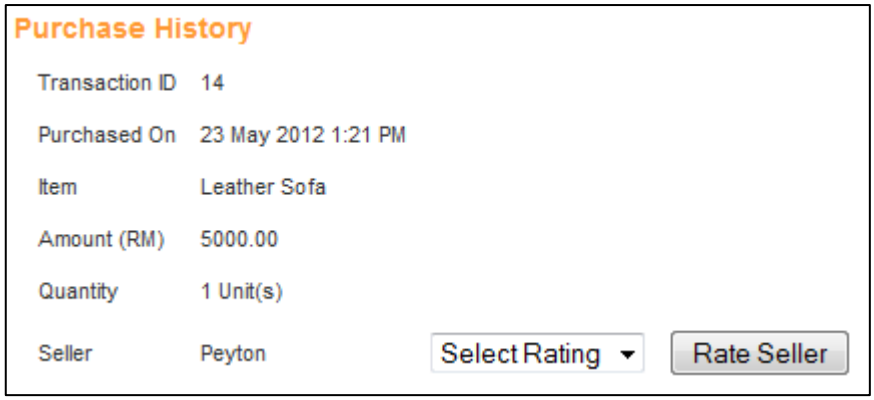


Figure 4.9: Rate User after Transaction

After a transaction, a buyer can browse to the transaction summary page and give rating to the seller by choosing the score and clicking the "Rate Seller" button. This can only be done if the user is the buyer in this transaction. Only one rating can be given for each transaction.

4.2 Reputation System

The reputation system applies fuzzy logic to calculate a weight that will be multiplied with the raw rating score given by the user. Below is an example of calculation from the system compared to normal summation method.

Assuming that user 'Kitty' is giving seller 'Peyton' a rating of 5 for a purchase of an item at price RM30 and Peyton has a clean record (without any previous rating).

Step 1: Fuzzification

Raw Rating Score: 5

i. User's Own Rating, *rr* = 0 (Kitty's user rating)

rr >=0 and <=1; low_rr=1 (Rater's rating has a degree of membership 1 for Low)

ii. Transaction Amount, *ta* = RM30 (The amount of the transaction)

ta >27.5 and <=40;

avg_ta = (-2/45) * *ta* + (20/9)

= (-2/45) * 30 + (20/9)

= 0.8889

(Transaction amount has a degree of membership 0.8889 for Average)

iii. Interval between current transaction and previous,

dd = Not Available (No previous transaction)

dd is given 99 to represent maximum interval between current transaction and previous when no previous transaction is made,.

dd >=21; high_dd=1 (Interval between trade has a degree of membership 1 for High)

Step 3: Rule Evaluation

Rule 22: When *rr* is Low, *ta* is Average, *dd* is High, rating weight is Average

By using Fuzzy operation 'OR' which takes a maximum value out of 3 factors,

Max[*rr*, *ta*, *dd*] = Max[1, 0.8889, 1]

= 1

Therefore, avg_rw = 1 (Rating weight has a degree of membership 1 for Average)

Step 4: Defuzzification

Since low_rw = 0; avg_rw = 1 and hi_rw = 0, Rating Weight only has degree of membership in Average.

The polygon formed by the graph in this case has the *X*-coordinates and *Y*-coordinates as below:

X_1=0.2

X_2=((3*avg_rw)+2)/10

X_3=(8-(3*avg_rw))/10

X_4=0.8

Y_1=0

Y_2=avg_rw

Y_3=avg_rw

Y_4=0;

Area of graph = $\frac{1}{2} \Sigma$ (($X_{i-1} * Y_i$) – ($X_i * Y_{i-1}$))

X-coordinate for Center of Gravity, (Rating Weight)

= $\frac{1}{6} \Sigma$ [($X_{i-1} + X_i$) * $\frac{1}{2}$ (($X_{i-1} * Y_i$) – ($X_i * Y_{i-1}$))]

= 0.5

Step 5: Calculate Final Rating

Current Rating Score

= Raw Rating Score * Rating Weight

= 5 * 0.5

= 2.5

∴ Peyton's final rating score = 2.5

In the case where user 'Peyton' already has previous ratings, a comparison is made between rating calculated using Simple Summation and Fuzzy Logic.

	Simple Summation	Fuzzy Logic
Ratings by 4 Users	i. 5 ii. 5 iii. 5 iv. 5	i. 5 * 0.7 = 3.5 ii. 5 * 0.1 = 0.5 iii. 5 * 0.2 = 1.0 iv. 5 * 0.2 = 2.0
Calculation	(5 + 5 + 5 + 5)/4 = 5	(3.5 + 0.5 + 1.0 + 2.0)/4 = 1.75

Table 4.1: Rating Comparison between Simple Summation & Fuzzy Logic

In the case of Simple Summation method, the raw rating score of '5' given by 4 different users are treated equally. Therefore, an average is obtained from the sum of the raw rating scores.

In the case of Fuzzy Logic, the raw rating score of '5' are multiplied by the weight calculated using Fuzzy Logic. The weights are different depending on the 3 factors:

1. Rater's Rating
2. Transaction Amount
3. Interval since Previous Transaction

This can reduce the possibility of user manipulating rating score. New user account having no or low rating score will eventually have low weight for its rating, the same goes to transaction involving very low price and transactions within short interval of time. All of these may be used to indicate possibility of manipulation by dishonest users.

CHAPTER 5

RESULTS & CONCLUSION

This chapter discusses about the result and the conclusion the project.

5.1 Results

This project has achieved all of its objectives to a large extent. Further explanations are as followed:

i. *To create a reputation system for an e-commerce system*

A reputation system has been created for the e-commerce system (Delphi) that allows buyers to rate sellers after a transaction.

ii. *To apply fuzzy logic in the computation algorithm for reputation system*

The reputation system mentioned earlier applies the technique of fuzzy logic to compute a weight based on the 3 criteria, a. rater's own rating, b. the amount of transaction, c. the time interval between the current trade and the previous trade by the same buyer and seller. The weight computed is then multiplied with the rating given by the rater to obtain the actual rating which is aggregated into the seller's overall rating.

iii. *To implement the reputation system in the an actual e-commerce system*

An e-commerce system (Delphi) is created and hosted on a real server to simulate an actual e-commerce system with its basic functionalities. The user rating system is then implemented in the e-commerce system.

5.2 Constraints

The use of fuzzy logic in this system only considers 3 factors in its calculation. This limits the accuracy of the system because certain cases of unfair ratings cannot be overcome by considering just the 3 of these factors. Other than that, the numerical range used in the membership functions of this system may vary according to the situation, especially when e-commerce activities can differ greatly across different places and group of users.

5.3 Discussion

Reputation system using fuzzy logic is one of the reliable systems. However, this system has low accuracy in making prediction. This system has only improved the current reputation system by adding a weight to each rating before calculating the final rating of a user.

In the future, improvement can be done on the fuzzy technique by using the idea of Bayesian which provide high accuracy in prediction. We may combine both of the techniques, to develop a high accuracy system in the same time solve the unfair rating problem. Besides, the other suitable rating criteria should also be considered to produce the precise reputation score.

5.4 Conclusion

Reputation system plays a major role in ecommerce system by providing a trust model for the users. This will encourage users to increase their own rating so that they have higher reputation in the community.

As a conclusion, it could be stated that this study has achieved the objectives; mainly to develope a reputation system for an e-commerce system and to apply fuzzy logic in computation technique. However, the usability of this prototype was being restricted due to the constraints as discussed earlier. Hence, further research in adapting alternative approaches is very much encouraged.

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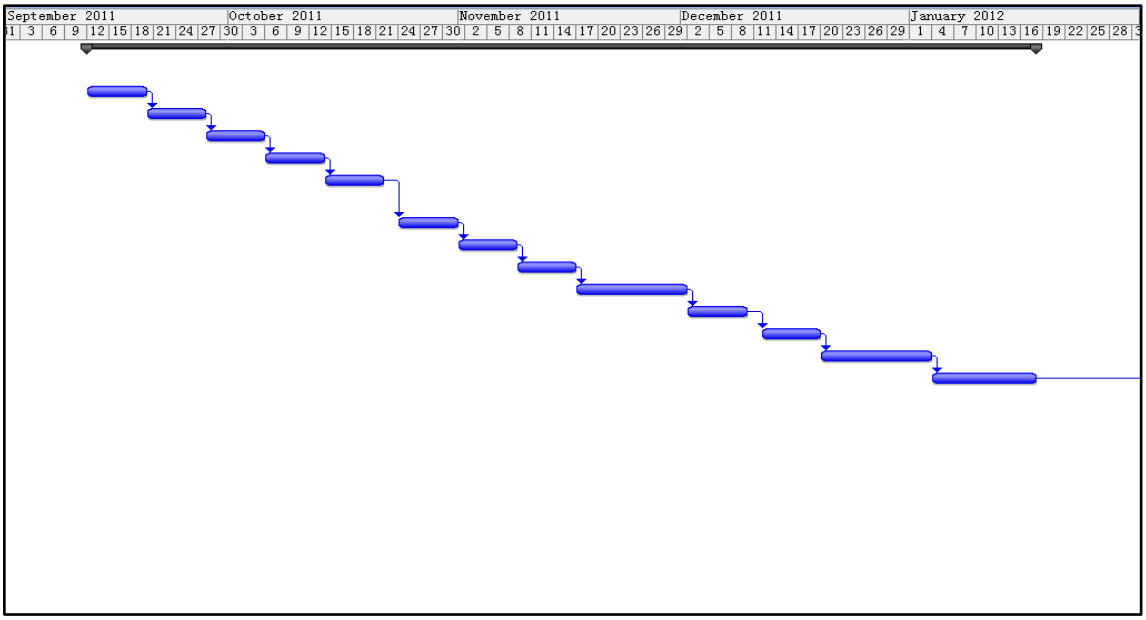
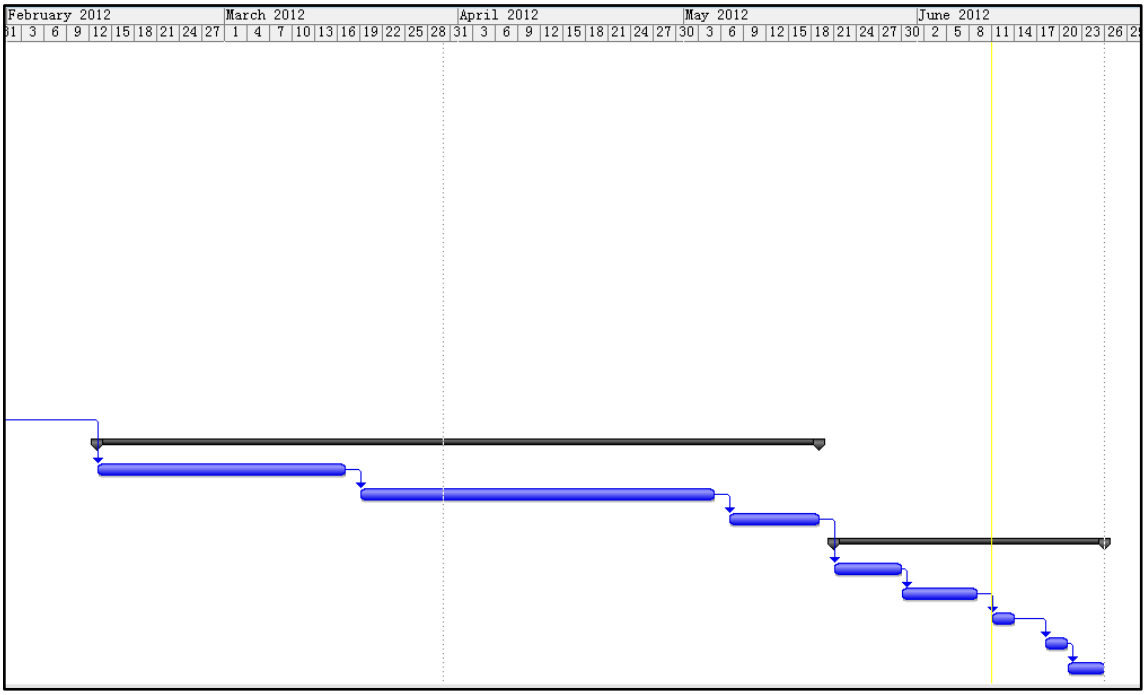
APPENDIX A

Project Gant Chart

	Task Name	Duration	Start	Finish	Predecessors
1	**Requirements Planing**	**92 days**	**Mon 9/12/11**	**Tue 1/17/12**	
2	Discuss Progress with Supervisor	6 days	Mon 9/12/11	Mon 9/19/11	
3	Submit Chapter 1	6 days	Tue 9/20/11	Tue 9/27/11	2
4	Discuss About Literature Review	6 days	Wed 9/28/11	Wed 10/5/11	3
5	Show material of Literature Review and Progress of Literature	6 days	Thu 10/6/11	Thu 10/13/11	4
6	Show the Comparison of Current Existing System and Discuss About Literature Review	6 days	Fri 10/14/11	Fri 10/21/11	5
7	Show the Progress of Literature Review	6 days	Mon 10/24/11	Mon 10/31/11	6
8	Finding Information About Methodology	6 days	Tue 11/1/11	Tue 11/8/11	7
9	Submit Literature Review and Discuss with Supervisor	6 days	Wed 11/9/11	Wed 11/16/11	8
10	Research Information About Methodology	11 days	Thu 11/17/11	Thu 12/1/11	9
11	Discuss Methodology and Show Progress	6 days	Fri 12/2/11	Fri 12/9/11	10
12	Submit Methodology and Discussion	6 days	Mon 12/12/11	Mon 12/19/11	11
13	Show Project Overview and Chapter 4	11 days	Tue 12/20/11	Tue 1/3/12	12
14	Submit Project Overview and PSM Draft	10 days	Wed 1/4/12	Tue 1/17/12	13
15	**User Design & Construction**	**70 days**	**Mon 2/13/12**	**Fri 5/18/12**	
16	Submit Chapter 1 - 3	25 days	Mon 2/13/12	Fri 3/16/12	14
17	System Development	35 days	Mon 3/19/12	Fri 5/4/12	16
18	System Testing	10 days	Mon 5/7/12	Fri 5/18/12	17
19	**Cutover**	**26 days**	**Mon 5/21/12**	**Mon 6/25/12**	
20	Discuss Chapter 4 - 5 with Supervisor	7 days	Mon 5/21/12	Tue 5/29/12	18
21	Submit Chapter 4 and 5 to Supervisor	8 days	Wed 5/30/12	Fri 6/8/12	20
22	Submit Thesis For Binding, Executive Summary, Poster	3 days	Mon 6/11/12	Wed 6/13/12	21
23	PSM Carnival	3 days	Mon 6/18/12	Wed 6/20/12	22
24	Submit Full Thesis	3 days	Thu 6/21/12	Mon 6/25/12	23




February 2012
March 2012
April 2012
May 2012
June 2012