University of Windsor
Scholarship at UWindsor

Electronic Theses and Dissertations

Winter 2014

A Hybrid Artificial Reputation Model

Gurdeep Singh Ransi
University of Windsor

Follow this and additional works at: http://scholar.uwindsor.ca/etd

Recommended Citation

Ransi, Gurdeep Singh, "A Hybrid Artificial Reputation Model" (2014). *Electronic Theses and Dissertations.* Paper 5012.

A Hybrid Artificial Reputation Model

By

Gurdeep Singh Ransi

A Thesis
Submitted to the Faculty of Graduate Studies
through the School of Computer Science
in Partial Fulfillment of the Requirements for
the Degree of Master of Science
at the University of Windsor

Windsor, Ontario, Canada

2013

A Hybrid Artificial Reputation Model

by

Gurdeep Singh Ransi

APPROVED BY:

_____
Dr. Myron Hlynka, Department of
Mathematics and Statistics

_____
Dr. Dan Wu, School of
Computer Science

_____
Dr. Ziad Kobti, Advisor
School of Computer Science

November 19, 2013

DECLARATION OF ORIGINALITY

I hereby certify that I am the sole author of this thesis and that no part of this thesis has been published or submitted for publication.

I certify that, to the best of my knowledge, my thesis does not infringe upon anyone's copyright nor violate any proprietary rights and that any ideas, techniques, quotations, or any other material from the work of other people included in my thesis, published or otherwise, are fully acknowledged in accordance with the standard referencing practices. Furthermore, to the extent that I have included copyrighted material that surpasses the bounds of fair dealing within the meaning of the Canada Copyright Act, I certify that I have obtained a written permission from the copyright owner(s) to include such material(s) in my thesis and have included copies of such copyright clearances to my appendix.

I declare that this is a true copy of my thesis, including any final revisions, as approved by my thesis committee and the Graduate Studies office, and that this thesis has not been submitted for a higher degree to any other University or Institution.

ABSTRACT

Agent interaction in a community such as an online buyer-seller scenario is often risky and uncertain. An agent interacts with other agents where initially they know nothing about each other. Currently many reputation models are developed that help consumers select more reputable and reliable service providers. Reputation models also help agents to make a decision on who they should trust and transact with in the future. These reputation models are either built on interaction trust that involves direct experience as a source of information, or they are built upon witness information, also known as word-of-mouth, that involves the reports provided by others. Neither the interaction trust nor the witness information models alone fully succeed in such uncertain interactions.

This thesis research introduces the hybrid reputation model combining both interaction trust and witness information to address the shortcomings of existing reputation models when taken separately. Experiments reveal that the hybrid approach leads to better selection of trustworthy agents where consumers select more reputed service providers, eventually lead to more gains by the consumer. Furthermore, the trust model developed is used in calculating trust values of service providers for the case study with a live website ecommerce.

DEDICATION

I dedicate this work to my parents and my sister. This work would never be done without their

love and support.

ACKNOWLEDGEMENTS

First and foremost, I am grateful to my advisor Dr. Ziad Kobti for providing me the opportunity to work in an exciting and challenging field of research. His constant motivation, support, innovative ideas, his own research and infectious enthusiasm have guided me toward successful completion of my thesis. My interactions with him have been of immense help in defining my research goals and in identifying ways to achieve them.

My sincere gratitude goes to Dr. Dan Wu for his valuable advice and helpful discussions during my thesis research. I would like to thank Dr. Myron Hlynka for his valuable comments and suggestions that helped me in my research.

I would also like to thank Dr. Nandan Parameswaran, Senior Lecturer in School of Computer Science and Engineering, University of New South Wales, Australia, who guided me in spite of being outside the University of Windsor. He gave his valuable time and support in my thesis work.

Finally I would like to thank my Family for their unconditional support and love.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Trust and reputation systems have been of great importance to human societies. The concept of trust and reputation have been of paramount importance in different disciplines such as psychology, sociology, philosophy and economy. However, in the past few years trust and reputation models have been extensively used in the field of Computer Science especially in artificial intelligence. Owing to this we will focus our attention on the discipline of Computer Science where the study of trust and reputation has acquired a great relevance recently. Two elements that have contributed substantially to increase the interest on trust and reputation in this area are the multi-agent system paradigm, and the spectacular evolution of e-commerce. The study of trust and reputation has many implications in the fields of information and communication technologies. Trust and reputation systems have been recognized as the key factors for adopting successful electronic commerce. In these systems, intelligent software agents are used which help search for trustworthy exchange partners present in the community, and also help in decision making whether partner is good and reliable to make a transaction or if the partner is not reliable and consequently no transaction would be made and will prevent from fraudulent transactions [2].

1.1 Reputation and Trust

According to Abdul- Rahman and Hailes[5], reputation is defined as "an expectation about an agent's behaviour based on information about or observations of its past behaviour."

In society, information is obtained from various other sources by means of word of-mouth, also known as witness information or asking third party. For example, a dishonest owner of a grocery store who sells products of lower quality or sells the product at higher price will quickly gain a reputation for dishonesty in the neighbourhood and would lose customers unless he improves his reputation. Additionally, a good reputation may also be used to advantage, as reputation is also considered a form of social capital, especially in commerce. Thus, reputational information is important in making effective and informed trust decisions. In [14], "reputation helps us to manage the complexity of social life by singling out trustworthy people – in whose interest it is to meet promises".

According to Ramchuran et al [57], trust is defined as "a belief an agent has that the other party will do what it says it will (being honest and reliable) or reciprocate (being reciprocative for the common good of both), given an opportunity to defect to get higher payoffs."

Trust values can range from complete distrust to a complete trust where distrust is the lowest value and complete trust is of highest value. It may be noted that the trust calculated is a subjective property of an agent and is not an objective property [15, 14].

1.2 Current Research Motivation

The concept of reputation has many implications in real life scenarios. Reputation finds its use in electronic markets such as eBay®[8] and Amazon®[7] [1]. Both direct and indirect interactions are the main sources of information to calculate a reputation value. In case of direct interactions, agents directly interact with other agents present

in a multi agent system. It is the most reliable source of information as it gives first hand information. In case of witness information or word of mouth agents collect the reputation value from other agents present in community [2]. However, these two sources alone cannot yield a real reputation score of a service provider, or in other words these are not authentic. This is because if reputation is based only on interaction trust (direct experience), the agent in that case interacts directly with other agents present in the community individually. As a result it would require a long time for an agent to reach a satisfying estimation level of trust as he has to come in direct contact with other agents. Therefore, interaction trust alone cannot reach a reliable reputation score. Furthermore, in case of witness reports, agents could be unwilling or unable to sacrifice their resources in order to provide reports. As a result, this approach alone could not guarantee a reliable estimation [6]. In this thesis we have present a hybrid reputation model and compare its results to other information sources. We use two experimental set ups. In the first we compare a hybrid model developed with the witness information as the source, and in the second we compare a hybrid model with interaction trust as a source of information. We also present a trust model which will calculate trust values of service providers from a list of providers.

1.3 Thesis Contribution

The main goals of this study are :

To develop a hybrid reputation model which involves both the sources of information which are interaction trust and witness information, and we compare its results with

each source taken alone. We also compare our model with SERM model of reputation.

To develop a trust model which will help to calculate trust value of service providers. We also implement a case study to test out the proposed trust model in real world application.

The main aim of the research is to develop a hybrid artificial reputation model which is used to calculate reputation score based on ratings in order to enable consumer select best services providers. Furthermore, the validity and applicability of this model will be tested through a case study.

1.4 Thesis Outline

Chapter 2 deals with the literature review and presents a background survey on computational trust and reputation models. It also describes various components involved in complex system modeling.

In Chapter 3, a hybrid reputation model involving interaction trust and witness information has been developed.

In Chapter 4, we have discussed different principals of trust. we introduce a trust model which will help to calculate trust value of service providers. We also implement a case study by collecting data from the Amazon® [7] website and explain all the details of the implementation.

The last chapter sums up the main points of this study and also guides the reader regarding the future possibilities of this study.

CHAPTER 2

Literature Review And Background Survey

In this chapter, various different components of the multi-agent systems have been discussed which plays an important role in complex modeling. This chapter also includes a literature review on computational trust and reputation models. This review will offer a panoramic view on current computational trust and reputation models.

2.1 Components in Complex Modeling

2.1.1 Agency

Agents are autonomous entities who act to achieve individual goals and are also capable to of exercising choice over their actions and interactions. In order to accomplish tasks for its user, the concept of an agent provides a convenient and powerful way to describe a complex software entity by acting autonomous. An agent can be defined in terms of its behaviour. The need for complex applications have raised due to increased technological complexity that systems consisting of multiple agents who can communicate in a peer to peer fashion. An agent should be capable of performing work with coordination and collaboration of other agents and this depends upon nature of environment [30][35][39][36].

2.1.2 Environment

Agents have their own area in which they act, react and communicate. This area is considered as a working environment of an agent. The agents have complete knowledge about their area. The agents are often placed in the environments in which they interact

and co-operate with other agents who have conflicting aims. These kind of environments are known as multi agent systems. The characteristics of an environment decide its complexity. The increase in the complexity of an environment makes the system more realistic and more accurate results can be obtained by the user [30].

2.1.3 Dynamics

Dynamic nature is an important characteristic or feature of complex environments. They keep on changing their states frequently which results in different working conditions for an agent at each step. The agent has to adapt to a new situation and overcome problems with action. Dynamic environments are helpful in simulating real world environments [37] [35] [30].

2.1.4 Heterogeneity

One of the characteristics of complex systems is their heterogeneous nature. Various different elements and individuals make the working environment for an agent and influence their performance. They give different platform to the agents by providing them unique working conditions in which the agents make different decisions and actions[37].

2.1.5 Social Interactions

Applying the social interaction concept to the complex multi agent system functioning is a natural step towards designing and implementing more intelligent and human like populations of artificial autonomous systems. The basic quality which defines this class of artificial systems is the agents ability to act according to the achievement of their private goals. When we consider agents in the context of multi agent system, their actions get involved in simple, complex and multiple social relations with other acting and acting

and autonomous entities. In such situation, agent who belong to broader multi agent population must consider other agents while planning and realizing their behaviour. Involving more than two agents in all the actions and practices and taking account of other agents activities, experiments or knowledge is known as social interactions. Through this system, the goals which are difficult to be achieved by an individual agent can be achieved. The agents are co-operative with each other in this system. In multi agent systems, social interactions are really important for acquiring human like behaviour [32][38].

2.1.6 Simulation

For attaining a deeper understanding of the behaviour of different parameters of the system, simulation is an effort to model a real life or hypothetical situation. It represents the main characteristics or behaviors of a selected physical or abstract system. We use simulation in many contexts, for example, to gain insight into the functioning of natural systems or human systems. Simulation is used to specify the rules of behaviour of individual entities, as well as the rules of their interaction. The simulated entities are known as agents and the simulations of their behaviour and interactions are called agent based simulation. The properties which describe the behaviour and interactions of the individual agents are known as elementary properties and the properties emerging on the higher collective level are called emergent properties. Simulation starts with set of assumptions, but it does not prove any theorems. A simulation generates data which can be analyzed inductively. The simulated data comes from a strictly specified rules instead of direct measurements of real world [29][31][39].

2.2 Multi-Agent Systems (MAS)

A Multi agent system is a computational system where multiple autonomous entities having different information or diverging interests interact with one another in order to satisfy certain goals[33][45][42]. It is a loosely coupled network of problem solvers that interact to solve problems that are beyond the individuals capability or knowledge of each problem solver[50]. These problem solvers are often called agents. The agents can be homogenous or heterogeneous, they may have common goals or individual goals[42][43]. The agents are able to operate in dynamic and open environments and often interact with other agents including both people and software. Multi agent system is used for many reasons. By providing method for parallel computation multi agents can speed up a systems operation. For example several independent tasks that are handled by separate agents in a domain divided into various components, can have benefit from multi agent system. Moreover multi agent systems can help in dealing with the limitation of time. Since multi agent system are inherently modular, it's easy to add new agents to them. In this manner they have the characteristic of scalability. The requirements coming from complex and dynamic environments can be dealt with multi agent technology. The agent based information systems have the potential to improve the competitiveness of enterprises due to their adapting and flexible nature.

The main characteristic of multi agent systems is the internal behaviour and external interactions between the agents[46]. The type of knowledge and the performance measure the agents utilize while choosing how to behave in model based, reactive, goal based and utility based environments are some of the characteristics of their internal behaviour. The ways in which the agents interact with each other for sharing information to do the tasks

are some of the characteristics of agents external behaviour. In multi agent system no agent has complete information or capability to solve the problem and thus has a limited viewpoint. In multi agent system common problems are solved by agents with co-operation. Multi agent systems are useful in the areas which involve interactions between different people or organisations, with different goals or proprietary information[49]. In this system the data is often decentralized. This lack of data centralization makes it difficult to determine the current state of the system. This kind of system can be categorized as a complex system. It is important to note that when there are different people or organisations, with different goals and proprietary information, then multi agent system is needed to handle their interactions [32][[38].

2.2.1 Application of MAS

Many domains are covered by multi agent systems such as military demining, wireless collaboration and communication, military logistics planning, supply chain management, financial portfolio management, software agents participating in online auctions or bargaining [47][48], electronic institutions[53], developing schedules for air traffic [44] and decentralized resource distribution in large storage facilities[51][52].
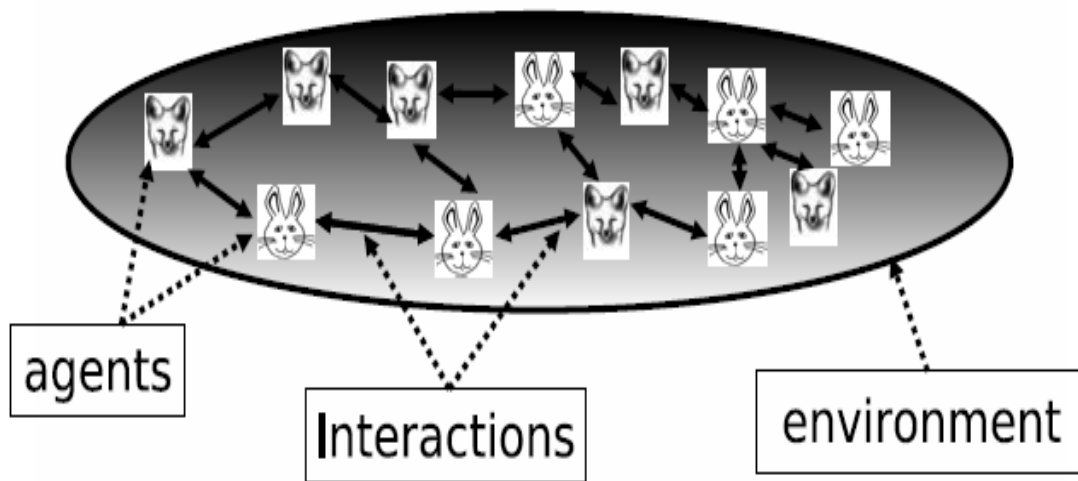
Figure 2.1: An agent-based model: The micro level entities, their actions and interactions, and the environment. [54]

2.3 Classification Dimensions of Computational Trust And Reputation Models

Trust and reputation can be used in wide range of situations. Owing to this, the classification of trust and reputation models sometimes becomes a difficult task. In this section, we classify the current computational trust and reputation models.

2.3.1 Conceptual Model

According to the conceptual model of reference, trust and reputation models can be characterized as:

Cognitive. As pointed out in [16], the cognitive approach basically means the mental state of one agent which leads to trust another agent or assign the act of relying on another agent, are the essential parts of the model.

Game-theoretical. Trust and reputation are considered 'subjective probabilities by which an individual, (A), expects that another individual, (B), performs a given action on which

its welfare depends' [17]. In this case, Trust and reputation are not the result of mental state of the agent.

2.3.2 Information Sources

Trust and reputation models are also classified based on the information sources. There are various different types of information sources which help to calculate trust and reputation values. Direct experiences and witness information are the most common information sources used by computational trust and reputation models [2].

2.3.2.1 Direct Experiences

Direct Experience is used to calculate reputation among agents in a multi agents system. This is further divided into two types. These are direct interaction in which agents directly interact with other agents present in the system and find out the reputation. The second type is direct observation in which agents directly observe the interaction of other agents present in system and calculate the reputation. The second type is direct observation which sis less common source of information, and direct experience is the most reliable source to calculate reputation from [2].

2.3.2.2 Witness Information

Witness information is also known as "word of mouth" as it uses the information gathered from other agents in the community. This is the most abundant in multi agent systems but is not as reliable as direct experience as the other agents may hide information for their own benefits [2].

2.3.2.3 Sociological Information

This reputation is based on social relations among agents in a community, Such as competition, co-operation etc. This kind of information is possible when there are many agents present in a community and interaction among those agents is good [2].

2.3.2.4 Prejudice

The use of prejudice can also help in calculating reputation of agents in multi agent system, but its use is not very common. However, we guess that as the complexity of a multi agent system increases, this feature will also be used for calculating reputation. Prejudice assigns reputation to an individual based on signs that identify the individual to be part of a particular group or community. The use of prejudice in multi agent system will be similar to positive intentions, which is the opposite to real life, as in real life it has negative intentions. The sign can be anything such as behaviour of an agent in a group that will represent the group [2].

2.4 Reputation Typology

Reputation typology shown below gives us an idea about the general classification of reputation. At the top most level reputation is classified as individual level reputation or group level reputation. If the agents interact individually reputation is said to be individual reputation and on the other hand if the agents form a group in a community then it would be classified as group reputation. Individual reputation is further classified as direct or indirect reputation based on the type of communication between the agents. Direct reputation means that agents in a community interact directly and in indirect reputation agents have witness information as a source. Direct source is further divided

into interaction trust and observed interaction. Similarly, indirect source can also be of two types i.e. witness information and sociological information. In our hybrid model we haven't used group reputation and observed reputation, so these two fields in diagram are highlighted. However, this can be used in future work of our model. Below is the figure representing reputation typology [11].
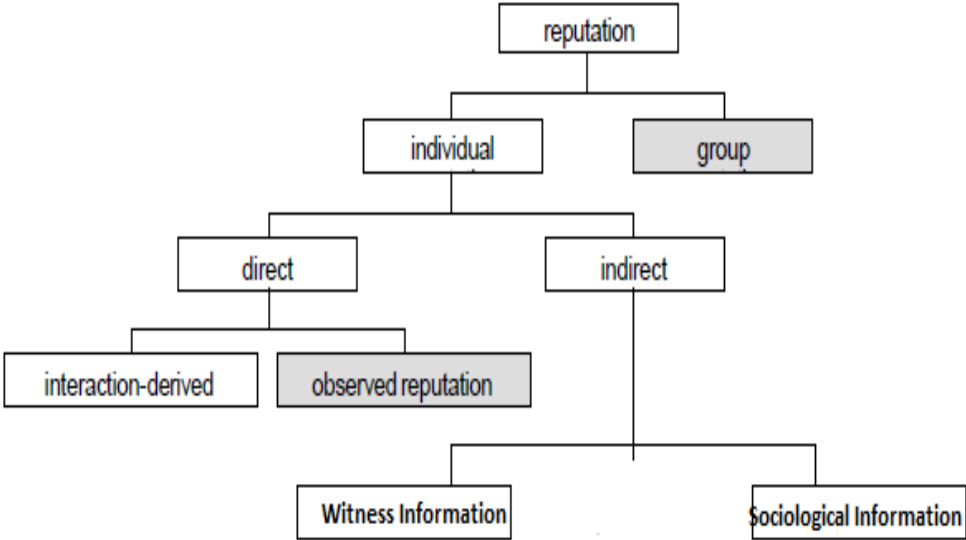
Figure 2.2 : Reputation Typology [11]

2.5 Reputation Network Architectures

2.5.1 Centralized Architecture

In centralized reputation architecture, there is a particular entity called central repository. It is responsible for the activities of gathering trust information from the community, performing calculations on this information and making the results of its calculations

public. In the figure 1 below, all the interactions between A, B, C and other agents present in a community are stored in reputation centre. This reputation center uses computation engine where all the ratings are computed. The ratings are globally available to all the members present in a community [1].
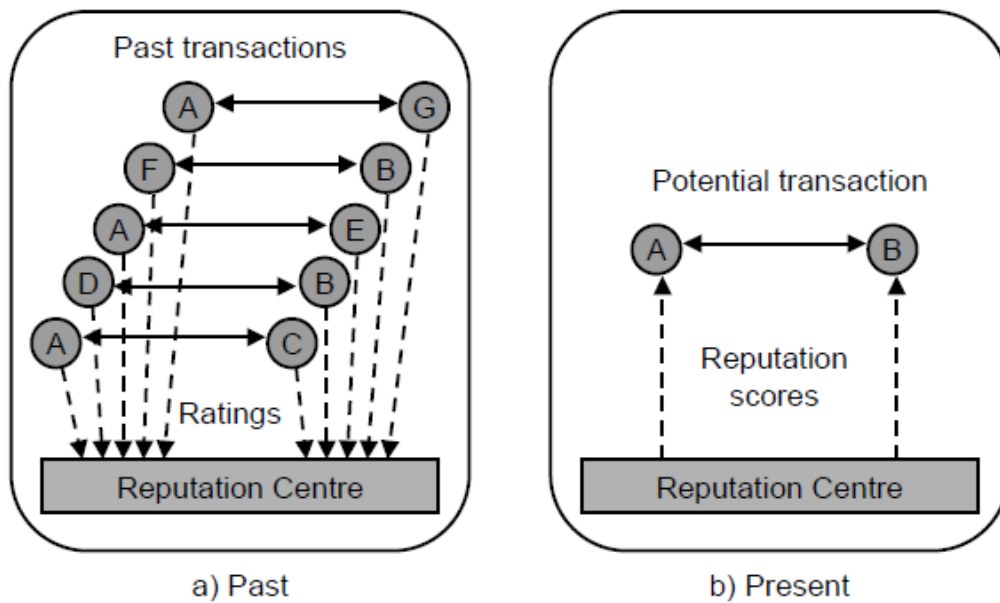
Figure 2.3 : Centralized Model Architecture [1].

2.5.2 Distributed Architecture

In this case there is no central repository or storage. The central reputation centre is replaced by several smaller distributed ones which means each individual stores its own interactions and when required to retrieve information then that agent has to be asked individually and there is no global access to ratings or reputation scores [1].
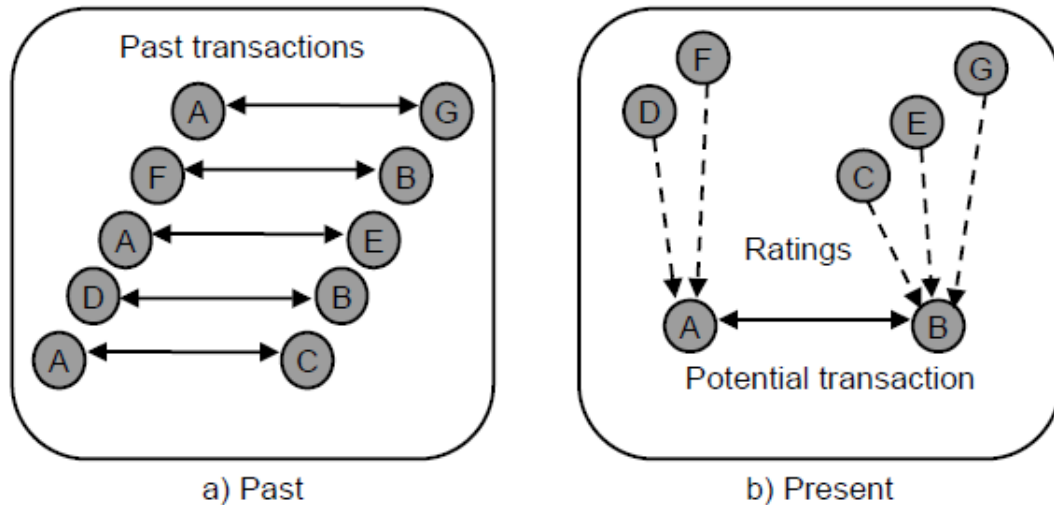
Figure 2.4 : Distributed Model Architecture [1].

2.6 Brief Introduction of Reputation Models

2.6.1 S. Marsh [2]

Marsh is one of the earliest to propose the trust model in 1994. The model takes into account direct interaction only. It differentiates three types of trust.

− **Basic trust.** This model is based on the general trusting tendency without knowing which agent is in front. It is calculated from all the experiences gathered by the agent during interactions. Good experiences lead to a greater trust and vice versa.

− **General trust.** In general trust, one agent trusts another agent without taking into account any specific situation. It is also called generalised trust.

− **Situational trust**. In it one agent has trust on another agent by taking into account a specific situation. The trust in this situation is context dependent due to the specific situation.

2.6.2 Online Reputation Models

eBay® [8] is one of the world's largest online marketplaces with a community of over 50 million registered users. Most items on eBay® are sold through english auctions and the reputation mechanism used is based on the ratings that users perform after the completion of a transaction. The user can give three possible values: positive(1), negative(-1), or neutral(0). The reputation value is computed as the sum of those ratings over the last six months. Similarly, Amazon® also uses the mean (in this case of all ratings) to assign a reputation value. All these models consider reputation as a global property and use a single value that is not dependent on the context. The information source used to build the reputation value comes from other agents that previously interacted with the target agent (witness information). As it is only based on witness information source which is third party source, they do not provide explicit mechanisms to deal with users that provide false information [2].

2.6.3 Sporas

In reputation model [18], only the most recent rating between two users is considered. The users with high reputation values have much smaller rating changes after each update then users with low reputation. Sporas is the evolved version of online reputation model. Measure of reliability and the preference given to most recent ratings are the two new features added in this model. These features help in improving the model and performing better. This model works better compared to other online reputation models.

2.6.4 Sen and Sejja Model

Both type of direct experiences i.e. direct interaction and indirect interaction are considered in Sen and Sejja's model [20]. Only direct interaction gives an exact perception of reality. The chosen mechanism to update the reputation value is reinforcement learning. The rules used to update the reputation value when there is a new direct interaction has a greater effect than the rule used to update the value when there is a new observation. The range of reputation value is from 0 to 1. If a value is greater than 0.5 it means good performance and if the value is less than 0.5 then it means bad performance. In this model, liars are assumed to lie consistently i.e. every time they are queried, they return a good value for a bad target agent and vice versa. To judge the goodness or badness of a partner from the point of view of witness information, the model uses the number of positive and negative answers received from witnesses. The model provides a mechanism to calculate how many agents need to be queried to reach a satisfying value so as to select a good partner. Agents to be queried are selected randomly.

2.6.5 AFRAS (A Fuzzy Model of Reputation in Multi Agent Systems)

In this model [19] the use of fuzzy sets is made to represent reputation values. The old reputation value and the new satisfaction value are combined using a weighted aggregation, once a new fuzzy set is calculated from a single value that they call remembrance or memory. Due to this, the agent gives more importance to the latest interaction than old reputation value. The remembrance factor is modeled on a function of the similarity between the previous reputation and the satisfaction of the last

interaction and the previous remembrance value. The importance of the past experiences is increased if the satisfaction of the last interaction and reputation assigned are similar. When the satisfaction of the last interaction and the reputation value are different, then it is the relevance of the last experience that is increased. The fuzzy sets model the notion of reliability of the reputation value. A wide fuzzy set for a reputation value represents a high degree of uncertainty over that value while a narrow fuzzy set implies a reliable value. Recommendations from other agents are aggregated directly with the direct experiences. The weight given to each factor is dependent on the reputation that the recommender has. The agent compares the recommendation with the real behaviour of the recommended agent after the interaction to calculate his reputation and increases and decreases the reputation of recommender accordingly.

CHAPTER 3

HYBRID REPUTATION MODEL

The reputation model proposed uses a hybrid approach which will combine both interaction trust and witness information. In this model, two kinds of agents are created: ProviderAgent and ConsumerAgent. Provider Agents act as service providers and provide services to ConsumerAgent. ConsumerAgent acts as service consumers, calculating the reputation of providers using the reputation model, consuming services and giving ratings. As in the hybrid model, service consumers source of information is differentiated. In this way, the reputation value of service consumer computed will be close to the true reputation of the service provider. Witness information helps gather more information. Interaction trust is more reliable source.

We have used two different settings to perform experiments with the simulation. In the first setting we have compared witness information as information source alone with the hybrid model. In the second setting we compare interaction trust as information source alone with the hybrid model.

3.1 Hybrid Reputation Model Computation Formula and Algorithm

In hybrid model we use two different sources of information which are interaction trust and witness information. We differentiate these two sources by having different values of k. When k =1, interaction trust is considered as source of information and at value of k =2 witness information is used and for hybrid we use both k=1 and k=2 .

In the formula below, 'a' represents service consumer and 'b' represents service

provider participating in interaction and 'a' gives rating to 'b' in terms of 'c'. So R_k(a,b,c) represents set of information collected through source 'k'. After each interaction 'a' will rate 'b' in terms of 'c' for its three criteria which are performance, arrival time, item described. The value of 'c' received will be of value either 0,1,2. As interaction trust is more reliable source than witness information so we give devise a rating function w_k(r_i) and r_i € R_k (a,b,c).

where   r($_i$) = record number.

   g_{ri} = rating grade of record (r_i) in the data set k.

   w_k(r_i) is rating weight function for each data set

$$R(a, b, c) = \frac{\sum r_i \in R_k(a,b,c) w_k(r_i) * (g_{ri}(T))}{\sum r_i \in R_k(a,b,c) w_k(ri)} \tag{1}$$

In above formula when we calculate reputation score for interaction trust so we put k =1 and when we need to calculate reputation score using source of information as witness information alone we substitute value of k =2. For hybrid model we will use both k =1 and 2 and (T) is the time difference between the current time and the time when rating (r_i) is recorded. Here we use the simulation round difference to represent the time difference.

ALGORITHM

Input : $R(a,b,c)$, is a reputation value which is to be evaluated. Each evaluation with value of $c \in \{0,1,2\}$, a is a service consumer agent and b is a service provider agent.

Input : W_k the rating weight function.

Input : T, is the time difference between current time and time when rating r_i is recorded

Process : a will rate b in terms of c and form a set named $R_k(a,b,c) \in r_i$ where all ratings are stored and k can be 1 or 2 depending upon the source of information selected.

    for each: R_k recorded in a record r_i at time T **do**

        calculate $R(a,b,c)$ according to (1)

    end for

Output : Reputation value ($R(a,b,c)$)

3.2.Hybrid Model Implementation and Experiments

In this model there are 25 consumer agents and 5 provider agents. At the beginning stage there is no history of interaction stored, so in first round of experiments consumer agents buy products from all 5 providers and rate them according to the service provided. This kind of interaction is direct interaction as consumer agents interact directly with providers and make a decision to transact. In this interaction, the value of 'k' will be set to 1 and w_k will be set to 60%. After transaction and using the product, consumers give ratings to their provider, which can be of value 0,1, or 2. The value 2 is highest, so it means product provided by provider was good. The value 1 means product provided by provider was fair and value 0 means unsatisfactory. For each consumer there is a set of criteria we have chosen to give ratings. We have chosen three criteria, that are item described, performance, arrival time. Now, the providers get ratings from consumers on these three criteria. The consumer gives rating on these three criteria that can be of value 0,1, or 2. So if consumer gives rating (2,2,2) it would mean that provider scored highest points in criteria item described, criteria performance and criteria arrival time which shows provider is selling good products since he received maximum value of 2 in all three criteria's. Similarly a provider can get rating in the form (2,1,2) or (1,2,2) or (2,2,1) or (1,1,1) and so on.

After this stage, there is some history of interactions stored. Now consumers ask the other consumers and they do not interact with providers any more. Now the interactions in our model is only between consumer agents and this indirect interaction is also called as witness interaction. Now value of 'k' will be 2 in the formula that we developed and

23

value of w_k will be 40%. Consumer agents do not interact with provider agents. Consumer agents interact with other Consumer agents who have already interacted with providers who submitted their ratings. The source of information when one consumer asks other consumer agent about provider now is of type witness information. After these interactions among consumer agents, consumer agents now trusts a particular provider agents based on information from other consumer agents, then makes a decision to transact. When the product is received then this consumer updates their beliefs about the provider, and new ratings are stored in a central repository. In first experimental setup we had 10 consumer agents who directly interacted with providers from time step 1 of simulation till time step 50. These 10 agents interacted with providers in direct way consumed the products and gave the ratings. These ratings were then averaged. However, rest 15 agents interacted with these 10 consumer agents in indirect way known as witness information who had direct interaction with providers in first 50 time steps. So in first set we had 10 agents with source of information as interaction trust and 15 agents with source of information as witness information. These 15 agents interacted from time step 51 to time step 100 and their ratings received were averaged.

After all interactions among consumer agents we get the values of ratings and multiply them with their respective weights according to the source of information which was used during interaction between providers and consumers. We calculate the reputation score using the weighted mean method formula as stated in (1), that means if the source of information used was interaction trust which is direct source and is most reliable source of information then it has more weight which is 60% as shown in the table 2 and if during the interaction the source of information was witness then it is weighted

as 40%. Here we have assumed the weight to be 60% and 40% for two different information sources. However, we can give weights as 80% and 20% also. But the weight of data source which involves interaction trust as a source of information should always be more as the information in direct interaction is more reliable then witness information. So we gave weight to interaction trust as 60% and witness information as 40%. This is because some data sources are more reliable than others and direct information source is always more reliable. After getting these ratings we have taken average of all these ratings which is termed as average user gain which signifies the gain that user obtained after consuming the products. For calculation of the next sets in our experiments we varied the source of information in other sets. A total of two sets were used and each set had total of 25 consumer agents and 5 provider agents. In set 1 we already had 10 consumer agents with source of information as direct interaction and remaining 15 had their information source as witness information. In set 2 of our experiment we increased the number of consumer agents which had direct interaction and decreased the consumer agents which used witness information. So in set 2, 15 consumer agents directly interacted with providers from time step 1 to time step 50 and other 10 consumer agents were having witness information as information source among themselves and interacted from time step 51 to time step 100. These all ratings received were averaged again.

The overview of hybrid interaction is shown in Fig 3.1 In the figure both the direct and indirect interactions are taking place. Consumer agent has direct interaction with providers and also indirect interaction with already interacted consumers. This makes the model as hybrid as we have differentiated the information sources of interaction among consumers.
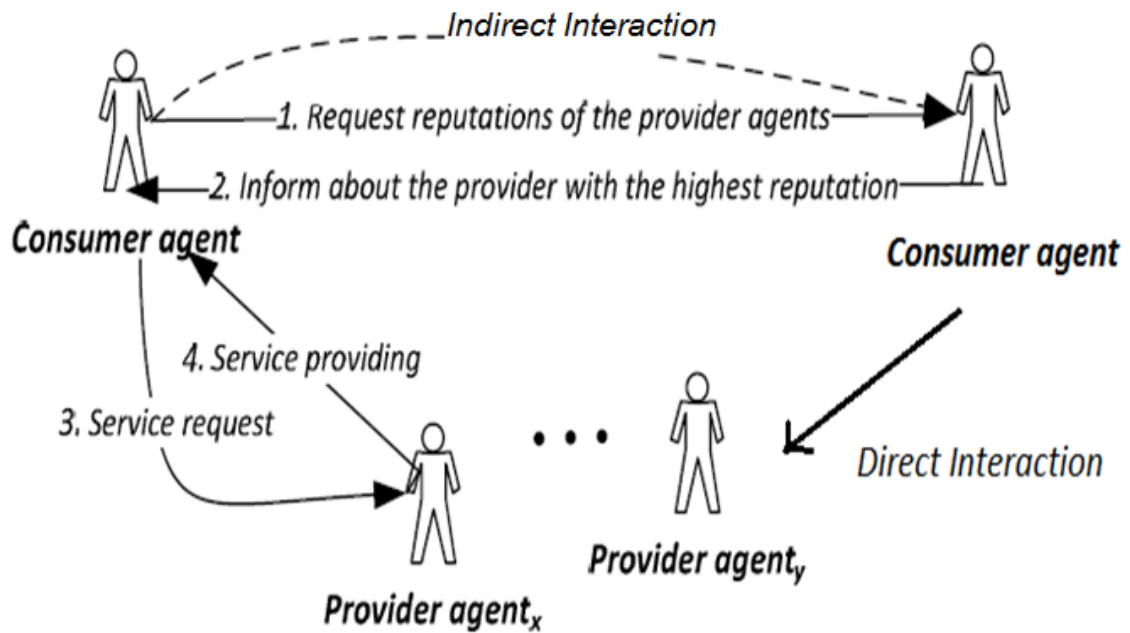
Fig.3.1   Overview of the hybrid model having both direct and indirect source of information.

Table 3.1

Variation of information source in hybrid model for service consumers

Number of sets	Number of Agents having Interaction trust as information source	Number of Agents having Witness information source
Set 1	10Agents	15Agents
Set 2	15Agents	10Agents

Average gain is calculated by averaging all the scores or ratings when interaction is hybrid based and then averaging all the scores and ratings with the two other information

sources separately. This average gain is represented as Average UG where UG means the gain that users obtain after transaction with providers. It was observed that the hybrid approach gives better results combining both the information sources.

3.3 Experimental Variables and Parameters

Table 3.2

 shows the values of variables and parameters used.

Simulation Variable	Symbol	Value
Number of Simulation Rounds	T	100
Number of Provider Agents	Np	5
Number of Consumer Agents	NC	25
Direct Experience reputation wt	Q1	60%
Witness Information reputation wt	Q2	40%

3.4. Experimental Results of Reputation Model

Fig.3.2   shows the comparison between witness - hybrid source of information and Fig.3.3 shows interaction trust - hybrid source of information. Dashed line represents the experiment results that involve the source as witness information alone and continuous line represents the hybrid model that uses both the sources of information which are interaction trust and witness information and third line that is dotted line

involves interaction trust as a source of information only. The Y-axis represents the average user gain (the gain that users obtained), and the X-axis represents the round of experiment. Simulations are run in rounds and the round number is used as the time value. The average user gain here signifies that when consumer agents interact with other consumers present in the simulation environment in hybrid way then they tend to obtain better goods or services provided by provider which means more benefit for consumers which leads to more gain. As a result, the average gain computed in the end is more in case of hybrid then individual sources of information. All of these approaches are proved to be beneficial to consumers. It shows all the information sources discussed above can help consumers to select profitable providers to transact. However, as seen in Fig.3.2 hybrid outperforms the approach that uses witness information only and in Fig.3.3 hybrid also outperforms when interaction trust is used alone. As we see in both the cases the continues line (which represents the hybrid approach) is above or in higher position than the dotted line and dashed line. In conclusion, through experiments we prove that hybrid is more helpful for consumers to select profitable providers.
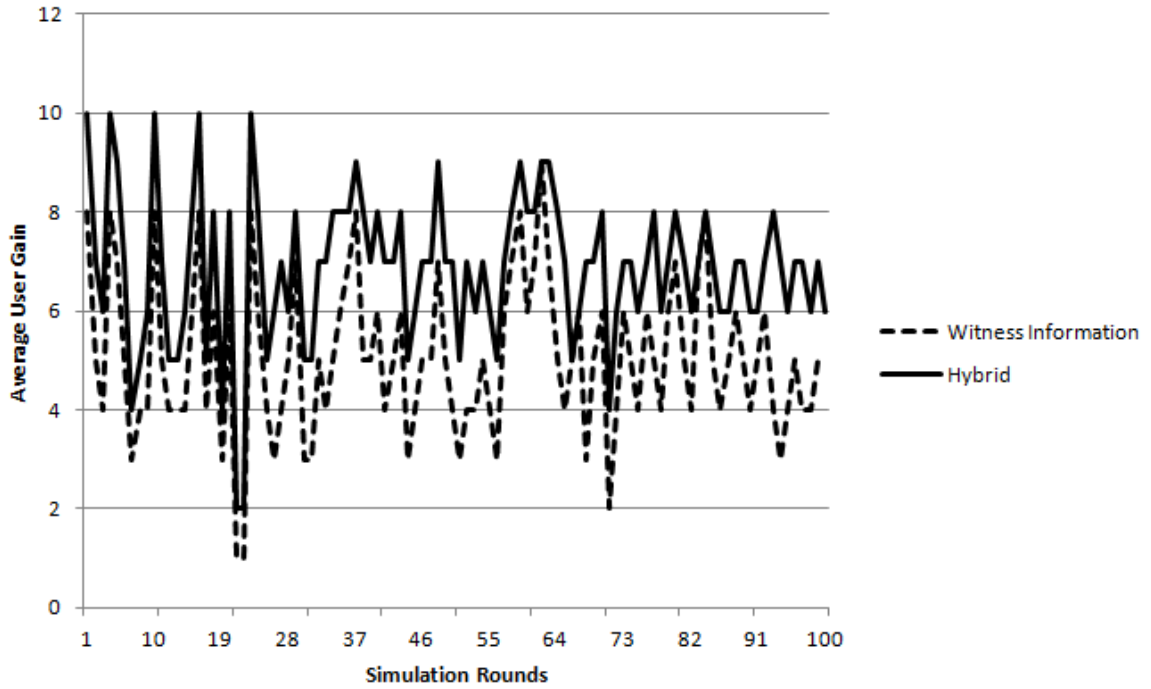
Fig. 3.2 Experiment results involving hybrid and witness as source of information
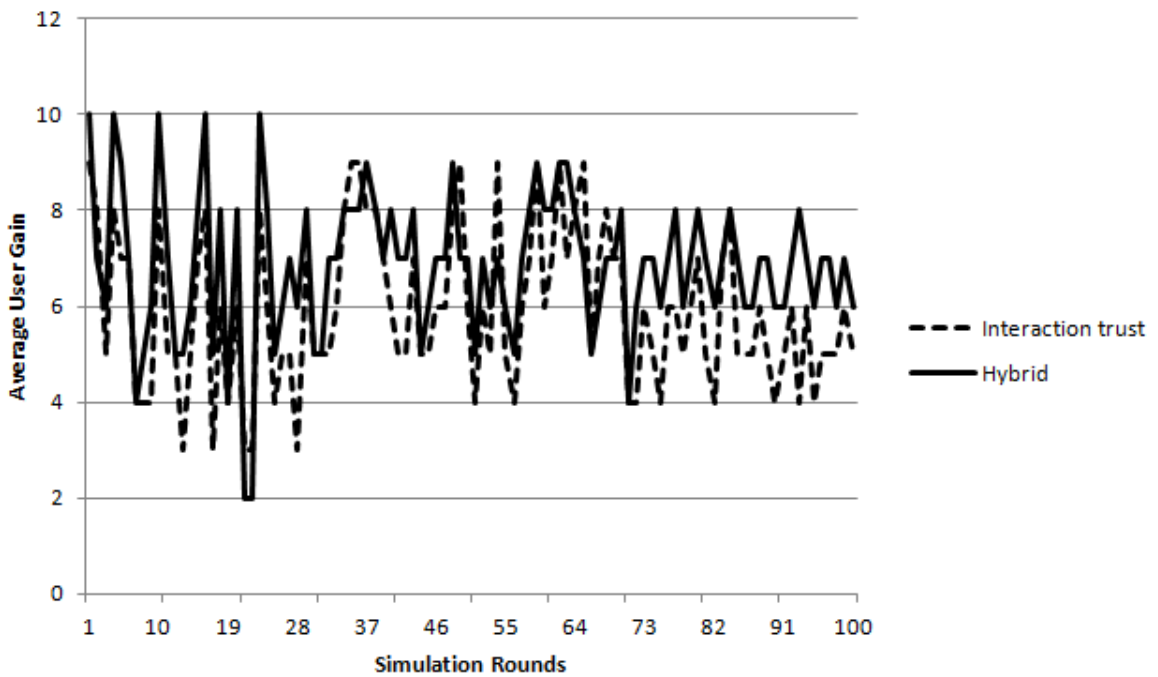

Fig. 3.3 Experiment results involving hybrid and interaction trust as source of information

3.4. Comparative study with SERM Model

3.4.1 SERM Model

In the SERM [59] centralized approach, a third-party agent keeps the references given from agents interacting with other agent in the MAS environment. Each reference is in the form of:

$Ref_i=(a, b, cr, cm, flx, rs)$, where: a is the truster agent, b is the trustee agent and cr (Correctness), cm (Completeness), flx (Flexibility) and rs (Response time) are the evaluation criteria. Ratings (r) vary from -1 (terrible) to 1 (perfect), while newcomers start with a reputation equal to 0 (neutral). The final reputation value (TR) is based on the weighted sum of the relevant references stored in the third-party agent and is calculated according to the formula:

$$TR=\Sigma Ref_i=p1*cr + p2*cm + p3*flx + p4*rs, \text{ where: } p1+p2+p3+p4=1. \quad (2)$$

Two options are supported for TR, a default where the weights are equivalent, namely pk=0.25 each and a user-defined, where the weights vary from 0 to 1 depending on user priorities.

For the comparison purposes, we used our own testbed. The testbed environment for evaluating our hybrid model consists of agents providing services and agents that use these services. We assume that the performance of a provider (and effectively its trustworthiness) is independent from the service that is provided. In order to reduce the complexity of the test bed's environment, it is assumed that there is only one type of service in the testbed and, as a result, all the providers offer the same service.

Nevertheless, the performance of the providers, such as the quality of the service, differs and is determined by the average user gain that a consumer gains from each interaction. Each agent interaction is a simulation round. The round number is used as the time value for events. The consumer agent will select one provider to use its service. Firstly, the consumer agent selects a provider, then, it uses the service of the selected provider and gains some value from the interaction called user gain (UG). The value of UG varies and it depends on the level of performance of the provider in that interaction. After an interaction, the consumer agent rates the service of the provider based on the level of performance and the quality of the service it received. The testbed in our experiment is populated with provider and consumer agents. In this evaluation, we used our hybrid model and SERM model and the testbed records the user gain of each interaction.

In order to obtain an accurate result for comparisons between reputation models, each one will be employed by a number of consumer agents. After 100 simulation rounds we figured out that the performance of SERM, which is based just on the weighted sum of the relevant ratings is considerably low, whereas the performance of the our model which is based on weighted mean which includes both the sources of information with time also as a factor is far better. A time factor is devised to ensure that the more recent rating will have higher weight to reflect the provider's recent behaviors.
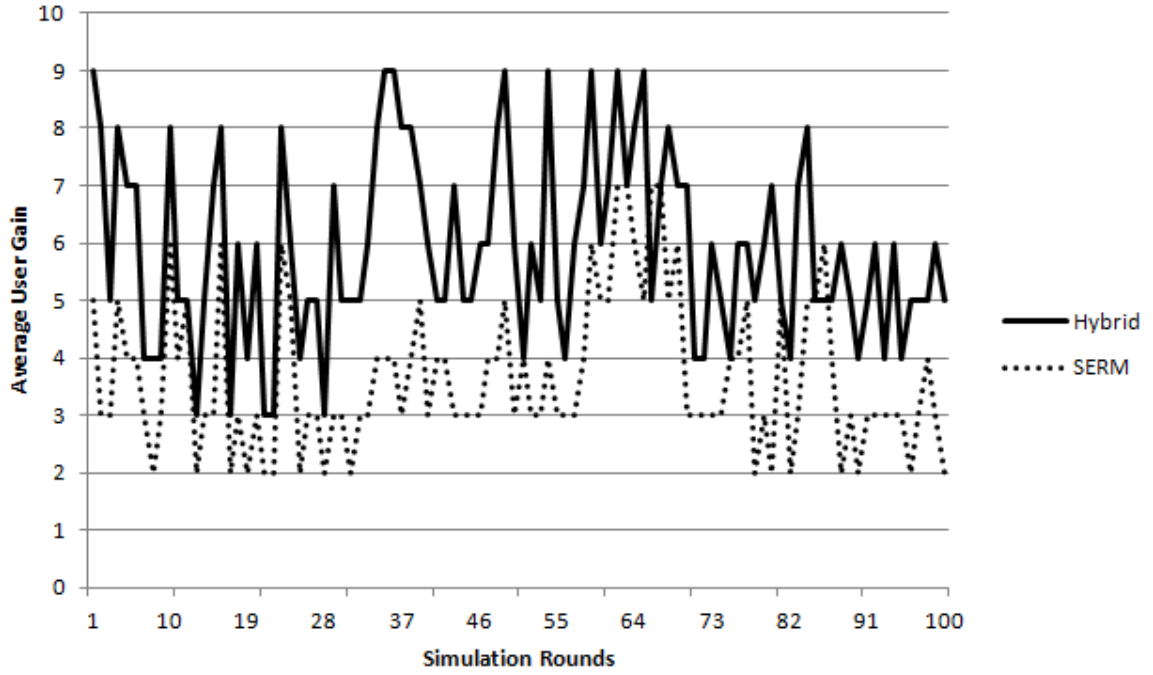
Fig. 3.4 Experiment results involving Hybrid Model and SERM Model.

CHAPTER 4

TRUST MODEL

4.1 Introduction

With the improvement in technology and increased used of internet at homes the impact of E-commerce trading is rising rapidly. Due to this the customer are now comfortably able to search and buy products online. An electronic market platform usually requires buyers and sellers to exchange offers-to-buy and offers-to-sell. However, this business of conducting transaction via a computer platform brings in new challenges. One of the major shortcomings of electronic trade is that consumers have to purchase goods from providers without any personal interaction. So this means there is no direct interaction between the provider and the consumer. This means that consumers may buy goods from companies which they have not interacted with before, and whom they do not know. Therefore, it leads to uncertainty about the product provided by provider and this platform needs to incorporate issues such as trust and help make the transaction more secured and reduce the uncertainty [55].

4.2 Ten Principals of Trust [56]

Every day we place our trust in people and the services they provide. We trust that our confidence won't be betrayed by our friends. In our everyday life we place trust unconsciously in our familiar environments. But e-commerce is not a familiar environment where we can place our trust blindly. This is because as compared to traditional commerce, e-commerce is more informal, in nature and as a result provides

fewer direct cues. One more reason regarding apprehensions involved in e-commerce is that it entails more legal uncertainties. As such in order for e-commerce to flourish, it becomes all the more necessary to make the consumer sure that they will not be cheated. In other words it's important to win the trust of consumers.

Trust in business to consumer (B2C) e-commerce is established very differently than in business to business (B2B) e-commerce environments because relationships are often shorter in term and more transaction oriented. Trust involves vulnerability. When people trust, they expose themselves to risk [56].

Principal 1 - Trust depends upon identity

The collective aspect of the set of characteristics by which a thing or a person is definitively recognizable or known is said to be its identity. In other words an identity is the set of persisting behavioral or personal characteristics by which an individual is recognizable. This persisting identity or individuality is an important aspect in establishing trust. The I - cards, passports, voter cards etc are the parameters to establish trust. But such identities told value only in the offline world. Contrary to it, the identities in the online world are virtual in nature. Thus in order to establish trust online, the unacknowledged aspect of identity needs to be strengthened which enable to create the desired atmosphere of trust[56].

Principal 2 Trust is based on information

Another aspect of developing trust is "knowledge". The possession of knowledge is an important tool to establish trust. While in the offline world this knowledge or information

has the advantage of spreading through the word of mouth, in the online world lot more collection of facts or data needs to be supplemented in order to establish trust. In the present scenario of the online world, the scope of the models containing information has to be widened. As for instance we can quote some famous social networking websites these days like facebook or twitter, which owing to their security policies like assurance of privacy, have amassed goodwill amongst the consumers [56].

Principal 3 Trust is a function of perception of risk

Winning trust can also be described in terms of "belief". There is always an element of anticipation or presentiment, a kind of premonition in the mind of the consumer while placing trust in an unknown firm. In other words, trust and risk have a special kind of reciprocal relationship. Risk in fact is essence of trust. Trust is usually measured in terms of consistency or dependability in an exchange situation. One interesting aspect of trust is that it more often doesn't comprise the ability to reason. It just depends upon one's ability to comprehend the situation or person. It can further be described as the state of being bound emotionally and intellectually to a course of action a person a firm. It is a kind of requiescence (passive protest). It is achieved gradually and is developed only through the fulfillment of commitments or consignments [56].

Principle 4: Trust deepens over time and with increased reciprocity.

Trust is enhanced through mutual or co operative interchange of favors or privileges amongst the firms. A close acquaintance, association or familiarity further helps to deepen the trust. trust can be said to be reciprocal in the sense that whenever a consumer

tends to put trust in a firm by taking considerable risk to himself, the other party also tends to feel motivated towards fulfilling reposed in it. It tries to live up to expectations of its consumer in order to win trust. Every time, when the expectations are met and the promises are fulfilled, the level of reliability or trust automatically enhances.

Generally it's not true that firms trust blindly. In other words it may said that they don't take justifiable risks in order to develop a trustworthy relation. Rather a gradual approach of trial and error is adopted.

One major factor on which the level of trust depends is the " reputation " of firm. Market value of a firm is generally related to its goodwill earned. For any firm, to create its niche in the world of trust, it is very important to be honest and trustworthy. Such a reputation tends to motivate the consumers some primary risks at least with the firm.

Every successful transactions in terms of trust helps in developing and strengthening business relations which eventually increases prospects of future profits. In this regard it will be fruitful to notice that fulfilling small commitments are equally important and needs to be taken very good care of. These may be taken to be the foundation for developing long lasting and promising relations [56].

Principal 5 Trust is a matter of degree

Trust is also a matter of degree. The extent of trust placed by the truster depends to a great extent on the characteristics of the trustee i.e. trustees 'trustworthiness'. Desirable trustee characteristics include loyalty, accessibility, integrity, consistency of behavior, competence, reliability, fairness, predictability, commitment and goodwill. Such attributes of the prospective partners increases the degree of trust which helps the

customer to have a positive stance.

The most tangible part of trust in business and relationships is the level of investment that each party is willing to contribute to the reliance. Since the general assumption is that the trust precedes commitment [56].

Principal 6 Culture affects trust.

It has been speculated that the trust plays critical role in stimulating consumer purchases over the internet. The global nature of the internet raises questions about the robustness about robustness of trust effects across cultures. Culture may also affect the antecedents of consumer trust i.e. consumer of different cultures might have different expectations of what makes a web merchant trustworthy.

From traditional marketing context, it may be inferred that consumer trust is more readily developed when the consumer has a positive stance in general, has had prior interactions with the merchant, is protected by social or legal structures. When consumer are scattered around the world these sources of trust are not readily available. Further, the fundamental basis of trust might vary across nationalities. The consumers coming from individualistic countries might have a higher trusting stance in general than the ones from collective countries.

Presently we see a growing trend towards globalization in establishing alliances and managing employees and venturing into new market trends. These trends suggest a need to view the concept of trust from the respective of national culture. Thus trust and with e - commerce being an international phenomenon, understanding the cross cultural aspects of trust creation is important [56].

Principal 7 Third party ratings are important in developing trust

It is not that only the first hand interaction affects trust. The views and opinions of other parties also matter. Better business bureau, consumer reports and the media in general are amongst those parties which operate in the offline world. Whereas the trust third parties i.e. TTP's are one set of organisations that try to promote trust on the web. A TTP will display its logo on a firms website if that firm has demonstrated that it confirms to the policy of TTP. Two of the most notable internet TTP's are TRUSte and BBBOnline. TRUSTe is a non - profit company that is trying to reduce consumer fears about privacy violations by allowing internet retailers to display their privacy policy. BBBOnline, another TTP is the internet counterpart of the 'better business bureau' [56].

Principal 8 Second party opinions are important in developing trust

In addition to third party opinions, the opinions of the second party also hold value. As second party has the experience in conducting similar transactions so their opinion holds value to the consumer. Friends and acquaintances play a vital role in this regard in the offline world. As far as the online world is concerned, this role may be played by even a stranger party that has the experience of working with the concerned firm under similar circumstances in the past [56].

Principal 9 First party information is important in developing trust.

The piece of information that a business concern provides about themselves is also critical to establishing trust online. The information concerning different aspects like

methods, policies or detailed description of products serves as an aid to the consumer. It helps to keep consumer within the 'comfort zone' and also help reposing faith in the business concern.

Unlike in the offline world, in the online world, which comprises a wider geographical area, the information concerning transactions needs to be stated in a more explicit manner by the first party. Further, the online business concern needs to lay down its policies more explicitly or otherwise they lack the benefit of customer's personal contact [56].

Principal 10 Formal and social control are important in developing trust.

Formal and social control also play important part in developing trust. By formal controls, we mean codified rules, procedures or rules and regulations. These rules and procedures help to specify patterns of behaviour. They also specify the nature of penalty in cases of non - conformance to these rules. Social controls on the other hand use cultural values and norms to bring about the needed conduct. While formal control is effective for short - term alliances, the social controls are effective for long - term alliances. It is because the social controls develop over time. One more aspect in which both controls differ is the level of information provided. In formal controls much more information regarding codes need to be provided [56].

4.3 Approach for trust model to calculate trust values of service providers

In this model, there are 25 consumer agents and 5 provider agents.

$$T = \frac{\sum_{i=1}^{n} r_i}{n}$$

r$_i$ = rating score recieved at each time step

n = total number of interaction.

T = Trust Value

In trust model consumer agents present directly interact with provider agents from time step 1 to time step 25. All the consumer agents have interactions provider agents. This happens for all the five providers. In this model we have used Boolean approach. The provider is providing good services or bad services. So if the provider is good then he gets Boolean value as 1 and if he is not good then he gets value as 0. Agents in a simulation experiment interact with provider and then make a transaction. After the transaction they give either a value of 1 or value of 0 depending on the product delivered by the provider. So first all the consumers interact with providers and make the purchase. One time step is one interaction. At each time step the value of trust is calculated depending upon the product provided by providers. If the at the end of simulation we calculate the trust values of all provider agents.

4.4 Experimental Results of trust model

In the Fig.4.2 below we can see the trust values of different providers over a period of time. X - axis of the graph represents simulation rounds which is the time value. Y - axis represents trust values. So the experiments successfully help to calculate trust values of service providers.
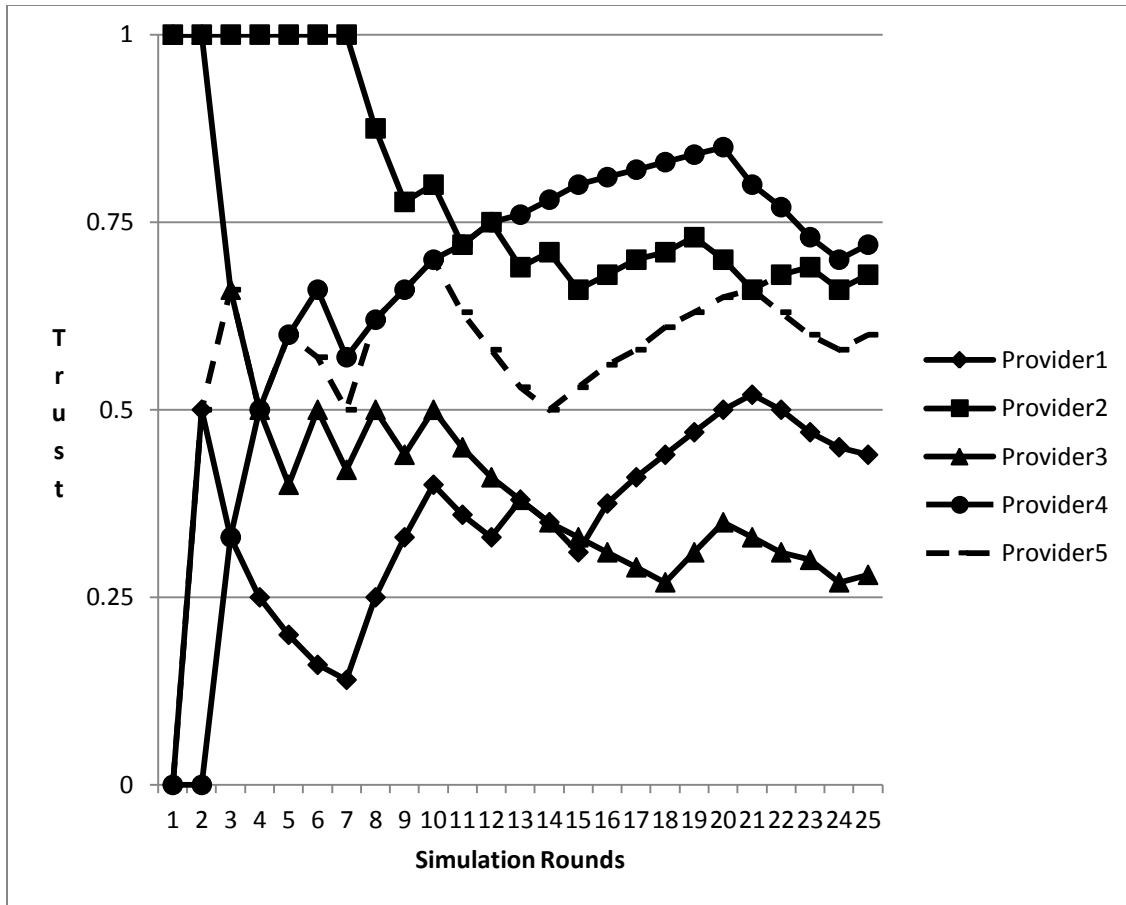
Fig. 4.1 Experiment results showing trust values of different provider agents

4.5 Case study in trust model

In order to test our model in real world application we collect the data from Amazon®

website and test our formula of trust on that data. We used a mozenda [58] software to

automate the collection of data. So we look at providers who are selling similar products

and we have to choose which among those list of providers is the most reliable and

trustworthy one so consumers can make a transaction based on the ratings observed. The

similar product we are using is "camera ". We chose this product for our case study

because this products has maximum data available in Amazon® website. Now we see

ratings for camera and we have different providers and the ratings they got over a period

of time will help us to decide which is the best provider. The data consisted of three data field values which are "name of the provider", "ratings received", "number of interactions" and the "overall rating score" they got. The ratings observed were given by consumers ranging from 1 to 5. The providers who got overall rating value greater than 2.5 were termed as honest and reliable ones. However, the providers who got rating values less than 2.5 were dishonest.

Data collection

The mozenda [58] is a data extraction software developed in 2007 to solve the problem of creating a software tool that would allow to quickly and easily extract information from the web. In mozenda we used point-and-click interface, which enables us to build and edit agents that harvest specific information and images from any website. Building an Agent is a process , where we simply type in the URL of the target website and navigate to the webpage we want to start gathering information from and then we click "Start a new agent from this page". To begin populating our data table, we click on the fields of data that we want to capture. we can either capture the item's text, create a list of items, or tell our agent to follow a link. To capture specific details we simply highlight the parts of text we wanted to capture. Mozenda will automatically recognize these text elements and replicate what we have done across multiple items and pages. Once we have the agent gathering the correct items in our list, we can add a "List Pager" that will navigate through multiple pages capturing similar items in our list. With the help of list pager we will get data from many pages in a short time. All the data collected is in the form of numbers as the ratings given by consumers is of numeric values. After specifying

mozenda the data we need to collect we now go to the Mozenda Web Console, where we can run the agent that we created in the Agent Builder. Finally we can export data captured from the web as CSV, TSV, or XML files which can be downloaded and viewed on our local computer in just seconds

In the tables below we see the ratings given by different consumers for the same product that is being sold by different providers. We test our trust model on "camera" product. Each table has four columns which specifies what is the name of provider who is selling the product, ratings given by consumers over a period of time, the number of interactions taking place and the total rating score

Table 4.1 : Shows the value of all ratings collected from Amazon® website for different providers selling similar product which is camera.

Product Camera	Ratings received	Number of interactions	OverallRating Score
Camera Depot	4,3,2,4,4,5,5,5	8	4.0
Camera Depot	5,4,2,3,3,2,3,4,5,5,5	11	3.7
Camera Depot	5,3,1,3,2,2,2,3	8	2.6
Camera Depot	4,3,4,4,1,1,1,1,1,1	10	2.1
Camera Depot	2,4,2,2,1,1,3,2,3,1,1,2	12	2.0
Camera Depot	1,1,2,2,1,1,1,1	8	1.2
Camera Depot	5,5,4,5,5,4,2,5,5,5,4,5	12	4.5
Camera Depot	5,5,3,5,5,5,4,4,4,3	10	4.8
Wegio	5,4,3,3,4,4	6	3.8
Wegio	4,4,2,1,1,3,1,1,2,2,1,3,5	13	2.3
Ritz	3,2,3,1,1,1,3	7	2
Ritz	5,5,4,1,3,2,4	6	4.1
Ritz	5,5	2	5
Ritz	2,2,1,1,1,1,2,1,1,1,1	11	1.2
Ritz	4,5,4,3	4	4

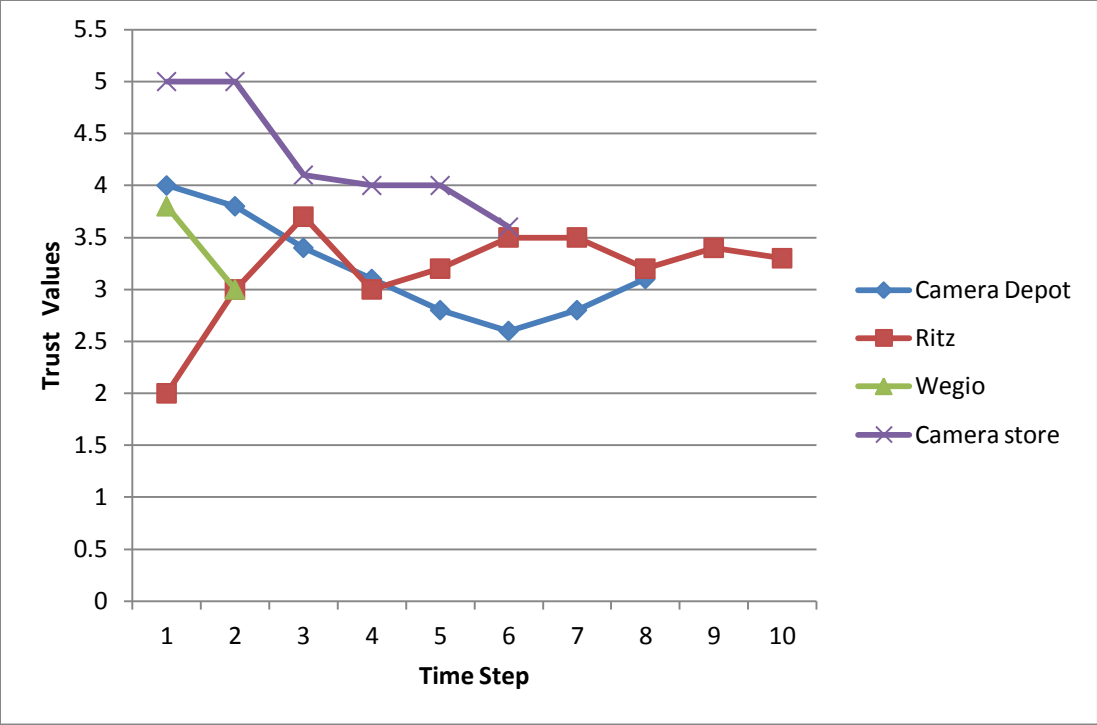| Ritz	5,5,4,5,5,4,5,5	8	4.8
Ritz	4,3,4,5,3,4,4	7	4
Ritz	1,1,	2	1
Ritz	5,5,5	3	5
Ritz	2,1,3,2,4	5	2.5
Camera Store	5,5,5,5	4	5
Camera Store	5,5	2	5
Camera Store	4,1,2,1,2	5	2.3
Camera Store	5,4,5,3,3,2	6	3.7
Camera Store	4,4,2,5,5	5	4
Camera Store	2,2,2	3	2

Fig.4.2 Shows trust values of all providers for camera as a product from Amazon® website.

From the above figure we see that all the providers with their trust values. Trust value of provider named "Wegio" is lowest which is 3.0 and trust value of provider named "camera store" is highest which is 3.6.

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

In this Thesis, we presented a hybrid reputation model that combines both the interaction trust and witness information. Interaction trust happens when consumer agents directly interact with provider agents and buy a product. Witness information is an indirect information source where a consumer agent has no interaction with providers but has indirect interaction with other consumer agents present. From experiments we find that the combination of the two leads to better and more reliable result. This model has accomplished the purpose of helping consumers to select reputable providers which finally helps consumer to obtain more gains. This thesis also provided comparison of our hybrid reputation model with SERM Model. However, in the next step the trust model is used to calculate trust value of the provider agents. We also tested our formula in real world data by collecting data from Amazon® website through the use of mozenda software. We can conclude from the results of case study that our formula is successful in calculating the trust values of providers from the list of providers.

In our future work we can add group reputation feature. Currently this model deals with individual reputation and asks for rating from individual consumer agents. Addition of group reputation [10] feature can help in making better and improved decisions to select provider agents.

REFERENCES

[1]   A. Jøsang, R. Ismail, and C. Boyd, "A survey of trust and reputation systems for online service provision," Decision support systems, vol. 43, no. 2, pp. 618–644, 2007.

[2]   J. Sabater and C. Sierra, "Review on computational trust and reputation models," Artificial Intelligence Review, vol. 24, no. 1, pp. 33–60, 2005

[3]   J. Rubiera, J. Lopez, and J. Muro, "A fuzzy model of reputation in multi-agent systems," In Proceedings of the fifth international conference on Autonomous agents. ACM, pp. 25–26,2001.

[4] J. Sabater and C. Sierra, "Regret: reputation in gregarious societies," In Proceedings of the fifth international conference on Autonomous agents. ACM, pp. 194–195,2001.

[5]   A. Abdul-Rahman and S. Hailes, "Supporting trust in virtual communities," In System Sciences. Proceedings of the 33rd Annual Hawaii International Conference on. IEEE, pp. 9–17,2000.

[6]   K. Kravari and N. Bassiliades, "Harm: A hybrid rule-based agent reputation model

based on temporal defeasible logic," Rules on the Web: Research and Applications, pp. 193–207, 2012.

[7]   Amazon.com, Inc. 17th July, 2013 Amazon.com[online]. Available: http://www.Amazon®.com.

[8]   eBay.com, Inc eBay.com[online]. Available: http://www.eBay.com.

[9]   T. Riggs and R. Wilensky, "An algorithm for automated rating of reviewers," In Proceedings of the 1st ACM/IEEE-CS joint conference on Digital libraries. ACM, pp. 381–387,2001.

[10]   X. Tong and W. Zhang, "Group trust and group reputation," In Natural Computation-ICNC'09. Fifth International Conference on, vol. 5. IEEE, pp. 561–565,2009.

[11]   L. Mui, " Computational models of trust and reputation: Agents, evolutionary games, and social networks," PhD Thesis, Massachusetts Institute of Technology, 2002.

[12]   N. Sundaresan, "Online Trust and Reputation Systems," Proceedings of the 8th ACM conference on Electronic commerce.ACM Press. New York, pp. 366–367, 2007.

[13] S. M. Jordi, "Trust and Reputation for Agent Societies," PhD thesis, Universitat Autònoma de Barcelona, 2003.

[14] B. Misztal. Trust in Modern Societies. Polity Press, Cambridge MA, 1996.

[15] D. H. McKnight, N. L. Chervany. The Meanings of Trust. Technical Report 94-04, Carlson School of Management, University of Minnesota, 1996.

[16] Esfandiari, B. and S. Chandrasekharan: 'On How Agents Make friends: Mechanisms for Trust Acquisition'. In Proceedings of the Fourth Workshop on Deception, Fraud and Trust in Agent Societies, Montreal, Canada. pp. 27—34,2001.

[17] D. Gambetta, Trust: Making and Breaking Cooperative Relations, Chapt. Can We Trust Trust?, pp. 213—237. Basil Blackwell, Oxford,1990.

[18] G. Zacharia,: 'Collaborative Reputation Mechanisms for Online Communities'. Master's thesis, Massachusetts Institute of Technology,1999.

[19] Javier Carbo Rubiera, Jose M. Molina Lopez, and Jorge Davila Muro. A fuzzy model of reputation in multi-agent systems. In Proceedings of the fifth international conference on Autonomous agents (AGENTS '01). ACM, New York, NY, USA, 25-26,2001.

[20] S. Sen and N. Sajja. Robustness of Reputation-based Trust: Boolean Case. In Proceedings of the First Int. Joint Conference on Autonomous Agents & Multiagent Systems (AAMAS). ACM, July 2002.

[21] Carter, J., E. Bitting, and A. Ghorbani:, 'Reputation Formalization for an Information-Sharing Multi-Agent System'. Computational Intelligence 18(2), 515—534, 2002.

[22]   S. Marsh, 'Formalising Trust as a Computational Concept'. Ph.D. thesis, Department of Mathematics and Computer Science, University of Stirling, 1994.

[23]   Mui, L., A. Halberstadt, and M. Mohtashemi: , 'Notions of Reputation in Multi-Agent Systems: A Review'. In Proceedings of the first international joint conference on autonomous agents and multiagent systems (AAMAS-02), Bologna, Italy. pp. 280—287, 2002.

[24] Schillo, M., P. Funk, and M. Rovatsos: , 'Using Trust for Detecting Deceitful Agents in Artificial Societies'. Applied Artificial Intelligence (Special Issue on Trust, Deception and Fraud in Agent Societies), 2000.

[25] P. Resnick and R. Zeckhauser. Trust Among Strangers in Internet Transactions: Empirical Analysis of eBay's Reputation System. In M.R. Baye, editor, The

Economics of the Internet and E-Commerce, volume 11 of Advances in Applied Microeconomics. Elsevier Science, 2002.

[26] M. Chen and J.P. Singh. Computing and Using Reputations for Internet Ratings. In Proceedings of the Third ACM Conference on Electronic Commerce (EC'01). ACM, October 2001.

[27] T. Grandison and M. Sloman. A Survey of Trust in Internet Applications. IEEE Communications Surveys and Tutorials, 3, 2000.

[28] P. Maes, R. Guttman, and A. Moukas. Agents that Buy and Sell: Transforming Commerce as We Know It. Communications of the ACM, 42(3):81.91, 1999.

[29] M. Batty and B. Jiang. Multi-agent simulation: Computational dynamics within gis. In Innovation in GIS VII: Geocomputation, pages 55–71, 2000.

[30] J. M. Bradshaw. Software agents. MIT Press, 1997.

[31] A. Drogoul and J. Ferber. Multi-agent simulation as a tool for modeling societies: Application to social differentiation in ant colonies. In Artificial Social Systems, volume 830, pages 3–23. Springer, 1992.

[32] J. Ferber. Multi-agents systems, 1999.

[33] F. Bellifemine and G. Rimassa. Developing multi-agent systems with a fipa-compliant gent framework. In Software Practice Expertise, volume 31(2), pages 103–128. ACM, 2001.

[34] S. J. Russell and P. Norvig. Artificial Intelligence: A Modern Approach. Pearson Education, 2003.

[35] K. Smith, R. Paranjape, and L. Benedicenti. Agent behavior and agent models in unregulated markets. In Applied Computing Review, volume 9(3). ACM, 2001.

[36] K. Sycara and D. Zeng. Coordination of multiple intelligent software agents. In Intel ligent and Cooperative Information Systems, volume 5(3), pages 181–211. 1996.

[37] H. V. D. Parunak, S. Brueckner, J. Sauter, and R. Matthews. Distinguishing environmental and agent dynamics: A case study in abstraction and alternate modeling technologies. In Engineering Societies in the Agents World (ESAW00), volume 1972, pages 19–33. ACM, 2000.

[38] N. T. Nguyen and R. Katarzyniak. Actions and social interactions in multi-agent systems. In Knowledge Information Systems, volume 18(2), pages 133–136. Springer, 2009.

[39] M. J. Wooldridge and N. R. Jennings. Software engineering with agents: pitfalls and pratfalls. In Internet Computing, volume 3(3), pages 20–27. IEEE, 1999.

[40] R. Xie, D. Rus, and C. Stein. Scheduling multi-task multi-agent systems. In Fifth international Conference on Autonomous Agents, pages 159–160, 2001.

[41] C. M. Macal and M. J. North. Agent based modeling and simulation: Desktop abms. In Winter Simulation Conference, 2005.

[42] R. Lelouche. Team of agents cooperating for intelligent tutoring. In Distributed Artificial intelligence, volume 1544. Springer-Verlag, 1998.

[43] J. Liu, H. Jing, and Y. Tang. Multi-agent oriented constraint satisfaction. In Artificial Intelligence, volume 136, pages 101–144. Elsevier, 2001.

[44] X. Mao, A. Mors, N. Roos, and C. Witteveen. Agent-based scheduling for aircraft deicing. In 18th Belgium - Netherlands Conference on Artificial Intelligence, pages 229–236, 2006.

[45] P. Mi and W. Scacchi. A knowledge-based environment for modeling and simulating software engineering processes. In Knowledge and Data Engineering, volume 2(3), pages 283–289. ACM, 1990.

[46] S. Poslad. Specifying protocols for multi-agent systems interaction. In Transport Autonomous Adaptive System, volume 2(4), pages 15–24. ACM, 2007.

[47] C. Preist and Maarten. Adaptive agents in a persistent shout double auction. In Information and computation economies, pages 11–18. ACM, 1998.

[48] J. Kalagnanam and D. C. Parkes. Auctions, bidding and exchange design. In Operations Research and Management Science, volume 5, 2004.

[49] K. Sycara and D. Zeng. Coordination of multiple intelligent software agents. In Intel- ligent and Cooperative Information Systems, volume 5(3), pages 181–211. 1996.

[50] K. P. Sycara. Multiagent systems. In American Association for Artificial Intelligence, pages 79–92. ACM, 1998.

[51] D. Weyns, N. Boucke, T. Holvoet, , and W. Schols. Gradient field-based task assignment in an agv transportation system. In EUMAS, pages 447–458. ACM, 2005.

[52] S. Jong, K. Tuyls, , and I. S. Kuyper. Robust and scalable coordination of potential- field driven agents. In *IAWTIC/CIMCA*. IEEE, 2006.

[53] A. Juan. On the design and construction of agent-mediated electronic institutions, Phd thesis. Technical report, Monografies de lInstitut dInvestigaci en Intelligncia Artificial, 2003.

[54] A.M. Uhrmacher and D. Weyns, *Multi - Agent Systems Simulations and Applications.* 1st.ed. Florida, USA : Taylor and Francis group, 2009.

[55] A. Hnativ and S.A. Ludwig, "Evaluation of trust in an ecommerce multi-agent system using fuzzy reasoning," *IEEE International Conference on Fuzzy Systems* , vol.2, pp.757,763, 20-24 Aug. 2009

[56] M. Daignault, M. Shepherd, S. Marche, C. Watters, "Enabling trust online," *Electronic Commerce, Proceedings. Third International Symposium on* , vol. 2, pp.3,12, 2002

[57] S. D. Ramchurn, D. Huynh, and N. R. Jennings. Trust in multi-agent systems. *Knowl. Eng. Rev.* 19, 1 (March 2004), 1-25, 2004.

[58] Mozenda, Inc. 17th July 2013, mozenda.com[online]. Available: http:// www. mozenda.com

[59] K. Kravari, E. Kontopoulos, and N. Bassiliades. Towards a Knowledge-based Framework for Agents Interacting in the Semantic Web, *IEEE/WIC/ACM Int.Conf. on Intelligent Agent Technology*, Vol. 2, pp. 482-485.2009.

VITA AUCTORIS

Gurdeep Singh Ransi was born in 1987 in Jalandhar, Punjab, India. He completed his Bachelor degree in Computer Engineering in 2009. Currently he is a Master's Candidate under Dr. Kobti's supervision in the School of Computer Science at University of Windsor, Ontario. He is expected to graduate in November 2013.