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Evaluation and Validation of Trust using Fuzzy Inference Model for Agent Based Systems

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Abstract : It is compulsory for Agent based systems to interact with each other in order to achieve designated goals. Agents encompass several features *i.e*. competency, skills, achievement rate, trust etc. Trust is one of the important features for achieving the goal during communication. In real world, Trust is subjective in nature which is not useful in virtual communities. Virtual communities need precise value to trust on each other for realization of task. Fuzzy logic provides a way for definite conclusion for imprecise input information. We propose a system empowered with fuzzy logic to analyse trust. A fuzzy inference system is designed and implemented in MATLAB to include: (*i*) to reduce the subjectivity of trust; (*ii*) To help virtual community for interacting on the basis of trust. We also designed a graphical user interface to evaluate the trust. A validation is carried out by evaluating different agent based systems.

Keywords : Agent Based System, Fuzzification, Fuzzy Inference System, MATLAB, Trust.

1. INTRODUCTION

Since Software Engineering came to light, It has been observed that complexity of software systems is continuously amplified. Northrop et al. [1] described about how the complexity within software systems is increased due to interaction with heterogeneous platforms, communication with unknown components through networks.

Now days, the software industry has grown in variety of domains affluently. With the advancement of software technologies flexibility, negotiation, decision, learning is also being considered parts of new technologies. Agents in agent based systems also possess these features. Agents are usually social in nature i.e. they have their own virtual community for achievement of goals. Michael Wooldridge [2] stated that the complexity of software have been displaying better understanding with time. Interaction becomes the important feature in the view of complexity therefore cooperation, coordination and negotiation become significant.

S. Arora et al. [3] analysed the variety of software paradigms and discussed comparison among them. Agents are an active object in comparison of objects in object oriented paradigm. With the development of software productivity, heterogeneity is improved for better results. Software paradigm is also succeeded from procedural to agent paradigm.

Agent based systems are developed with the help of software agents; communicating each other to achieve a goal using communication language. Being social in nature, Agents have their own virtual community towards achievement of goal. Trust plays an important role in order to communicate with other agents. Trust helps an agent in virtual community to know the reputation of agents and also works as decision support system. In agent based system, evaluation of trust is difficult process; It takes into consideration several factors, also helps virtual community of agents to interact with each other. S. Arora et al. [4] has proposed the relating factors of trust *i.e.* Reliability,

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Negotiation, Failure Analysis and Generality. Although trust depends on numerous quality aspects, but we consider only these four factors which have major impact on trust. With the help of these factors trust can be evaluated. It is difficult to find the reliable evaluation method to calculate precise value of trust.

Soft Computing is the best way to solve these types of problems; It works with approximate models. Soft Computing was introduced by Professor Lofti Zadeh [5] in 1994 to deal with imprecision and uncertainty. Fuzzy logic is used for formalization of approximate logic with the approximate reasoning, rules etc. Fuzzy logic imitates human mind which have approximate modes rather than precise.

Fuzzy logic is generally used as a solution for complex systems having uncertainty and ambiguity. Fuzzy logic is useful for automated systems to deal with uncertainty. Fuzzy logic makes human beings capable enough to map approximate knowledge capabilities to knowledge based systems. The fuzzy sets concept is based upon grades which belong to degree of membership; variables represent imprecise concepts as linguistic variables.

Output is drawn as per input given in fuzzy inference process using fuzzy logic. The fuzzy variables are decomposed into logical number of fuzzy sections. Each section must overlap somewhat between 10% and 50% with its neighbours. The fuzzy inference process involves membership functions, logical operations and rules. It can be implemented with the help of Mamdani or Sugeno type. Fuzzy set is produced as an output in Mamdani type fuzzy inference, whereas either constant or a linear (weighted) mathematical expression is in Sugeno-type inference.

The uniqueness of this paper is the use of fuzzy logic to deal with imprecise values. This paper proposed solution in the form of a fuzzy inference system to evaluate the trust of an agent based system. A Graphical User Interface (GUI) is also proposed for ease to use of fuzzy inference system for users, not familiar with MATLAB.

In this paper MATLAB is used to develop the fuzzy inference system and GUI. Fuzzy logic toolbox helps to solve problems having trade off between significance and precision which is managed by human beings [6]. GUIDE (graphical user interface design environment) is used for designing customised application with the help of several tools. GUIDE helps to design user interface and it automatically generates the code for user interface [7]. The behaviour of MATLAB file can be updated according to application. In Section II related works are explained whereas in Section III objectives are discussed. Section IV proposed a methodology of fuzzy inference system. In Section V, a fuzzy inference system is proposed to evaluate the trust. A Case study based on security system is discussed. At the end validation of fuzzy inference system is presented. In last section VI, conclusion is outlined.

2. RELATED WORKS

The literature has been analysed and relevant research is done on the evaluation of trust on agent based systems. The proposed approaches have not used soft computing techniques.

A simulator is proposed by Mieczyslaw A. Klopotek et al. [8] to measure up different trust algorithms. In these network four types of node defined i.e. good family nodes, neutral family nodes and bad (evil, hostile) family nodes. The nodes with attractive information for agents come into the good family nodes. The nodes have nothing significant information, are in category of neutral nodes. Bad family nodes wipe out other agents, if they interact. The algorithms are proposed to uncover the bad nodes *i.e.* ebay, average, EigenTrust, BetaSystem, among these BetaSystem is found as the best algorithm in unknown network environment.

Hongwei Tao et al. [9] defined metric model to measure the trustworthiness of software on the basis of attributes of software and four critical attributes trust criteria of monotonicity, acceleration, sensitivity and substitutivity. The scale of trustworthiness in model is to be a symbol of quality in this model and the above attributes will contribute and their contribution solely varies for different types of software.

Mansura Habiba [10] defined suit of metrics which is inclined on attributes *i.e.* safety or trust, openness and efficiency of Multi Agent Systems Architecture. These suggested metrics are assessing the excellence in different problem domains and system architectures. Validation is aligned with two different problem domains, one is complex emergency disaster management and other is library management. This is also authenticated on five different architectures. These metrics are applicable on different scope *i.e.* metrics for openness is out of scope for non-open multi-agent system.

Anna Gutowska et al. [11] proposed a framework to collect and provide reputation ratings about the seller's. Two types of agents are used: User Agent & Provider Agent (Web Service). User agent creates a network to exchange their transaction ratings. These ratings are based on compulsory and optional parameters. Based on that reputation metric is calculated which is the average of compulsory parameter rating and optional parameter ratings. Jones Granatyr et al. [12] proposed trust and reputation model on the basis of dimensions, principles and types of interaction. With the analysis, we proposed a framework to calculate the trust in quantity with the help of fuzzy inference system. This system helps the virtual communities to trust on each other on the basis of precise value.

3. OBJECTIVE

The objective of determining the trust is as follows:

1. To Design a Mamdani fuzzy inference system in MATLAB.
2. Design Graphical User Interface (GUI) for easy to use.
3. To validate the fuzzy inference system on Agent Based Systems.

4. METHODOLOGY

2.1. Subjects

We recommend an agent based security system and two agent based applications namely Book Trading and Party applications. These applications have been taken from jade.tilab.com. All applications have been developed in Java Agent Development Environment (JADE).

2.2. Research Instrument

1. Fuzzy tool of MATLAB 7.7.0.471 (R2008b).
2. Graphical User Interface Development Environment (GUIDE) of MATLAB 7.7.0.471 (R2008b).

2.3. Procedure

In the present study, a fuzzy inference system is developed in MATLAB to evaluate the trust of an agent. For calculating trust, four input variables are used *i.e*. Reliability, Negotiation, Failure Analysis and Generality. The output variable i.e. trust is evaluated using fuzzy inference system. A Graphical User Interface (GUI) has also been prepared for the convenience of users of this system. The procedure of framework is shown in Figure 1.

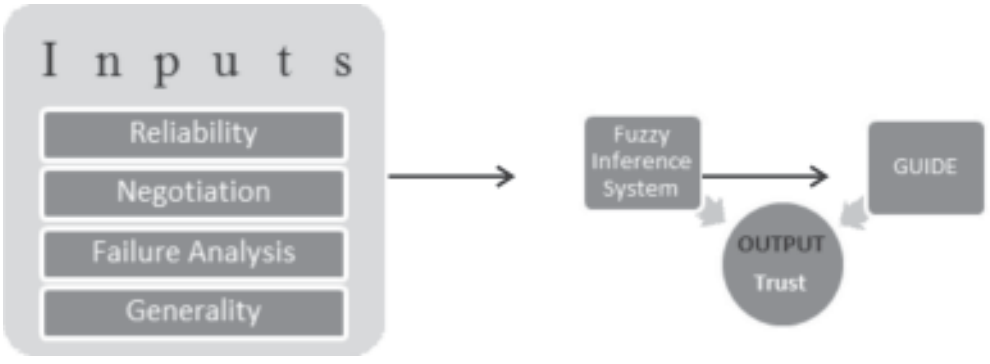

Fig. 1. Framework of evaluation of trust

2.4. Rule Base

Forty Six rules have been formed and used to evaluate the trust built upon four aspects *i.e*. Reliability, Generality, Negotiation, and Failure Analysis. Reliability plays major role in assessment of trust, Pressman [13] said that software reliability is the probability of failure free operation in particular environment for a specified time. Generality

refers to the variety of tasks performed by system. Negotiation means the process of coordinating the activities during agent communication for accomplishment of goal. Failure Analysis relates to correction of errors and estimation of costs of the same. We support that reliability carries higher priority than other aspects, therefore it impacts trust majorly as compared to other aspects.

2.5. Inference

Inference is used to obtain the membership value and performs deductive calculation by using information with various methods. Many different shapes may be defined to represent the membership functions such as: triangular, bell shaped etc. For MIN inference, the output member function is cut off, whereas in PRODUCT inference, it is scaled by the rule.

2.6. Composition

A fuzzy subset for output variable is formed by those subsets which are assigned to each output variables. For composition MAX or SUM are used. In MAX composition, the maximum point of fuzzy subsets is aggregated output fuzzy subset. For SUM composition, the sum of the fuzzy subset is assigned to the output variable by inference rule.

2.7. Defuzzification

S.N. Sivanandam et al. [14] said that the conversion process of fuzzy quantity into a concrete quantity is called Defuzzification. Defuzzification trims down a collection of membership values on unit interval into single scalar quantity. Two fundamental techniques are used for defuzzification i.e. centroid and maxima. The precise output value is evaluated by finding a balance point of a property that can be the total geometric figure, the weight of each fuzzy set, the area of the largest fuzzy set or the area of the largest intersection. The maxima method evaluates the variable values with maximum truth value as precise value for output variable.

2.8. Graphical User Interface Development Environment (GUIDE)

GUIDE (graphical user interface design environment) provides tools for designing user interfaces for customized applications. GUIDE helps to design user interface and automatically generates the code for user interface. The behaviour of MATLAB file can be updated according to the application. It provides a way to easy use of system to the user.

5. PROPOSED SYSTEM

A Fuzzy Inference System is designed in MATLAB to validate the trust metric. As stated above Trust shall depend upon Reliability, Generality, Negotiation, and Failure Analysis. The fuzzy variables are decomposed into logical number of fuzzy sections. Each section must overlap somewhat between 10% and 50% with its neighbours. Each of which has three membership functions i.e. LOW, MEDIUM and HIGH (Figure. 2). Output variable trust also has five membership functions: VERY LOW, LOW, MEDIUM, HIGH and VERY HIGH.

Input variables like Reliability, Generality, Negotiation, and Failure Analysis are fuzzified with the help of triangular shaped membership functions. In this type of membership function, values are either strictly increasing or strictly decreasing. For triangular shaped member function trimf is used. The output fuzzy set is shaped by degree of support. The output fuzzy set assigned by the consequent (trust) of fuzzy rule. The linguistic variables are indicated to choose for representation of this fuzzy set. Forty six rules are designed in this system. The output fuzzy sets for each rule are combined into a single output fuzzy set. At last, the resulting fuzzy set is defuzzified.

A GUI is designed using GUIDE in MATLAB to enhance expediency of users. The values of Reliability, Negotiation, Failure Analysis, Generality are given as input by user and trust factor is evaluated by clicking on Evaluate button. This is done with the help of integration of fuzzy inference system with GUI shown in Figure 3. This experiment evaluates the value of trust of agent.

Fig. 2. Fuzzy inference system.

5.1. Case Study : Security Alarm System

Security plays a major role in our lives. Here we discuss security in the respect of organization, home etc. Normally each organization is equipped with security systems *e.g*. guards, alarms. We believe that it is difficult to manage security in all sensitive areas. Following are areas to provide the security:

1. Location of threats *e.g*. Parking area
2. High activity area
3. Sensitive areas

Different prevention strategies are followed by organizations. Some of them are following:

1. Guards for checking employees
2. Proximity cards for employees
3. Escorts for management people
4. Better lighting in all areas

Fig. 3. GUI for evaluation of trust.

Still there are chances of threats because of human error. Guard permit the persons who have I-card with them. It is not necessary that the image on I-card exactly matches with the face of the person carrying card due to number of reasons. Reasons may be certain changes in face with age or hair style, weather etc. Guard may permit all the persons having I-card without checking the details. So there is a threat that superfluous person can enter the organization causing destruction.

Proximity cards are used to mark attendance as well as to verify the identity of an employee. It is not necessary that proximity cards are scanned by the person to whom it is issued. Proximity cards are often misused if stolen by superfluous persons.

Because of these reasons, Security systems can be automated for better results. Automated security systems add safety and provide better solutions for unknown threats. These types of systems control the lighting and 24 hours close monitoring of all areas where you cannot reach.

It can be easily managed by agent based system. Because of its situatedness nature, the agent stays, observes the surroundings and raises the alarm as changes occur in the environment. Agent stays in the organization and continuously keeps on observing it. If any undesirable person or activity is observed, agent activates itself. It sends the signal to raise the alarm and also call the security to manage the undesirable activities. The security system is managed by different agents and process to be followed by different agents is described with the help of Figure 4.

The different agents participate to achieve the goal to maintain the security. Each agent has their own designated tasks in the system. They cooperate, coordinate, and interact with each other for safe and secure surroundings. The working of agent is described below:

1. **Home Agent :** Home agents are placed at sensitive areas. All susceptible areas are under observation all time. Home agent aims to observe the surroundings constantly to manage the security. Home agent needs the images and details of undesirable activity. Home agent performs the following tasks:
   - It perceive the environment
   - Reacts on objectionable entity or activity
   - Sends the signal to Call agent.
   - Detects the objectionable entity or activity
   - Sends the signal to alarm agent
2. **Alarm Agent :** Alarm agent gets activated by the Home agent. Alarm agent waits to get signal from Home agent and raises the alarm and gives alert to security persons. Securities staff gets alert at the same time and they can reach the appropriate location and take action against it. As security alarm is raised security staff gets the position of unauthorized activity. Security staff starts taking action for that. Following actions are taken by Alarm agent:
   - Raise the alarm
   - Send the location to security staff
   - Get the location of unauthorized activity
   - Detect the type of activity

Fig. 4. Process of security alarm system.

3. **Call Agent :** Like Alarm agent, Call agent also gets activated by the Home agent. As they get trigger by home agent, they make a call to security head or police as set in the software. The responsibility of call agent also depends upon the type of activity. The activity risk can be categorized into different ranges i.e. low, medium and high. For low risk there is no need to make a call. In medium risks only organization authorities are to be informed. Whereas in high risks information is sent to higher authorities as well to police. The activities performed by the call agent are:
   - Identify the risk
   - Categorize them
   - According to category make a plan
   - Make a call on the basis of agent

   The benefits of automated security system are as follows:
   - Home agent is more vigilant than human guard.
   - Home agents can be placed in all areas
   - Alarm agent raises alarms in shorter time rather humans
   - Call agent informs the security persons as well as authorities at the same time while human may take more time to communicate.

5.2. Validation

In the experiment, trust is measured with the help of a fuzzy inference system. For the evaluation of trust, we need to analyse factors *i.e.* Reliability, Generality, Negotiation, and Failure Analysis. The factors Reliability, Generality, Negotiation, and Failure Analysis are employed as input variables; Trust is treated as output variable. In the above security system reliability of Alarm agent and Call agent build upon the Home agent and time to send signal by Alarm agent and activation time of self. In this system, multiple Home agents work together. If one Home agent is not being able to work then another agent automatically works on its behalf. The work of Call agent is to identify the type of risk; on the basis of risk, negotiation is done to make a call. In the security system, Generality and Failure Analysis are low, whereas Negotiation is medium and Reliability is high, so trust is medium.

We have also tested our system on agent based applications like Book Trading and Party applications developed in Java Agent Development Environment (JADE). We have run these systems almost one hundred times with different inputs and different number of agents, On that basis, result has been evaluated.

In Book Trading system, two types of agents i.e. seller agent and buyer agent participate. In this system, multiple seller agents sell books, where as buyer agent buy the book on behalf of user with lowest price available. The Reliability and Negotiation is high in the system because book with lower price is bought by buyer agent, Generality and Failure Analysis is found low, on the basis of that we can say that trust factor is also high in this system.

In party application, one host agent and multiple guest agents communicate with each other. The host agent is responsible for initiating party by inviting guests. As the party starts, host agent selects one guest agent and tells the rumor and introduces two guests. Guest agent also initiates introducing each other and spreading rumor among them. If rumor is heard by guest agent for the first time, they tell the host. If all guest agents have heard the rumor, the party ends. In this application, Reliability is high and Generality, Negotiation and Failure Analysis are low, so trust is medium.

5.3. Result Analysis

Trust helps agents to believe for achievement of goal. In agent based systems, agents are communicating with each other for performance of task. Each agent will do either designated task or do autonomously. For the measurement of trust, study has been done in detail for agent based systems. Reliability and negotiation have major impact on evaluation of trust, whereas generality and failure analysis are founded as lower comparing to others. The fuzzy inference system is evaluated on agent based systems for finding the trust. As result, it is found that trust is high in book trading system and medium for party and security system. We have tested our fuzzy inference system on agent based systems; according to the results it is believed that this system helps to evaluate the trustworthiness of system.

6. CONCLUSION AND FUTURE WORK

In Agent based systems, agents communicate with each other for attainment of their objectives. This can be effectively done if agents have trust among them. In real life trust value is treated to be subjective, so a method is required which provides some precise value to the system. Fuzzy logic is the best answer for these types of evaluations. A fuzzy inference system was proposed to evaluate the trust as precise value for better communication among agents. In this system four input factors were taken which were Reliability, Generality, Negotiation, and Failure Analysis and trust was taken as an output. A GUI is also proposed to use fuzzy inference system easily by all type of users. We also validated our system on a security system and two agent based systems were developed in JADE. We conclude that our fuzzy inference system produce accurate, factual and truthful results.

Further result can be evaluated with other soft computing techniques. Hybridization of approaches can be done *i.e*. neuro-fuzzy, fuzzy-neuro etc. The results can be obtained from other techniques and cross validation can be done.

7. REFERENCES

1. L. Northrop, P. Feiller, R. P. Gabriel, J. Goodenough, R. Linger, T. Longstaff, R. Kazman,,M. Klein, D. Smidth, K. Sullivan, and K. Wallnau, "Ultra-Large Scale Systems: the Software Challenge of the Future", B. Pollack Ed., Software Engineering Institute, Carnegie Mellon, 2006.
2. Michael Wooldridge, "An Introduction to Multiagent Systems", "John Wiley & Sons"
3. Sangeeta Arora, Dr. P. Sasikala, Dr. C.P. Agarwal ,Dr. Arun Sharma, 2012, "Developmental Approaches for Agent Oriented System – A Critical Review", CONSEG 2012.
4. Sangeeta Arora, Dr. P. Sasikala, 2015, "Proposal for Performance Evaluation of Agent Based Systems", CSI-2015
5. Lofti Asker Jadeh, George J. Klir, Bo Yuan, Fuzzy Sets, Fuzzy Logic, and Fuzzy Systems, Publisher World Scientific, ISBN 9810224214, 9789810224219
6. http://in.mathworks.com/help/fuzzy/what-is-fuzzy-logic.html
7. http://in.mathworks.com/discovery/matlab-gui.html
8. Mieczyslaw A. Klopotek, Michal Wolski, 2006, "Simple Reputation Metrics for Mobile Agent in Open Environment", "Proceedings of the International Multiconference on Computer Science and Information Technology", pp. 253 – 261
9. Hongwei Tao, Yixiang Chen, 2009, "A Metric Model for Trustworthiness of Softwares", "Proceedings of IEEE Conference on Web Intelligence and Intelligent Agent Technologies", pp.69-72
10. Mansura Habiba, 2012, "Metrics for Evaluating Agent Oriented Software Engineering Model", "Proceedings of IEEE Conference on Informatics, Electronics & Vision", pp.17-22
11. Anna Gutowska, Dr Kevan Buckley, 2008, "Computing Reputation Metric in Multi-agent E-commerce Reputation System", "Proceedings of IEEE Conference on Distributed Computing Systems Workshops", pp. 255-260
12. Jones Granatyr, Vanderson Botelho, Otto Robert Lessing, Edson Emílio Scalabrin, Jean-Paul Barthès , Fabrício Enembreck , "Trust and Reputation Models for Multiagent Systems", ACM Computing Surveys, Volume 48 Issue 2, November 2015, Article No. 27
13. Roger S. Pressman, "Software Engineering: A Practitioner's Approach", McGraw-Hill Series, ISBN 0073655783
14. S.N. Sivanandam, S.N. Deepa, "Principles of Soft Computing", Wiley-India, 10:81-265-1075-7