Expert Systems with Applications 38 (2011) 10240–10251

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Trust estimation in a virtual team: A decision support method

Zhi-Ping Fan [a], Wei-Lan Suo [a,b,*], Bo Feng [c], Yang Liu [a]

[a] Department of Management Science and Engineering, School of Business Administration, Northeastern University, Shenyang 110004, China
[b] Institute of Policy and Management, Chinese Academy of Sciences, Beijing 100190, China
[c] Department of Decision Sciences, School of Business Administration, South China University of Technology, Guangzhou 510640, China

ARTICLE INFO

Keywords:
Decision support
Trust estimation
Virtual team
Multiattribute decision analysis (MADA)
2-Tuple fuzzy linguistic representation model

ABSTRACT

Trust plays an important role in the operation and management of virtual teams. It is also a foundation of the cooperation between members. In the operation of a virtual team, trust estimation is a very significant issue to know about the trustworthiness of each member and cooperation situations between members. The purpose of this paper is to propose a decision support method for estimating the trust level. A trust estimation framework with two dimensions of reputation and collaboration is developed. From this, a fuzzy multiattribute decision analysis (MADA) approach based on the 2-tuple fuzzy linguistic representation model is proposed to measure the performances on reputation and collaboration. By the measurements of the performances, the trust level of each member and the virtual team can be identified so as to improve the management of the virtual team. Furthermore, a Web-based trust estimation system (WTES) is designed and developed to support the activities of trust estimation in a virtual team. Finally, an application is provided to illustrate the applicability of the proposed decision support method.

1. Introduction

With the development of information and telecommunication technologies, more and more organizations, especially those tackling with knowledge-intensive R&D projects, are adopting the form of virtual teams to accomplish various tasks (Chen, Chen, & Chu, 2008; Hung, Dennis, & Robert, 2004; Kanawattanachai & Yoo, 2002). Virtual team is a group that consists of geographically and/or temporally dispersed members (Jarvenpaa & Leidner, 1999; Powell, Piccoli, & Ives, 2004; Zhu & Zhou, 2006). It has quite a number of advantages over traditional teams, such as the better utilization of distributed human resources without physical relocation of employees (Lipnack & Stamps, 1997), remote asynchronous and real-time collaboration (Warkentin, Sayeed, & Hightower, 1997) and so on. In a virtual team, members can share their knowledge and resources to jointly develop new products, new technologies, or practical solutions (DeSanctis & Monge, 1999; Lavrač et al., 2007). However, the operation of a virtual team is more complex than that of a traditional one. Virtual team is a loose formation based on common interests of members who do not usually collaborate based on formal contracts and obligations (Lavrač et al., 2007) and lack the face-to-face communication (Cascio, 2000; Hung et al., 2004; Jarvenpaa & Leidner, 1999). In the operation and management of a virtual team, trust plays a very important role (Greenberg, Greenberg, & Antonucci, 2007; Kanawattanachai & Yoo, 2002; Lipnack & Stamps, 1997; Piccoli & Ives, 2003) and it is also a foundation of the cooperation between members (Kanawattanachai & Yoo, 2002; McAllister, 1995). The higher trust level of members could produce more positive attitudes (Dirks & Ferrin, 2001), maintain favorable cooperation relationships (Zhang, Liu, & Zhu, 2008), facilitate communication and knowledge sharing between members (Levin & Cross, 2004; Renzl, 2008), and finally promote the team performance (Iacono & Weisband, 1997; Jarvenpaa & Leidner, 1999; Kanawattanachai & Yoo, 2002; Keyzerman, 2003). Whereas, the lower trust level of members would hamper a team to accomplish tasks effectively (Iacono & Weisband, 1997). Thus, it is a necessary and significant work to estimate the trust level of members in a virtual team. Through trust estimation, team leader(s) could know about the trustworthiness of each member and cooperation situations between members.

Some studies dealing with the trust estimation problems can be found (Castelfranchi & Falcone, 2001; Chen & Chen, 2009; Chen et al., 2008; Lavrač et al., 2007; Msanjila & Afsarmanesh, 2008; Mun, Shin, Lee, & Jung, 2009; Schmidt, Steele, Dillon, & Chang, 2007; Zhang et al., 2008). In these studies, reputation and collaboration are regarded as two important perspectives of trust estimation. Furthermore, the trust level is usually measured by aggregating the performances on reputation and collaboration. For example, Lavrač et al. (2007) proposed a hierarchical multiattribute decision support model to estimate the trust level of a collaborative network organization, where the trust level is measured by computing a weighted sum of scores of reputation and collaboration.

* Corresponding author. Address: Department of Management Science and Engineering, School of Business Administration, Northeastern University, Shenyang 110004, China. Tel.: +86 24 8368 7753; fax: +86 24 2389 1569.
E-mail addresses: zpfan@mail.neu.edu.cn (Z.-P. Fan), suoweilan_neu@yahoo.com.cn (W.-L. Suo).

0957-4174/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2011.02.060

Various trust estimation models proposed in previous studies significantly contribute to solving the problem of trust estimation. However, some limitations occur when these models are applied. Although the trust level can be estimated using a model by aggregating the performances on reputation and collaboration, e.g., a weighted sum model, the trust estimation result could not clearly reflect the real situation of reputation and collaboration, respectively. In deed, reputation and collaboration should be respectively measured because their meanings are different. If the performances on reputation and collaboration are both higher, then the trust estimation result could really reflect the higher level. On the other hand, few models for estimating the trust level involve processing multiple formats of assessment information, such as fuzzy linguistic terms, crisp numbers and so on. In fact, both subjective assessment information with human perception and objective assessment information based on actual situations are often used in trust estimation, where they can be of multiple formats. Moreover, it is necessary to point out that the existing studies on trust estimation mostly focus on models or methods, whereas implementations of decision support systems for trust estimation are neglected. It is also important how to design or develop a decision support system since the trust estimation in a virtual team is a periodic activity that involves several decision procedures. Hence, to solve the above problems discussed, it is necessary to develop a new decision support method for estimating the trust level. This is the motivation of our study.

The purpose of this paper is to propose a decision support method for estimating the trust level. A trust estimation framework with two dimensions of reputation and collaboration is developed. On the basis of the framework, a fuzzy MADA approach is proposed to measure the performances on reputation and collaboration, where the 2-tuple fuzzy linguistic representation model (Herrera & Martínez, 2000) is used to process fuzzy linguistic terms and crisp numbers involved in the estimation process. Furthermore, to solve the practical trust estimation problems using the proposed method, a Web-based trust estimation system (WTES) is designed and developed to support the activities of trust estimation.

This paper is organized as follows. Section 2 presents the background and related work on trust estimation. Section 3 presents a trust estimation framework with two dimensions of reputation and collaboration. In Section 4, a fuzzy MADA approach based on the 2-tuple fuzzy linguistic representation model is proposed to measure the performances on reputation and collaboration. In Section 5, a WTES is designed and developed to support the activities of trust estimation in a virtual team. In Section 6, a real example is used to illustrate the application of the proposed method. Finally, Section 7 summarizes and highlights the main features of the method proposed in this paper.

2. Background and related work

2.1. Concepts of trust

Trust is an interesting topic. It has been paid attention by many scholars from different disciplines, such as psychology, sociology, economics, philosophy, computer science, and management science. In the existing research, various definitions of trust have been proposed (Artz & Gil, 2007; Deutsch, 1958; Geyskens, Steenkamp, & Kumar, 1999; Grandison & Sloman, 2000; Mayer, Davis, & Schoorman, 1995; North, 1990; Renzl, 2008; Zucker, 1986). Also, corresponding antecedent and outcome factors of trust have been identified (Artz & Gil, 2007; Boyle & Bonacich, 1970; Cook & Wall, 1980; Mayer et al., 1995; Williamson, 1993). Table 1 presents a summary of definitions, antecedent and outcome factors of trust.

In addition, some scholars have studied the components of trust in virtual teams (Greenberg et al., 2007; Jarvenpaa, Knoll, & Leidner, 1998; Kanawattanachai & Yoo, 2002; Nakayama, Binotto, & Pilla, 2006). Herein, Greenberg et al. (2007) showed that trust is composed of three components: ability, integrity and benevolence, all of which play important roles in different stages of establishment and operation of a virtual team. Jarvenpaa et al. (1998) emphasized that trust depends on members' ability, benevolence and integrity. Kanawattanachai and Yoo (2002) showed that trust relies more on cognitive components (e.g., competence, reliability, professionalism) than affective ones (e.g., caring, emotional connection to each other) through an empirical study. Nakayama et al. (2006) pointed out that trust is related to competence, loyalty and receptiveness.

2.2. Trust estimation models

Various conceptual models have been proposed to deal with the trust estimation problems in different scenarios such as multi-agent systems, virtual organizations/enterprises or virtual teams. For example, Castelfranchi and Falcone (2001) proposed a socio-cognition-based trust model, which is used to support decision makers to make a rational decision on agent delegation. In this model, the trust state between two agents is determined by their mental ingredients (beliefs and goals). Schmidt et al. (2007) proposed a customizable trust estimation model for multi-agent systems based on fuzzy logic. In this model, the trust level of an agent is estimated by the integration of business interaction reviews and credibility adjustment. Richardson, Agrawal, and Domingos (2003) proposed a trust estimation model for Semantic Web. Using this model, one user's trust level can be measured according to the trustworthy user sets specified by others. Based on the work of Richardson et al. (2003), Lavrač et al. (2007)

Table 1
Definitions, antecedent and outcome factors of trust.

Disciplines	Definitions	Antecedent factors	Outcome factors	Sources
Psychology	One's expectation and predictability about the likelihood that another's future actions will be beneficial and favorable	Trustworthy intentions; ability; intention to produce	Belief	Cook and Wall (1980) and Deutsch (1958)
Sociology	Socially embedded properties to represent the relationships between people	Past interactions; motivation	Ascription; social cohesion	Boyle and Bonacich (1970) and Zucker (1986)
Economics	A cause to reduce the opportunism among transaction parties	Index of caution based on prisoner's dilemma; contract	Economic performance	North (1990) and Williamson (1993)
Computer science	Mechanisms to verify that the source of information is real as it claims to be	Policies; competence; reputation	Security; privacy	Artz and Gil (2007) and Grandison and Sloman (2000)
Management science	Employees' faith in an organization's goal attainment, leaders and the belief that organizational action will be beneficial for them	Competence; integrity; benevolence	Satisfaction; long-term orientation; cooperation	Geyskens et al. (1999), Mayer et al. (1995) and Renzl (2008)