Expert Systems with Applications 38 (2011) 8466–8476

Contents lists available at ScienceDirect

Expert Systems with Applications

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

Virtual organization for open innovation: Semantic web based inter-organizational team formation

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ARTICLE INFO

Keywords:
Virtual team formation model
Knowledge and collaboration
Open innovation
Social network

ABSTRACT

Companies and research institutes are always threatened by rapid technological developments and corporate M&A. They are trying to secure a sustainable competitive advantage using outside knowledge and expertise under open innovation to overcome these shortcomings. As a quantitative and systematical method of selecting virtual team members for open innovation, we present a virtual team formation model and a prototype to verify its efficiency. The test scenario shows how to form a virtual team through internal and external human resources when developing a new product.

1. Introduction

Over the past 10 years, emergence of the web has brought about significant changes in society, including the IT market. These changes are expected to become even more dramatic owing to the evolution of web technology. With the emergence of web 2.0, which is based on the values of participation, openness, and sharing, the IT market is interested in a user-based service paradigm. The corporate environment is changing to a flexible environment that utilizes the concept of participation, openness and sharing. The web is becoming a platform in which the user directly participates in services and produces new business models, which are often referred to as "next-generation web" or web 3.0. The semantic web is the concept that always comes up when the future of the constantly evolving web is mentioned, and many experts consider this as the keyword of the next-generation web (Berners-Lee, Handler, & Lassila, 2006).

Like the changes in the web environment, the knowledge network known as the open innovation strategy in the corporate management paradigm is becoming a key factor that enhances corporate competitiveness through open innovation. Connect & Development (C&D) is one of the open innovation models to acquire novel internal and external ideas. Professor Henry Chesbrough of U.C. Berkeley stated, "Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. [This paradigm] assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology." He added that "an open business model will bring innovation" (Chesbrough, Vanhaverbeke, & West, 2006).

Open innovation through the external knowledge network is in the spotlight because firms are limited in maintaining competitiveness alone by themselves due to increasingly faster technological developments and fiercer competition. Accordingly, companies must build a knowledge network to get new external ideas and supplement the limited internal competence. External knowledge that is needed to reinforce competitiveness and core internal knowledge must be effectively blended for integration of knowledge. With this goal, many companies are collaborating or jointly performing research, and this process has the characteristics of virtual organization (VO).

How to find the external knowledge and expertise required for building a knowledge network for a company to survive and how to form a team for a project are the issues that arise in a complex and dynamic management environment where there are many competitors and new technologies. In this study, the concept of virtual organization was used to discover project opportunities, and to present a model to form a virtual team to successfully carry out the project, the internal and external experts were evaluated quantitatively in terms of knowledge and collaboration under a semantic web environment.

The rest of this paper is organized as follows. Section 2 surveys literature related to the semantic web, virtual organization, assessment of a team, selection of team managers and team members, and social network. Section 3 presents a model for semantic web

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doi:10.1016/j.eswa.2011.01.044

based virtual team formation (SVTF). Section 4 uses a prototype for testing the effectiveness and efficiency of the SVTF model, and Section 5 presents our conclusions.

2. Related works

2.1. Semantic web

The World Wide Web (WWW) proposed by Berners-Lee in 1989 greatly affected the distribution of information. Many people expressed their thoughts and research results in a simple markup language called HTML, and uploaded them onto the web for easy access and efficient sharing of information (Antoniou, Van Harmelen, & NetLibrary, 2004; Fensel, 2003). However, it became increasingly more difficult to find the information one wanted from the web's huge volume. Not only was there a great cache of information but application programs that provide services began to emerge. People began to experience difficulties in finding the appropriate programs and using them.

To overcome this problem, a method called software agent was proposed in the field of computer engineering. Software agent means an intellectual software that performs tasks for a person such as the search engine Google.

People started wanting to make such agents that would perform simple tasks more intellectually to satisfy the needs of their busy daily lives. This form of software agent cannot work properly because of the structural problem in the web. In other words, people can understand the information on the web but the software cannot. To overcome this problem, Berners-Lee proposed in 1999 a semantic web, a next generation web technology based on W3C (Antoniou et al., 2004; Berners-Lee et al., 2006; Fensel, 2003).

Semantic web emerged to provide a new space for intellectual agents. The content of HTML documents that is produced by humans must be expressed in the form of metadata to create the structural space for an intellectual agent to work. To express the HTML content to the software agent, the concepts or thoughts of humans must be expressed. Thus, a semantic concept is used to express the metadata for a software agent, and the expression of a semantic concept of a human for the software agent to understand is called ontology (Fensel, 2004).

In the new ontology, there exists a large scale ontology with hundreds of thousands of concepts using the high standard ontology with complex concept of Web Ontology Language (OWL) and the conditional concept technology including SWEET (Raskin & Pan, 2005) ontology used in aerial topography in NASA as well as the ontology in medical and bio fields. In the field of knowledge management, there has been research on knowledge representation (Jussupova-Mariethoz & Probst, 2007; Kamsu Foguem, Coudert, Béler, & Geneste, 2008), and knowledge sharing (Aziz, Gao, Maropoulos, & Cheung, 2005; Chen, 2008), as well as product information model (Giménez, Vegetti, Leone, & Henning, 2008; Zhao & Liu, 2008a, 2008b). In addition, research on integration of applications or different organizations is actively being carried out (Arroyo, Sicilia, & Dodero, 2007; Bellatreche, Dung, Pierra, & Hondjack, 2006; Fox, Barbuceanu, & Gruninger, 1996; Izza, Vincent, & Burlat, 2008; Jagdev, Vasiliu, Browne, & Zaremba, 2008; Lin & Harding, 2007).

2.2. Virtual organization/virtual enterprise

For companies and organizations to actively respond to today's rapidly changing environment, it is necessary to develop a mechanism to quickly change the network of companies, organizations, and persons to look for business opportunities. Virtual enterprise or virtual organization is the concept presented to meet this requirement. VO has been considered as one of the most promising paradigms for future collaborative networks (Camarinha-Matos & Afsarmanesh, 2001, 2003; Goranson, 1999; Park & Favrel, 1999; Schultze & Orlikowski, 2001). By definition, VO is "a temporary alliance of enterprises that comes together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks" (Camarinha-Matos & Afsarmanesh, 2001). By adopting the idea of highly flexible organizations and by reconfiguring themselves to cope with the needs and opportunities of the business environment, the organizations have been able to take advantage of a number of benefits such as agility, complementary roles, operational dimension, competitiveness, resource optimization, and innovation (Camarinha-Matos & Afsarmanesh, 2003). Since VO is somewhat large in size, a virtual team (VT) was used in this paper.

2.3. Assessment of a team

To evaluate the capability of a team, we must first evaluate the abilities of persons (usually researchers and professors), who make up the smallest units of the team. The persons can be evaluated by defining their abilities required for the project. Most researchers define the ability of project managers with indicators and attributes such as strategy, culture, knowledge, leadership, talent, and administration. The ability of each person is evaluated through the subjective evaluation of the department manager or expert (Bozbura, Beskese, & Kahraman, 2007; Huang, Huang, Huang, & Jaw, 2004; Pettersen, 1991).

To assess the abilities of team members, we focus on the knowledge (problem solving, technical skill) and the collaboration (interpersonal relations, interpersonal skill) factors which are the common elements of the abilities of a manager. To overcome the shortcomings of the findings obtained so far, it is necessary to evaluate the persons' qualifications for each new project's characteristics and perform the evaluation objectively and quantitatively in terms of knowledge and collaboration.

2.4. Selection of project team members

The model for selecting team members can be divided into two categories: models for forecasting the employees' performance by means of historical data in the organization (Chien & Chen, 2008; Huang, Tsou, & Lee, 2006) and models for selecting persons who meet the requirements for projects (Bhadury, Mighty, & Damar, 2000; Tsai, Moskowitz, & Lee, 2003; Tseng, Huang, Chu, & Gung, 2004).

In these models, evaluations rely on the department managers' subjective evaluations. Since there is no formulated way to select qualified team members required for a specific project, the project managers tend to select any number of persons who are acquainted with as project team members without any proper evaluation.

2.5. Social network

To measure the collaboration ability required for persons, we use the social network analysis (SNA). The SNA allows us to look into the collaboration and information flows in an organization (Dustdar & Hoffmann, 2007). The three major relationships of collaboration – communication, coordination, and cooperation – can be analyzed using the measures of SNA, such as density, degree centrality, and closeness centrality (Sofia Pereira & Soares, 2007).

Some studies have suggested a way of analyzing the organizations or industry sectors using SNA. Some studies provide informa-