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Towards an Agent-Oriented Business Collaboration Model

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ABSTRACT

Business collaborations have gained prominence in many domains mediated by information technology platforms. These collaborations, normally referred to as virtual enterprises (VEs) consider varying core competencies of participants. The VEs' dynamic nature requires participants to be dynamically selected and engaged. This requires a flexible systematic approach, lacking in existing literature, to handle varying forms of VEs. This study aims to consider a VE from an enterprise integration viewpoint and to develop an agent-based model that supports the VE's formation and operation phases. This model will provide support to business managers in making decisions efficiently by delegating part of the processes to software agents. An agent-based VE (ABVE) model prototype is developed. Case studies from various domains are used in the demonstration of the model's applicability and possible generalization. After evaluation it is shown that users are motivated to use the model as an effective tool for VE formation and collaborations in diverse domains with an 88.86% acceptance rate.

KEYWORDS

Agent-Based Model, Search and Selection, Team Formation, Virtual Enterprise

1. INTRODUCTION

1.1. Background

It is becoming a trend for enterprises to team up with a view of enhancing their competitive edge over their peers in the marketplace and to adapt to the technological innovations that are rapidly changing the business landscape. In these marketplaces, the consortium of these enterprises can effectively handle new business opportunities. A virtual enterprise (VE) is an alliance of autonomous entities (individuals, businesses), that have a common goal and work together, in a collaborative way. To achieve the goal, they collaboratively employ their varied competences and resources. It is of critical importance that business to business (B2B) relationships are effective as they enable the organizations to enhance their own ability to be more competitive. This research focuses on supporting B2B

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collaborations by using software agents. A crucial competitive factor of a VE is its ability to form an alliance that is customer focused.

In slightly over a decade, there have been a number of VE implementation models being proposed as highlighted in (Camarinha-Matos, Afsarmanesh, & Ollus, 2005; Romero & Vernadat, 2016). Industrial applications of VEs have been developed for the following industries: automotive industry, electronics and telecommunications, IT, building construction, transportation, chemical, food, textile, moulds among others. Manufacturing and supply chain are typical problems solved by VEs.

The lifecycle of a VE is divided into three phases (Pego-Guerra, 2006): 1) formation, 2) management and 3) dissolution. The formation phase establishes the goal and the objectives of the VE, according to the product demand. It also identifies the functional requirements that organization needs to fulfil. After the functional requirements are known, the core capabilities needed by VE are determined. Several enterprises may have these core capabilities, but only few of them are selected as members of the VE. This process is defined as the partner evaluation and selection process. Once the partner evaluation and selection process is finished, the VE enters its management phase. The management phase focuses on how to achieve the goals and objectives of the VE. In the management phase, members collaborate and integrate their core competencies to satisfy the functional requirements, identified in the formation phase. The performance of partners is also evaluated in this phase. Finally, once the product demand is met, the VE dissolves, and its members find other value-adding chains, where their core capabilities can be used. The dissolution phase deals with ending the relationship among partners and eventually the evaluation of the results of the collaborative work.

One of the approaches applied in modelling VEs is the use of multi-agent systems approach (Musumba & Wamuyu, 2016). There are many past works focusing on agent-based approaches and systems. However, they do not address a VE model holistically. They simplify the concept of a VE and focus on a single aspect or a single phase in the lifecycle of a VE. Existing works also lack solutions that are flexible and applicable across diverse sectors. Existing models lack dynamism and are incapable of handling varied VE requirements in diverse domains. Various partner selections and collaboration processes exist but are non-adaptive to diverse domains. They are also human resource intensive and costly. Integration of human negotiation capabilities in the VEs, which are key in forming practical consortia is seldom.

This work proposes a systematic approach to modelling VEs so that various forms of VEs can be realized thus allowing flexibility. This is demonstrated by the use of case studies from varied domains. This study spans software agents' technology and virtual enterprises. Software agents' technology is considered to be a special branch of distributed artificial intelligence (DAI). This study uses case scenarios to demonstrate the applicability and possible evaluation of the model.

1.2. Problem Formulation

The Virtual Enterprise formation and collaboration problem can be formulated using 'the switching principle' (Mowshowitz, 1999), which separates the abstract requirements of the tasks from their satisfiers. Switching is the dynamic assignment of satisfiers to the abstract requirements in such a way that the strategic goals of the VE are met. The abstract requirements are the needs of the tasks and the satisfiers are the resources required to meet those needs. In this problem, the tasks identified during problem analysis are the abstract requirements, and the partners are the satisfiers of those tasks. In principle, the problem can be interpreted as an assignment problem and represented using a bipartite graph, as shown in Figure 1 as adapted from Musumba and Wamuyu (2016).

As described in Musumba (2017), a bipartite graph is a graph whose vertices can be divided into two independent sets, for example, U for enterprises and V for activities, such that every edge (u, v) connects a vertex from U to V and (v, u) from V to U. There is no edge that connects vertices of same set. In Figure 1, the activities are represented on the right and the enterprises on the left. It represents a pool of potential partner enterprises and the project tasks. That is, many enterprises can have the competencies needed for several tasks and one task can be implemented by more than one