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An advanced adoption model and an algorithm of evaluation agents in automated supplier ranking

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ABSTRACT

Intelligent evaluation agent has been the most recent attempt toward automated supplier bid selection based on customer preferences. It has been proven to have advantages for successful supply chain coordination. Based on a formerly implemented real-time supply chain coordination system using intelligent agents, this work further investigates the problem to devise an intelligent fuzzy algorithm to evaluate supplier bids without direct human intervention. The general decision model of agent technology adoption has been explained in detail to provide a roadmap for managers and engineers in their movement toward multi-agent working environments. Then, the hybrid evaluation mechanism has been discussed step-by-step. Afterward, the approach has been carefully implemented and verified via a real-world case study. In this regard, a collection of twelve assessment criteria classified in two categories of customer suggestions and design specifications have been considered. This work has key advantages over earlier ones, including: modeling agent technology adoption in supply networks, description of an autonomous assessment mechanism using intelligent agents, making the best out of three useful methodologies of F-AHP-QFD, considering features of customer order and his/her preferences throughout the decision making process, and coordination of supply processes using a bidding system based on pervasive and ubiquitous computing mechanisms.

1. Introductory words

Putting the concept of autonomous real-time coordination of supply chains into action has been the main subject matter of our recent research and publications [1–9]. The major purpose of the project has been to employ the power of ubiquitous and pervasive computing based on intelligent agents (as useful tools of distributed artificial intelligence) in order to design and implement different modules required in a typical supply chain coordination system. The detailed description of an autonomous system for supply chain coordination is presented in Appendix A. One of the critical jobs in such a system is to evaluate and select suppliers properly. The procurement phase in the coordination process plays a strategic role and external suppliers exert an ever growing pressure on the success or failure of a business [10,11]. This article proposes the basics of a supplier evaluation agent that selects the best supplier bid using a hybrid algorithm. This algorithm has been explained comprehensively and has been verified in practice. On the other hand, agent technology adoption in such environments needs an accurate decision model which has been explained in detail. The rest of this section introduces distributed artificial intelligence and supplier evaluation agent, and summarizes the following sections.

1.1. Distributed artificial intelligence (DAI)

Literature on distributed artificial intelligence (DAI) is chiefly concerned with how automated agents can interact and solve problems effectively. A number of earlier articles [12–17] briefly explain the research areas of DAI and divide them

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into two main groups:

(1) DPS (Joint Distributed Problem Solving), which considers how the work of solving a particular problem can be divided among several processors. Each of the processors is intelligent, but they all have a common goal and common preferences.
(2) MAS (Multi-Agent Systems), which coordinates intelligent behavior among a set of autonomous intelligent agents. Each one may have different goals and different interests, which may conflict with the interests of other agents in the system.

In the supposed environment, each partner (supplier, customer, buyer, etc.) has its own preferences regarding the solution to be achieved, and the interests of different agents may conflict. There are different approaches for solving supply chain coordination problems and resource allocation problems in MAS environments. Often, techniques from game theory and economics are applied to MASs, since these fields are concerned with solving similar problems among human players, assuming that each player is self-motivated [18–21]. Negotiation is proposed in DAI as a means for agents to communicate and negotiate in order to arrive at mutually beneficial agreements. It is used in DPS environments in order to find a mutual agreement among agents with conflict knowledge and abilities [22].

1.2. Supplier evaluation agent

Supplier evaluation is a term used in business and refers to the process of evaluating and approving potential suppliers by realistic and measurable assessment. The purpose of supplier evaluation is to ensure a portfolio of best in class suppliers is available for use [23]. Supplier evaluation is also a process applied to existing suppliers in order to measure and observe their performance for the purposes of reducing costs, mitigating risk, and driving continuous improvement [24]. The "Supplier Evaluation Agent" holds an "Evaluation Engine" to be used in its real-time decision making processes. There are three parties influencing the decision on which supplier bid to select: customers, manufacturers, and suppliers. In fact, the best choice is the result of the best trade-off between the constraints imposed by all parties.

The evaluation agent makes use of an advanced precise mechanism to assess supplier bids based on the designated criteria in real-time. The mechanism is composed of Fuzzy logic combinations with AHP and QFD. This research investigates the decision model for agent technology adoption and then presents the detailed structure of the evaluation engine.

1.3. Paper organization

The article is organized as follows; Section 2 proposes the adoption model and structure of evaluation agent. The concepts will be verified through a real-world case study in Section 3. This section prepares all the practical steps to put the assessment model in execution. Sections 4 and 5 have been devoted to discussing the methodology, suggesting areas of research for interested academics and practitioners, and outlining the concluding remarks. The paper ends with a list of resources referred to throughout the text and list of acronyms used in the article is given in Appendix B.

2. Adoption model and structure of evaluation agent

2.1. Decision process of agent technology adoption

The domain of application for the intelligent evaluation model has been intended to be all organizations with decentralized single-product supply chain of at most three tiers where a potential need for agent technologies exists. Such organizations potentially adopting agent technologies have been represented as individual nodes in the sample graph of Fig. 1. Directed connections (edges) between nodes have been used to represent the influence of one organization over another in a decision to adopt or not adopt agent technologies. Thus, for example, a company making large or frequent purchases may be able to influence technology decisions of its suppliers. Because different industries have different degrees of concentration and different networks of influence, several different network topologies have been considered which are believed to be representative of the diversity of real-world manufacturing and business networks. These will be represented later.

In the practical model, nodes have been then modeled as independent and autonomous decision-makers, each node making decisions to progress (or not) throughout a technology adoption lifecycle. The five stages in this lifecycle are:

1. Not adopted;
2. To be adopted;
3. Trial adoption;
4. Partial adoption; and
5. Full adoption.

Time in the model has been assumed to be discrete and linear, with nodes making decisions between consecutive time-spots. Each time-spot may be viewed as a generation in the adoption lifecycle. At each stage in the lifecycle, a node may decide to proceed to next stage, to remain at current stage, or to return to preceding stage. For each node and for each