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An agent-based framework for supply chain coordination in construction

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Abstract

Supply chain coordination has become a critical success factor for supply chain management (SCM) and effectively improving the performance of organizations in various industries. Coordination refers to the integration of different parts of an organization or different organizations in supply chain to accomplish a collective set of tasks and to achieve mutual benefits. This paper defines the concepts of construction supply chain (CSC) and construction supply chain management, especially regards construction supply chain management as the coordination of interorganizations decision making in construction supply chain and the integration of key construction business processes and key members involved in construction supply chain. Much research and practice indicate that there still are many problems in construction, most of which are supply chain problems. The research analyzes the problems in construction supply chain. In order to resolve these problems and improving the performance of construction, an agent-based framework for construction supply chain coordination is designed based on the agent technology and multiattribute negotiation and multiattribute utility theory (MAUT). The framework, which integrates the construction organizations in construction supply chain and multiattribute negotiation model into a multiagent system (MAS), provides a solution for supply chain coordination in construction through multiattribute negotiation mechanism on the Internet. Finally, the prototype of the framework is developed and tentatively run based on an imaginary construction project. The trial run reveals the feasibility to implement the agent-based framework for coordination in construction.

Keywords: Construction; Coordination and management; Intelligent agent; Multiattribute negotiation; Multiagent systems; Supply chain

1. Introduction

In recent years, the application of supply chain management (SCM) philosophy to the construction industry has been widely investigated as an effective and efficient management measure and strategy to improving the performance of construction, which has suffered from high fragmentation, large waste, poor productivity, cost and time overruns, and conflicts and disputes for a long time [1–3], and to address adversarial interorganizational relationship of organ-

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ization by increasing number of construction organizations and researchers [1,4–12]. SCM can be considered as the coordination of distributed decision making of organizations or participants on material flow, information flow, human flow, and cash flow in supply chain from systems perspective.

According to Lau et al. (2004) [48], SCM is defined as "coordination of independent enterprises in order to improve the performance of the whole supply chain by considering their individual needs". This definition describes the main function and principle of SCM, i.e., coordination. Swaminathan and Tayur [13] classify SCM issues into two broad categories: configuration (design-oriented) issue that relates to the basic infrastructure on which the supply chain executes, and coordination (execution-oriented) issues that relate to the actual execution of supply chain. Schneeweiss and Zimmer [14] also regard SCM as a management activity that has to do with the coordination of logistic process being locally controlled by various independent organizations (decision-making units) in the environment of internationalization and globalization of markets together with an increased focus on organizations' core competence. Up to now, supply chain coordination has become a very popular research topic among the research community in SCM and a vital management issue of organizations in the collaborative–competitive business environment.

Coordination is "managing the dependencies between activities" [15]. It is defined as a mutually beneficial and well-defined relationship entered into by two or more organizations to achieve common goals. It also refers to the integration of different parts of an organization or different organizations in supply chain to accomplish a collective set of tasks and to achieve mutual benefits. It involves more formal relationships, objectives and actions which are mutual, compatible and common, not necessary a centralized authority [16].

Multiagent systems (MAS) technology offers new means and tools for supply chain coordination [17,18]. According to Wooldridge and Jennings (1995) [49], an agent is a self-contained program capable of controlling its own decision making and acting based on its perception of its environment, in order to one or more goals. An agent must possess any two of the following three behavioral attributes: autonomy, cooperation, and learning [19]. MAS comprises a number of intelligent agents, which represents the real world parties and cooperate to reach the desired objectives. In MAS, each agent attempts to maximize its own utility while cooperating with other agents to achieve their goals [20]. The main advantage of MAS is its responsibilities for acting various components of the engineering process or participants of the business process which is delegated to a number of agents. MAS is suitable for domains that involve interactions between different organizations with different objectives and proprietary information [21]. Based on these discussions, we can clearly see that SCM system is a typical MAS, where the participants are delegated to different agents. Furthermore, agent-based supply chain coordination has been proved to be an effective mechanism to improve the performance of SCM [22–24].

The core principles of SCM and agent technology provide new perspectives for construction supply chain (CSC) management. However, little research has been conducted to investigate the application of intelligent agent to coordination problems in CSC. The Centre for Integrated Facility Engineering of Stanford University established a distribution cooperative CAD environment entitled AgentCAD, which presented a framework for collaborative distributed facility engineering [25]. Anumba et al. [26] presented the key features of an agent-based system for collaborative design of portal frame structures and made a significant contribution by allowing for peer to peer negotiation between design agents. Pena-Mora and Wang [27] proposed a collaborative negotiation methodology and a computer agent named CONVINCER, which incorporates that methodology to facilitate or mediate the negotiation of conflicts in large-scale civil engineering projects. Min and Bjornsson [28] presented a conceptual model of agent-based supply chain automation, in which a project agent gathers actual construction progress information and sends to subcontractor agents and supplier agents, respectively, over the Internet. They evaluated an agent-based SCM model compared with traditional SCM practice through simulation. Ren et al. [29] developed multiagent system for construction claims negotiation (MASCOT) to resolve inefficiency problems. Kim and Paulson [30] presented an agent-based compensatory negotiation methodology to facilitate the distributed coordination of project schedule changes wherein a project can be rescheduled dynamically through negotiation by all of the concerned