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Transportation Research Procedia 12 (2016) 325 – 338

Transportation Research Procedia

www.elsevier.com/locate/procedia

The 9th International Conference on City Logistics, Tenerife, Canary Islands (Spain), 17-19 June 2015

An Intelligent Multi-agent Based Model for Collaborative Logistics Systems

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Abstract

In recent years, there has been a steady growth in the use of information systems in the logistics domain towards facilitating an agile distribution process. This study investigates the problem of collaboration planning in logistics and proposes an agent-based approach for better management of collaborative logistics. Based on the approach, a decision support system is designed that utilizes RFID technology for ensuring inventory accuracy.

The proposed approach involves three steps. In the first step, a conceptual agent based model is designed. In the second step, the game theory method is utilized to intensively study and analyze suppliers' collaboration and carriers' collaboration that represent major objectives proposed in the preceding model. Finally, correctness of the games is verified by formulating them mathematically. Developed optimization equations are fundamental to the operation research field. They employ the simplex and goal algorithms of linear programming.

Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics

Keywords: Agent based model; decision support system; game theory; less than truck load; linear programming; supply chain management

1. Introduction

Citizens' demands are increasing and accordingly, there is a considerable load on developing efficient distributive logistics. This accentuates the need to develop an optimized approach for handling and managing freights' distribution to eliminate any existing problems. Supply chain management is usually performed in collaboration between various logistical entities. The collaboration especially in the transportation field is happening by exchanging commodities

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Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics
doi:10.1016/j.trpro.2016.02.069

and sharing vehicles' weights (Bailey *et al.*, 2011).

The collaboration requires rapid and effective technique. Agent technique is recommended because it provides velocity and accuracy in performing the work. Accordingly, implementing an agent based model will speed up the supply chain process, make it just-in-time, just-in-request, more accurate, and efficient.

Major addressed problem is the unorganized distribution of freight, which creates lots of negative consequences such as the LTL problem. This problem results in crowding of the city roads and air pollution, which in turn affects citizens' health negatively. Hernández *et al.* (2011) claim that LTL idle weights in transporting vehicles. Another considerable problem is the unorganized communication between various logistical entities, which causes deficiency in satisfying customers' requests. Thus, it is significant to investigate the reasons behind these and other problems and solve them, which is the goal of this study.

2. Conceptual Agent-based Model

The designed model as illustrated in Figure 1, includes six autonomous agents interacting properly with each other as well as with the surrounding environment. To achieve the overall goal of the model, each agent has a major role to play. Following is an explanation of each agent in the proposed intelligent decision support system:

- The RFIDG Agent: The agent major role is to receive data from the RFID reader and places them into the merchandise database after filtering to ensure their accuracy. Moreover, the agent removes duplicate scanned records and displays alert messages in case of sensing exotic behaviors. Such as scanning a product that has been placed in the wrong area. Since scanning products involve human intervention, then there are chances for errors. Thus, the agent's major role becomes significant. Besides its major role, the RFIDG agent holds all products unfiltered information. Then, whenever any supplier inquires about any particular information of a specific product that is not entered into the filtered accurate database, the supplier will contact the RFIDG agent to get that particular detail.
- The Retailer Agent: When a human retailer logs into the system to request a shipment; the retailer agent notifies both the supplier agent and the carrier agent. It notifies the supplier agent to allow it to search in its database about the requested freight. While, notifying the carrier agent to enable it to check in its records for arranged shipments with LTL that will pass nearby the retailer's saved location in the system, it also recommends lower cost delivery of shipments to that retailer in a specific date, which will eliminate the LTL problem.
- The Supplier Agent: Once the retailer agent informs the supplier agent about a new retailer's request; the supplier agent starts searching inside its database about the requested product and then, replies back to the retailer about the status of the request as either available or not. It also recommends another availability date of the needed product or another available amount if different from retailer's request. In case the retailer requests unavailable commodity or more than the available amount in supplier's depot, the supplier agent will search other suppliers in the system who have enough amount of the requested commodity with reasonable price and high quality, and will recommend to the original supplier to collaborate with them. Suppliers' collaboration allows satisfying customers' needs. Note that for each specific supplier, the agent keeps record of the most collaborated suppliers. Thus, it recommends them first at later times for that specific supplier, which makes the supplier agent an intelligent agent. In addition, the supplier agent rate suppliers' performance, which is based on many criteria such as availabilities of their products, qualities, prices, and coping situation with other suppliers. In the recommendation list of suppliers to collaborate with, suppliers with higher rates get listed after the most collaborated suppliers.
- The Carrier Agent: In case the shipment request is confirmed by the retailer then, the supplier agent informs the carrier agent that there is a shipment delivery request. Therefore, the carrier agent will search inside its database for an available vehicle in the required date and with adequate weight to assign it to the delivery order. Afterwards, the carriers' database will be updated automatically and a confirmation number is generated and sent through the agent to both the supplier and the retailer. Moreover, once a retailer logs-in to the system, the carrier agent gets notified by the retailer agent that she needs a freight delivery. Hence, the carrier agent looks for arranged delivery vehicles with LTL that will pass nearby that retailer's location to offer lower cost shipments to that retailer enabling him to allocate the available empty weight in the shipping vehicle. The carrier agent rates carriers' performance, which is based on their efficiency in delivering freights to right retailers and within expected times. For instance, the carrier agent weights a carrier high if he always delivers on time and lowers his rate if he has late deliveries for few times.