Market-Based Task Allocation and Control for Distributed Logistics

Valentin Robu
CWI, Dutch National Center for Mathematics and Computer Science
Kruislaan 413, NL-1098 SJ Amsterdam, The Netherlands

ABSTRACT

This position paper outlines possible research directions related to market-based methods, especially as they apply to logistic settings. First, we describe some of the characteristics of the logistics domain. Next, we identify and discuss some fundamental research problems which we consider open and relevant for this domain, from the agent-based electronic markets perspective.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Intelligent Agents, Multiagent Systems

General Terms

Algorithms, Economics, Experimentation

Keywords

market-based methods, negotiation, repeated auctions, logistics, transportation, supply chain management, decision theory

Distributed logistics and supply chain management represent a very promising, yet challenging area of application for multi-agent systems. Traditional solutions to logistic problems, such as those studied in classical Operations Research (OR), are typically centralized and computationally intensive. Such solutions do not lend themselves to changing market situations and do not cope well with unforeseen events. Furthermore, many of the models previously developed for these problems (both in the agent and OR communities), although allow for a more distributed and flexible planning, assume strict cooperation on the part of the agents.

Many works discuss market-based control as a promising alternative for distributed coordination of large-scale multi-agent systems (see [1] for some early results). The focus of our work is the application of these techniques to transportation logistics and supply chain management problems. This research is carried out as part of the Distributed Engine for Advanced Logistics (DEAL) project, which groups together several universities, but also several large logistic providers in the Netherlands.

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Logistics is a highly competitive sector, where profit margins are typically low. Actors in the logistic world can be classified into two types. The first of these, Third-Party Logistics companies (3PL) own their own transport capacity (i.e. truck fleet), which they use to transport acquired orders (tasks). Fourth Party Logistics companies (4PL) do not own any transport capacity of their own, but operate by acquiring large transportation orders from shippers and sub-contract them, by breaking them up among a group of 3PL companies. There are two forms of market organization which can model the interaction between the companies in this supply chain. The first is direct negotiation between the 4PL company and a number of trusted 3PL companies. In current practice, this type of negotiation is performed as a series of 1-1 negotiations over the set of orders which a 3PL company can sub-contract from the 4PL.

Automating negotiation over tasks in this settings raises several fundamental challenges. Negotiations are high dimensional, and, most importantly, the evaluations that company agent assigns to different sets of orders may be highly inter-dependent. This is because evaluation that a 3PL company assigns to a set of orders depends on how efficiently it can plan transportation of these orders, given available transport capacity. In [2], we report a novel utility graph method to model this type of negotiations, which enables agents to reach efficient deals with a limited number of negotiation steps. In future work we will consider automatic construction of such utility graphs, as well as the extension of this model to the 1-many case, by taking into account the value of outside options.

The second form of market organization involves auctioning the tasks, either as combinations or one by one, to 3PL companies or even individual trucks (e.g. [3]). The use of auctions has a long history in task allocation problems. Combinatorial auctions are widely used to model such problems, since they can be proven to have good truth-revelation properties. However, in dynamic domains, tasks arrive over time, so the complete set of tasks that needs to be assigned is not known in advance. For these settings, repeated and sequential auctions are a natural choice - but finding efficient bidding strategies for sequential auctions remains an important open research problem.

1. REFERENCES

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