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The 2007 procurement challenge: A competition to evaluate mixed procurement strategies

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ABSTRACT

Global competition is putting a premium on the ability to manage risk through flexible and agile web-enabled procurement practices. This article discusses the design of the 2007 "supply chain management – procurement challenge" (SCM-PC), a competition designed by the first three authors to evaluate the performance of mixed procurement strategies that balance risk through combinations of long-term, quantity-flexible contracts and one-off contracts. Specifically, the SCM-PC challenge revolves around a PC assembly scenario, where web-enabled trading agents developed by different teams compete for components required to assemble different types of PCs.

Collectively the authors represent the top three entries in the 2007 procurement challenge. They present the strategies their teams developed for the competition, compare their performances, and discuss lessons learned from the competition.

1. Introduction

The web is enabling manufacturing enterprises to explore more flexible and agile procurement practices. As product life cycles become shorter and demand becomes more difficult to predict, both manufacturers and suppliers are looking for new ways of sharing risk. Manufacturers are trying to move away from static, long-term contracts that would require them to take unacceptable levels of risk, while trying to secure price and availability guarantees from their suppliers. Simultaneously, suppliers are seeking demand and payment guarantees from their customers. This in turn translates into long-term procurement contracts, where suppliers and manufacturers often agree on some levels of flexibility (e.g. quantity, price, or service levels). These contracts are often supplemented with one-off procurement arrangements to accommodate surges in demand or address significant price disruptions.

1.1. The supply chain trading agent competition and the procurement challenge

The international supply chain trading agent competition ("TAC-SCM") was established to stimulate the development and evaluation of novel web-enabled supply chain trading strategies. The competition, which was introduced in 2002 (Arunachalam and Sadeh, 2005), has been held as an annual event since the summer of 2003, attracting over 120 entries from 60 teams in 21 countries in its first 5 years. It revolves around a personal computer (PC) assembly scenario, where agents developed by different teams compete against one another for customer orders for different types of PCs and for the different components required to assemble these PCs. Each game brings together six agents developed by six different teams and simulates 220 days of operation, with each day being simulated in 15 s. The tournament requires agents to compete in hundreds of games, each simulating different market conditions and bringing together different combinations of competitors.

In 2006, encouraged by the success of the supply chain trading competition, the first three authors embarked on the design of a variation of the TAC-SCM scenario that focuses solely on procurement decisions. The motivations for the design of this new game were several:

- *Evaluate procurement decisions in isolation*: By requiring supply chain trading agents to simultaneously compete in component and finished-goods markets, the original TAC-SCM competition (now referred to as the "TAC-SCM baseline game") requires agents to continuously manage a complex set of decisions (i.e. customer bidding, procurement and coordination between both

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sets of decisions), making it sometimes difficult to determine why one agent performs better than another. By designing a variation of the game that requires agents to focus solely on the procurement side of the problem, the authors wanted to make it easier to evaluate the performance of competing procurement strategies. Insight gained from such a game is expected to also be easier to transfer to industry, given the typical decoupling between procurement and marketing decisions imposed by today's enterprise resource planning (ERP) architectures.

- *Introduce quantity-flexible procurement contracts*: The TAC-SCM baseline game uses a uniform mechanism for agents to negotiate procurement contracts with suppliers. This mechanism does not explicitly distinguish between long-term and one-off procurement contracts, though it has been shown that successful TAC-SCM agents modulate the horizons and quantities of their procurement contracts to effectively implement hybrid strategies that combine both long-term and short-term contracting practices (Andrews et al., 2007). By explicitly introducing quantity-flexible long-term contracts, the new procurement challenge (SCM-PC) requires agents to more explicitly decide how to balance one-off and long-term procurement, making it easier to analyze and compare the behavior of different agents.
- *Lower the barrier to entry*: By introducing a variation of the TAC-SCM game that requires teams to only worry about procurement, it was felt that the procurement challenge would lower the barrier to entry for prospective competitors and possibly entice new teams to join the TAC-SCM community.

The specifications of the "supply chain management – procurement challenge" (SCM-PC), as it is now known, were published in late 2006 and the web server and agentware required for the competition were released in early 2007. The remainder of this article provides a detailed description of the procurement challenge (Section 3), including the motivations behind key design decisions, descriptions of the top three agents in the first edition of the tournament held at AAAI-2007 in Vancouver in July 2007 (Section 4), and a detailed account and analysis of the results of the tournament (Section 5). A summary of lessons learned and concluding remarks are provided in Section 6.

2. Related work

The procurement challenge builds on three complementary lines of research:

1. Sourcing and procurement
2. Autonomous bidding
3. Supply chain management games

This is further discussed below.

2.1. Sourcing and procurement

An important line of research in supply chain management has been concerned with the trade offs associated with different sourcing and procurement strategies. For instance, Pyke and Johnson have argued that different types of sourcing strategies are better suited for different situations, with critical, high-value added components better handled through strategic partnerships and commoditized components available from multiple sources more effectively handled through dynamic e-procurement (Pyke and Johnson, 2003). Peleg et al. compared such pure strategies with a mixed strategy combining both short-term and long-term elements, showing that the superiority of one strategy over the others depends on contract terms (Peleg et al., 2002). Bensaou helped debunk the myth that Japanese car manufacturers rely solely on long-term strategic partnerships with suppliers, instead advocating the management of portfolios of buyer–supplier relationships covering a wide spectrum of possible arrangements (Bensaou, 1999). A review of models for constructing short-term and long-term contracts in business-to-business markets has been conducted by Kleindorfer and Wu (2003). Elmaghraby also provides an excellent review of trade offs between different sourcing strategies (Elmaghraby, 2000). de Albeinitz et al. have shown that portfolios of quantity-flexible procurement contracts used in combination with spot market procurement can contribute to reducing the manufacturer's expected profit and financial risk (de Albeniz and Simchi-Levi, 2005). More recently, Nagali et al. have reported using new risk management techniques to support the development of portfolios of procurement contracts to save hundreds of millions of dollars in procurement costs at Hewlett-Packard (Nagali et al., 2008). Collectively, this body of work suggests that decisions relating to balancing one-off and long-term procurement contracts are becoming increasingly important and that their complexity warrants additional research.

2.2. Autonomous bidding

The artificial intelligence and electronic commerce research communities have developed autonomous bidding agents that combine machine learning and stochastic optimization techniques. Work in this area has revolved around the development and benchmarking of bidding agents in the context of the trading agent competition. A first game known as TAC-Travel was introduced by Wellman et al. (1999) with the first tournament held in July 2000. This game requires travel agents to compete against one another for air tickets, hotel reservations and event tickets to best match the requirements of their different customers. Techniques developed in the context of the TAC-Travel scenario are discussed in Wellman et al. (2007).

The supply chain trading competition, which was introduced in 2002 by the third author, was developed for the same research community but focuses on a supply chain trading scenario, where PC assembly agents concurrently compete for customers for different types of PCs and for the components required to assemble these PCs (Arunachalam and Sadeh, 2005). During its first 5 years, the TAC-SCM scenario has attracted over 120 entries from 21 countries and resulted in over 50 publications (Trading Agent Competition Website, 2007). These include overall analysis of different tournaments (e.g. Arunachalam and Sadeh, 2005; Andrews et al., 2007), novel supply chain trading techniques (e.g. Benisch et al., 2006; Kiekintveld et al., 2007) and descriptions of entire agents. In the latter category, Kiekintveld et al. discuss how their DeepMaize agent dynamically coordinates sales, procurement and production strategies while maintaining profitability (Kiekintveld et al., 2004). Fuzzy reasoning techniques used in the SouthamptonSCM agent are discussed in He et al. (2006). Details about the TacTex agent are provided in Pardoe et al. (2006) and Pardoe and Stone (2007), including a discussion of machine learning techniques developed to predict bid prices of other agents (Pardoe et al., 2004). Benisch et al. (2008) provides an in depth description of the different modules composing the CMieux agent. Podobnik, Petric and Jezic describe their CrocodileAgent agent in Podobnik et al. (2006) and Petric et al. (2007a,b); Stan et al. discuss their PhantAgent entry in Stan et al. (2006). Mathematical programming models and heuristic algorithms for bidding and scheduling developed for the Botticelli agent are detailed in Benisch et al. (2004). In Keller et al. (2004), the RedAgent team presents an internal market architecture to coordinate micro-agents that individually handle different subsets of decisions. Descriptions of many other