Research Applications of the MAGNET Multi-Agent Contracting Testbed*

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What is MAGNET?

MAGNET is a testbed for exploring decision processes and agent interactions in the domain of multi-agent contracting. We are interested in learning how a community of heterogeneous, self-interested agents, can operate to discover resources, make commitments, and carry out plans that involve multiple tasks and require coordination among agents. We assume that this community of agents contains some agents who have goals that they themselves cannot fully satisfy. They may lack the abilities, or they may lack the resources, to carry out at least some of the operations in their plans. There are also other self-interested agents in the community who have resources to offer, and who are willing to make those resources available to other agents in a way that maximizes their value to the agents that control them.

The MAGNET system (Collins *et al.* 2001) consists of Customer agents, Supplier agents, and a market infrastructure that mediates interactions among agents and provides them with ontological and statistical information in support of planning, negotiation, and decision-making activities. MAGNET provides support for a variety of types of transactions, from simple buying and selling of goods and services to complex multi-agent contract negotiations. In the latter case, MAGNET is designed to negotiate contracts based on temporal and precedence constraints, as well as price.

Experimental research in this area requires a simulation environment that is sufficiently rich to be easily adapted to a variety of experimental purposes, while being sufficiently straightforward to support clear conclusions. MAGNET is not a complete simulation of a working market environment. Instead, it is focused on the process of determining the form and content of Requests for Quotations (RFQs), on the management of the bidding process, and on the evaluation of bids submitted by potential suppliers. It has the ability to generate plans with well-defined statistics, or to accept hand-built plans or plans extracted from real-world data. Bids are generated by a community of abstract suppliers, again with well-defined statistics. All the major decision processes are driven by plug-in components, with documented APIs and a great wealth of configuration parameters. Data collection capabilities are well-suited to statistical studies.

The MAGNET Customer Agent framework is being released to the research community in 2002. This demonstration will explore the types of experimental work that can be carried out with this framework.

MAGNET Architecture

Agents may fulfill one or both of two roles with respect to the MAGNET architecture, as shown in Figure 1. Customer agents pursue their goals by formulating and presenting Requests for Quotations (RFQs) to Supplier agents through a market infrastructure (Collins *et al.* 1998). The RFQ specifies a task network that includes task descriptions, a precedence network, and possibly other time constraints. Customer agents attempt to satisfy their goals for the least net cost, where cost factors can include not only bid prices, but also goal completion time and risk factors. More precisely, these agents are attempting to maximize the utility function of some user, as discussed in detail in (Collins *et al.* 2000).

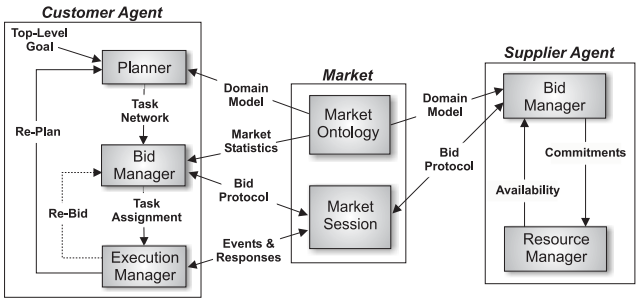

Figure 1: The MAGNET architecture

Supplier agents attempt to maximize the value of the resources under their control by submitting bids in response to those RFQs, specifying what tasks they are able to undertake, when they are available to perform those tasks, and at what price. Suppliers may submit multiple bids to specify different combinations of tasks, with prices and time constraints.

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One of the important problems the Customer's Bid Manager component must solve is the allocation of time to the various stages of the negotiation process. The timeline in Figure 2 shows an abstract view of the progress of a single negotiation. At the beginning of the process, the Customer agent must allocate deliberation time for its own planning, for supplier bid preparation, and for its own bid evaluation process. Two of these time points, the Bid deadline and the Bid Award deadline, must be commumicated to suppliers as part of the RFQ. The Bid deadline is the latest time a supplier may submit a bid, and the Bid Award deadline is the earliest time a supplier may expire a bid. The interval between these two time points is available to the customer to determine the winners of the auction.

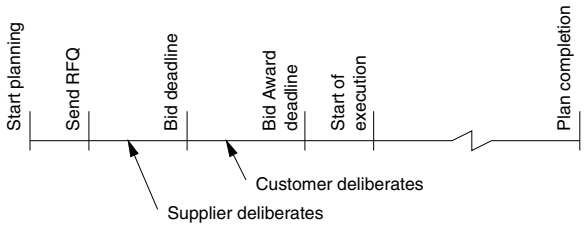

Figure 2: Typical Agent Interaction Timeline

In order to support the allocation of deliberation time, we have used the MAGNET testbed to run a series of experiments aimed at determining the time required to solve the Winner Determination problem (Collins & Gini 2001) given estimates of the problem complexity that are available prior to receiving bids.

The Demonstration

The demonstration environment will include a Customer agent and a set of abstract Supplier agents. User interfaces will allow inspection and manipulation of each component. The demonstrations will focus on activities and decision processes within the Customer agent, including planning, composing a Request for Quotes, managing the bidding process, and determining auction winners.

The first demonstration will help visitors visualize the components of the MAGNET system, their interactions, and their decision processes. Using the Customer agent's interface, visitors will be able to work through a "typical" contracting scenario, consisting of a series of steps:

1. Choose a plan to accomplish some goal from a library of plans, or compose a new plan from a set of task types supported by the market. The plan may be composed and/or viewed using a Gantt-chart user interface.

   To assist in composing the plan, the market will provide statistics on the various types of tasks, such as typical task duration and cost, the number of suppliers who typically bid on that type of task, and resource availability data that will impact lead time and the probability of finding resources within a specified time window.

2. Compose a Request for Quotes (RFQ) from the plan. With the help of decision support from the agent, the user will develop an RFQ that specifies the plan, the time limits for the tasks making up the plan, and a timeline for the bidding process. The user interface will show timelines graphically.

3. Submit the RFQ to the market for bids. The market will distribute the RFQ to all suppliers who have registered interest in one or more of the task types specified in the plan.

4. View the status of outstanding RFQ's. This will query the market to obtain information on number of suppliers who have been notified, and will show progress of the bidding process.

5. View incoming bids. Each bid will specify a set of tasks, a price, and resource availability times. They may be overlaid graphically on the original RFQ schedule to help spot feasibility conflicts.

6. Evaluate bids. Users will use the Agent's decision support tools to search for sets of bids that minimize cost, compose feasibly together, and meet the user's risk tolerance levels. Several different Winner Determination search methods are available.

7. Award bids. The user may select a set of bids that covers the plan and composes a feasible plan (or not, if desired), and award them to their respective suppliers.

The second demonstration will focus on the process of setting up and running experiments using the MAGNET framework. One experiment will show how we measure the performance of various winner determination methods. The second will show how the details of the RFQ generation process affect the suppliers' ability to bid, and the impact of the resulting bids on the customer's bid evaluation process.

References

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