Trading Agent Competition Demo: Classic and Supply Chain Management Scenarios

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Introduction

The Trading Agent Competition (TAC) provides an international forum for research into the design and analysis of trading agents and automated trading mechanisms. The competition has been run yearly since the first competition in 2000, and currently consists of competitions in two separate scenarios: Classic and Supply Chain Management (SCM). A team at the Swedish Institute for Computer Science (SICS) developed the game server software and is running the 2004 TAC competition[1]. Both scenarios present automated trading agents with challenging scheduling and resource allocation problems which should be of interest to ICAPS attendees. Our objective in this demonstration is to promote TAC as a forum for testing and evaluating approaches for planning and scheduling in complex domains.

TAC is an attractive research environment for several reasons. It focuses many researchers with diverse approaches on a single problem, facilitating collaboration and direct comparison of competing approaches. Using a problem specification designed by a third party also removes some of the potential for bias associated with researchers choosing their own test domains. To the extent that the competition scenarios remain the same each year, TAC also provides a useful standard for benchmarking overall progress in trading agent research. Finally, TAC is a fun and entertaining event that promotes research on the interesting problem of building capable trading agents.

Classic Scenario

The TAC Classic game presents a travel-shopping task, where traders assemble flights, hotels, and entertainment into trips for a set of eight probabilistically generated clients. Clients are described by their preferred arrival and departure days (pa and pd), the premium (*hp*) they are willing to pay to stay at the "Towers" (T) hotel rather than "Shanties" (S), and their respective values (e_1, e_2, e_3) for three different types of entertainment events. The agents' objective is to maximize the value of trips for their clients, net of expenditures in the markets for travel goods. The three categories of goods are exchanged through distinct market mechanisms.

Flights. A feasible trip includes air transportation both ways, comprising an inflight day i and outflight day j, $1 \leq i < j \leq 5$. Flights in and out each day are sold independently, at prices determined by a stochastic process. The initial price for each flight is $\sim U[250, 400]$, and follows a random walk thereafter with an increasingly upward bias.

Hotels. Feasible trips must also include a room in one of the two hotels for each night of the client's stay. There are 16 rooms available in each hotel each night, and these are sold through ascending 16th-price auctions[2]. Agents submit bids for various quantities, specifying the price offered for each additional unit. When the auction closes, the units are allocated to the 16 highest offers, with all bidders paying the price of the lowest winning offer. Each minute, the hotel auctions issue *quotes*, indicating the 16th- (*ASK*) and 17th-highest (*BID*) prices among the currently active unit offers (Wurman, Walsh, & Wellman 1998). Starting at minute four, one of the hotel auctions is selected at random to close, with the others remaining active and open for bids.

Hotel bidders are also subject to a "beat-the-quote" rule (Wurman, Wellman, & Walsh 2001), requiring that any new bid offer to purchase at least one unit at a price of $ASK + 1$, and at least as many units at $ASK + 1$ as the agent was previously winning at *ASK*.

Entertainment. Agents receive an initial random allocation of entertainment tickets (indexed by type and day), which they may allocate to their own clients or sell to other agents through continuous double auctions (Friedman & Rust 1993). The entertainment auctions issue *BID* and *ASK* quotes representing the highest outstanding buy and lowest sell offer, respectively, and remain open for buying and selling throughout the 12-minute game duration. A client may sell tickets that it does not own, but must pay a penalty of 200 per ticket for any "short sales" not covered by the end of the game.

A feasible client trip r is defined by an inflight day in_r, outflight day out_r, hotel type (H_r, which is 1 if T and 0 if S), and entertainment types (E_r, a subset of $\{1, 2, 3\}$). The

[1] More information can be found at the TAC website http://www.sics.se/tac, including information on the 2004 tournament, game specifications, and general information on TAC.

[2] EBay calls this a "Dutch" auction (though in the economics literature a Dutch auction is something entirely different).

value of this trip is given by

$$v(r) = 1000 - 100(|pa - in_r| + |pd - out_r|) + hp \cdot H_r + \sum_{i \in E_r} e_i.$$

At the end of a game instance, the TAC server calculates the optimal allocation of trips to clients for each agent, given final holdings of flights, hotels, and entertainment. The agent's game score is its total client trip utility, minus net expenditures in the TAC auctions.

Supply Chain Management Scenario

The Supply Chain Management scenario (TAC/SCM) was introduced in TAC-03. It was developed by researchers at Carnegie Mellon and the Swedish Institute for Computer Science (Sadeh *et al.* 2003; Arunachalam *et al.* 2003).

In the TAC/SCM scenario participants create an agent representing a PC (personal computer) assembler. In each game six agents operate in a common market environment over a simulated year (220 game days of 15 seconds each). The environment constitutes a *supply chain*, in that agents trade simultaneously in markets for PC components and a market for finished PCs. Agents may assemble for sale 16 different PC models, defined by the compatible combinations of four component types: CPU, motherboard, memory, and hard disk. The six assembler agents procure component supplies from eight supplier agents and sell finished PCs to a single entity representing customers. Trades at both levels are negotiated through a *request-for-quote* (RFQ) mechanism, in which buyers issue requests, sellers respond with offers, and buyers choose which offers to accept as orders. At the end of the game, agents are evaluated by total profit, with outstanding inventory valued at zero.

On each day, the agent may receive offers and component delivery notices from suppliers, and RFQs and orders from customers. It then must make several decisions:

1. What RFQs to issue to component suppliers.
2. Given offers from suppliers in response to the previous day's RFQs, which to accept.
3. Given component inventory and factory capacity, what PCs to manufacture.
4. Given inventory of finished PCs, which customer orders to ship.
5. Given RFQs from customers, which to respond to and what price to offer.

Each of the above decisions has challenging scheduling components. For instance, the manufacturing decision must assign the limited resources of components and factory cycles available in each day to producing PCs to fill orders. This decision is complicated by the different prices, deadlines, and penalties for late deliveries associated with each order. The decision of what prices to offer customers is affected by whether the PCs can be feasibly produced given component and capacity constraints, how expensive the production will be, and how much profit the agent believes it can extract. Implicitly or explicitly, this decision requires assigning resources to the potential customer orders and accounting for future opportunities to bid on customer RFQs and buy components. A final example is that agents must trade off the cost of acquiring components against the arrival time of the components when making procurement decisions.

Several general features of the supply chain domain make it a particularly challenging class of environments for planning and scheduling. First, agents operating on a supply chain face substantial *uncertainty*. Notable examples are the limited information agents typically have about the particular state of the other agents (e.g. current inventory levels) and uncertainty about future levels of customer demand. Nevertheless, agents cannot avoid making commitments (e.g. to procure component supplies) before all relevant uncertainty is resolved. Second, supply chain operations can be highly *dynamic*. Decisions made at one time can propagate and affect conditions elsewhere on the chain at disparate times, and external conditions may cause sudden changes in resource availability and production values. Finally, the other production operations on the supply chain are also controlled by self-interested agents, so there are naturally *strategic interactions*. Agents can exploit the structure of these interactions to make predictions about developments in the game.

Demo Format

The demonstration will involve viewing live TAC games in progress using the standard game viewers. The viewers provide a graphical representation of the important game events as they happen, and provide a good starting point for describing the game. For TAC/SCM there is also a post-game data viewer that provides additional statistics for post-game analysis that may also be demonstrated. More detailed documentation on the game specifications will be available for interested parties.

The system is available immediately at `http://www.sics.se/tac`. Documentation, links to public game servers, and a binary release of the server are all available at the website. TAC tournaments are open to any interested groups that agree to abide by the basic tournament rules. The finals of the 2004 competition will be held in conjunction with AAMAS-04 from 20-22 July, with preliminary qualifying rounds beginning on 7 June.

References

Arunachalam, R.; Eriksson, J.; Finne, N.; Janson, S.; and Sadeh, N. 2003. The TAC supply chain management game. Technical report, SICS. Draft Version 0.62.

Friedman, D., and Rust, J., eds. 1993. *The Double Auction Market*. Addison-Wesley.

Sadeh, N.; Arunachalam, R.; Eriksson, J.; Finne, N.; and Janson, S. 2003. TAC-03: A supply-chain trading competition. *AI Magazine* 24(1):92–94.

Wurman, P. R.; Walsh, W. E.; and Wellman, M. P. 1998. Flexible double auctions for electronic commerce: Theory and implementation. *Decision Support Systems* 24:17–27.

Wurman, P. R.; Wellman, M. P.; and Walsh, W. E. 2001. A parametrization of the auction design space. *Games and Economic Behavior* 35.