Sardine: An Agent-facilitated Airline Ticket Bidding System

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ABSTRACT
This paper discusses the limitations of current on-line auction systems and presents our guidelines for more dynamic attribute-based bidding. Our prototype application for airline flight bidding demonstrates our vision for interfaces that facilitate negotiation between buyers and sellers.

INTRODUCTION
Despite the growth in the number of online auction sites, there is still a need for a more dynamic, personalized bidding experience. Existing bidding and auction sites over-emphasize bid price as the sole parameter determining the match of a buyer and a seller. We believe that for dynamic pricing systems to truly benefit the buyer and seller, the negotiation interaction needs to extend further than a simplistic exchange of bid and ask prices [6].

On-line auction systems, such as eBay [1], Amazon Auctions [2], and Priceline's airline bidding system [3] violate several principles we believe are necessary for a bidding system to benefit both the buyer and the seller. These principles are:

- Offers should be evaluated and selected on multiple criteria, not just price.
- The negotiation should be a non-binding arrangement, allowing the buyer to make multiple bids on multiple offers, increasing the chance of a successful match.
- Sellers should have the tools to evaluate bids based on complex criteria, not just immediate revenue.

To demonstrate these guidelines, we have built an alternative airline flight bidding system called SARDINE (System for Airline Reservations Demonstrating the Integration of Negotiation and Evaluation). This system is in on-going stages of development and the application we present in this paper demonstrates our current progress.

Airlines today already perform limited dynamic pricing and consumers are accustomed to the concept of different prices for different flights and changing prices over time. For these reasons, we feel it is a good domain to explore, and we plan to apply our techniques more generally to other domains.

OVERVIEW OF SARDINE
The SARDINE System presents a method for buyers to submit ticket bids to airlines and for airlines to respond to each bid. The system uses software agents to coordinate the preferences and interests of each party involved, as shown in Figure 1. The Buyer Agent collects the buyer's preferences and correlates these parameters with available flights from a reservation database (Step 1). The user then tells the Buyer Agent how much to bid and the Airline Agents receive the bids from the Buyer Agent (Step 2). Finally, the Airline Agents consider the individual bids based on flight yield management techniques and specific buyer information (Step 3).

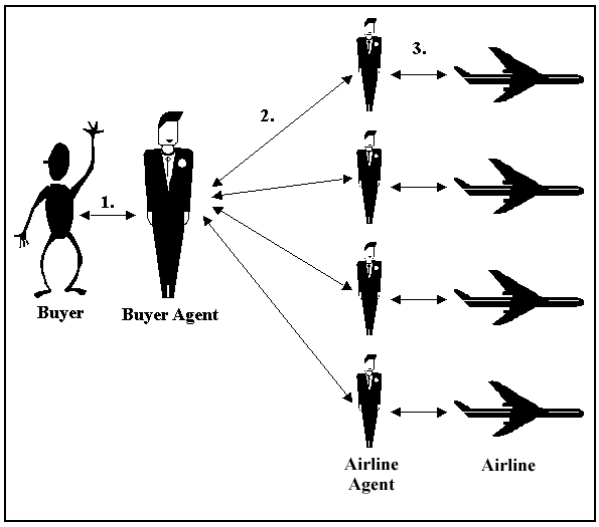

Figure 1: Agent Interaction

Step One
To collect the buyer preferences, the Buyer Agent asks the buyer to indicate his/her preferred flight parameters and how flexible he/she is on each parameter. After specifying an "ideal" date of travel, time of day, airline, number of connections, etc, these preferences are submitted to the Buyer Agent for analysis.

The flexibility rating of "very flexible," "somewhat flexible," and "not flexible" is used by the Buyer Agent to determine an acceptable range for each parameter. For example, a departure time of 5pm, "not flexible" translates to an acceptable departure time between 4:45pm and 5:15pm, "somewhat flexible" means between 2:45pm and

7:15pm, and "very flexible" means between 12:45pm and 9:15pm.

Additionally, this flexibility metric is used as an indicator of how important each parameter is to the user. When a user is very flexible on a certain flight attribute, this indicates it is not as important as an attribute that the user is not flexible on.

Figure 2 presents the distance function used to match the user's preferences to the available flights. *Weight* and *range* for each parameter, i, is computed from the flexibility rating, as described above. The *ideal* value is the value entered by the buyer for the parameter and the *actual* value is the value for that parameter of a located available flight. Summing over all parameters computes the distance the available flight is from the user's ideal flight. The Buyer Agent locates the best flights for the user by minimizing this distance function.

$$dist = \sum_i weight_i \left(\left| \frac{ideal_i - actual_i}{range_i} \right| \right)$$

Figure 2: Flight Distance Function

Step Two

After the buyer examines the flights, he/she can bid on any number of the proposed flights. Effectively, this falls into the category of an "OR" combinatorial auction [4]. A combinatorial auction is one where the user submits simultaneous, multiple bids. In this case, these bids are mutually exclusive of one another, and thus an "OR" versus "AND" combinatorial auction.

When the user submits the bids, the Buyer Agent passes the bids to the appropriate Airline Agents.

Step Three

The final step in the bidding process is for the Airline Agents to analyze the flight bids and determine if they should be accepted or rejected. As part of yield management, the airline industry performs extensive analysis of their scheduling, flight frequency, and fares and adjusts prices in the form of dynamically changing the number of available seats in each booking (i.e. price) class. Our work on the Airline Agent interface is still in-progress, but our hypothesis is that by combining the yield management data the airline industry already uses with just-in-time, individualized analysis, an airline could maximize revenue over each plane flight in real-time with more precision. Furthermore, based on the pricebot dynamic theories of Greenwald, Kephart and Tesauro [5], the Airline Agent could implement one of several pricing strategies to automatically fluctuate prices to maximize profits. The current implementation of the system does not include dynamic pricing. We simply assume a minimum price for each flight.

Final Step

Once all bids have been returned as accepted or rejected, the buyer is notified of the results. All accepted bids automatically become flight reservations (for a limited time, T), but are not booked for purchase. By viewing the accepted bids, the buyer can make the final decision on which airline flight is the best choice. Because it is difficult for buyers to understand their own utility function, this interaction allows for the buyer to change his/her mind during the bidding process.

FUTURE WORK

In the area of seller-side agents, we are interested in examining the added benefits a merchant has in participating in this one-to-one negotiation. We believe that with more detailed information on buyer utility, such as is available in SARDINE, the seller has a greater ability to customize product offerings to increase revenue. The airline industry is a rich field for examining yield management, and with detailed data available, we feel this is a ripe area for focusing on how on-line, just-in-time pricing can increase airline revenues.

Another direction of this work will involve taking these theories on flight bidding systems into the realm of other industries. We predict that by building prototypes of dynamic pricing in other domains, this research can evolve into general solutions for human-computer interaction in more on-line bidding systems.

CONCLUSION

The SARDINE System addresses existing problems in e-commerce negotiation systems and presents an interface for individualized negotiation and product tailoring. This is accomplished in three ways. 1) By allowing the buyer to express to a self-representing agent a preference for multiple aspects of a flight, the flights presented to the buyer are a more satisfactory match with the buyer's utility than traditional methods. 2) By allowing a buyer to simultaneously bid on multiple flights, the chance of finding a flight that meets the buyer's criteria is increased. And 3) the airline's interests are represented by the Airline Agent, allowing the airline to individually consider a bid in light of available aggregate data and data dependent on the immediate situation.

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HARDWARE AND SOFTWARE REQUIREMENTS

The Sardine System is a web-based application built using Java Servlets. It runs locally on a laptop, so it does not require a connection to a network during demonstration.

Sardine System:

Software: Java SDK 1.2.2, JSWDK 1.0.1

Interfaces: Java Servlets, HTML

Datasources: SQL Server, XML

Hardware: a Pentium (266MHz) laptop running Windows 98 with 80Mb RAM.

For Demonstration purposes:

Additional hardware required: projection monitor for displaying.