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Negotiation and Auction Mechanisms in E-procurement: Systems and Experiments

Gregory Kersten[1], Pierpaolo Pontrandolfo[2], Rustam Vahidov[1] and Dmitry Gimon[1]

[1] InterNeg Research Centre, Concordia University, Montreal, Canada
[2] Dep. of Environmental Eng. and Sustainable Development, Politecnico di Bari, Bari, Italy

Abstract

Auctions and negotiations are mechanisms used in market exchanges. Behavioral economics experiments focused on the mechanism efficiency which required highly simplified problems and contexts. This paper discusses an on-going project involving an experimental comparison of auction and negotiation mechanisms embedded in software which we have developed. The experiments are situated in an e-business context which resembles real-life e-procurement. Both reverse multi-attribute auctions and multi-bilateral negotiations are used in a transportation service procurement scenario. The potential contribution includes the verification of theoretical claims that auctions are more profitable for auction givers than negotiations. It also includes the formulation of guidelines for appropriate design of multi-attribute market mechanisms and their selection.

Keywords: auction and negotiation, multi-attribute auctions, online auctions, e-negotiations, decision support systems, experimental study, e-procurement.

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1. Markets, transactions and mechanisms

Exchange mechanisms are sets of rules, which specify the functioning of a market and the permissible behavior of its participants. The three standard mechanisms are: (1) catalogues, where requests and offers are posted; (2) auctions, where one side automates the process during which participants from the other side compete against each other; and (3) negotiations, where the participants bargain over the conditions of an exchange. One or more of these mechanisms are implemented in every e-marketplace.

There are many variants of each of these mechanisms. Catalogues may contain a fixed listing of goods and prices or allow for some flexibility so that customers can obtain a price discount based on, for example, a coupon, order volume or type of credit card.

Auctions can be either single-sided, where one seller auctions off goods to a number of bidders, or double-sided, where competition is employed on both sides of a market. They may differ in the process (e.g., ascending and descending), bidder acceptance, winner determination and other rules.

Negotiation is a rich and ill-defined family of processes used for exchanging goods or services among buyers and sellers, and for resolving inter-personal and inter-organizational conflicts. It is an iterative communication and decision making process between two or more participants who cannot achieve their objectives through unilateral actions. It involves an exchange of information comprised of offers, counter-offers and arguments with the purpose of reaching a consensus (Bichler, Kersten et al. 2003).

The economic view is the dominant one in auction mechanisms. In fact, the field of market design is almost exclusively focused on the mechanism design and applied auction theory. This focus has a major ramification upon practical market design: *the decision regarding which exchange mechanism to use favors auctions* (Kersten, Chen et al. 2008).

The high degree of structure of auctions and the ability to describe them completely and unequivocally using a set of rules led the computer science community involved in e-commerce transactions, including negotiations, to propose replacing auctions with negotiations or claim that “negotiations are auctions”. Sandholm (1999) makes an opening statement saying that “Negotiation is a key component of e-commerce” in an article that is entirely devoted to auctions. Similarly, other authors who write about electronic business negotiations discuss solely auctions (Beam, Segev et al. 1996; Kumar and Feldman 1998; Ströbel 2000).

Procurement activities undertaken by business organizations differ in terms of their complexity, risk associated with a failed exchange, importance and profit impact. This led (Kraljic 1983; Handfield and Straight 2003; Larson, Carr et al. 2005) to the identification of four types of buyer-supplier relationships: acquisition, strategic, noncritical and leverage. Different mechanisms are selectively suggested for the four types of relationships. Recent studies (Subramanian and Zeckhauser 2004; Bajari, McMillan et al. 2009) confirmed that business organizations follow these guidelines in implementing their procurement strategies. Auctions are used in noncritical and leverage relationship when goods are simple and have a low-to-medium priority. Negotiations are used in strategic and leverage relationship when goods are complex and have a critical-to-high priority.

About 70% of corporate revenue is spent on purchasing; savings of 5% translate into very significant amounts of money for companies of every size (Peleg 2003; Wagner and Schwab 2004). Reverse auctions have been shown to achieve an average gross savings of 15-20 percent (Cohn 2000). Most of these auctions are single attribute. However, a survey by Ferrin and Plank (2002) found that over 90% of purchasing managers based their decisions on both price and non-price variables (e.g., durability, service, lead-time, and trust).

The consideration of attributes other than price, describing the item and/or the bidders, introduces a level of complexity that is difficult to address for many real-life situations. Therefore many organizations tend to modify the pure single-attribute auctions. The modifications include: (1) pre-selection of bidders so that only bidders who are known to meet the additional criteria are included; (2) giving incumbents an advantage because their qualifications are known; and (3) the use of disclaimers such as "the lowest bid may not be awarded the contract" (Bichler and Kalagnanam 2005; Engelbrecht-Wiggans, Haruvy et al. 2007; Schoenherr and Mabert 2007). The results of such auction modifications are mixed because of collusion and selection of inferior offers (Elmaghraby 2004; Katok and Wambach 2011). In some situations the process becomes an auction in name only, as is the case with an auction in which neither the winner nor any other bidder is awarded the contract.

Most procurement decision problems are multi-attribute and, as such, there is a need for developing multi-attribute auctions that can be used in e-procurement. The first step in this direction is the design of an auction procedure. Then such auctions can be experimentally studied. The most recent survey of experimental auction research (Kagel and Levin 2012) does not include any multi-attribute auction experiment.

In summary, there is a need to better define the distinction between auction and negotiation as well as to fill a gap in the literature concerning which mechanism best fits specific e-procurement problems. The selection of the most appropriate exchange mechanism is not a trivial problem. First, the desired performances have to be identified. In this respect, at least two aspects should be considered: transactional performance (effectiveness and efficiency of the transaction) and relational performance (building or enhancing the buyer-supplier relationship). Second, comparing the extent to which a given mechanism impacts on the performance requires distinguishin such an impact from that of other variables. As such, the comparison has to be done adopting the same e-procurement problem as well as IT system.

This paper reports an ongoing study in which we address three specific issues:

1. Design of a multi-attribute auction procedure and its implementation in a system which can be used by buyers and sellers.
2. Design and implementation of decision support aids which can support bidders and negotiators.
3. Behavioral comparison of multi-attribute auctions and multi-bilateral negotiations in which the participants use the same business case.

We use a multi-attribute auction procedure which does not require information about the bid-taker's preferences and allows the bidders to make progressive bids (i.e., so that in every round the bids are better for the buyer than bids made in the previous round (Pontrandolfo, Wu et al. 2010; Kersten, Pontrandolfo et al. 2012). In this paper we discuss two systems: (1) Imaras, in which a multi-attribute auction procedure is implemented; and (2) Imbins, which is a system for multi-bilateral negotiations, and report on two experiments with both systems.

2. Auctions and negotiations

Auctions are defined by an explicit set of rules which determine resource allocation and prices on the basis of the bids made by the market participants (McAfee and McMillan 1987). The following four characteristics differentiate auctions from other exchange mechanisms (Kersten, Chen et al. 2008):

1. Auction rules are *explicit* and known to bidder prior to the auction. Therefore, rules cannot be modified during the auction.
2. The rules describe the mechanisms completely thus allowing for the determination of one or more winners solely based on the bids. Auctioneers or any other parties have no discretion in the winner choice.
3. Rules typically include:
   (a) *bidding rules* stating how bids can be formulated and when they can be submitted;
   (b) *allocation rules* describing who gets what on the basis of submitted bids; and
   (c) *pricing rules* stating the corresponding prices the bidders have to pay; and
4. Auction rules allow mapping of bids on a single dimension – the price. Auctions focus on prices to achieve either an efficient allocation or revenue maximization.

2.1 Multi-attribute auctions

Che (1993) and Branco (1997) initiated studies on the buyer's payoffs in the two-attribute (i.e., price and quality) auctions. The private information of buyers determining the utility can be represented in one dimension; this shortcut allows applying the auction design apparatus to these problems. More recently, Beil and Wein (2003) analyzed the problem of designing the multi-attribute auction. They were in particular concerned with finding a scoring rule to maximize buyer's utility

The highly stylized information exchange in auctions makes it impossible for the sellers (buyers) to learn the preferences (needs, limitations) of the buyer (sellers). Therefore, much effort in multi-attribute auctions experiments has been devoted to the role and scope of preference revelation schemes. Bichler (2000) conducted several such experiments in which the bidders (sellers) were given the utility (value) function of the buyer. The results show that multi-attribute auctions do not provide substantial benefits over comparable single-attribute auctions. In other words, even with fully-revealed utilities the additional complexity outweighs the theoretical gains.

Koppius and van Heck (2002) conducted experimental studies on the impact of information availability on the mechanism efficiency. The information availability specifies the type of information that is given and when, how and to whom it becomes available during the auction.

They studied two types of multi-attribute English auctions: (1) auctions with unrestricted information availability, in which suppliers are provided with the standing highest bid and the corresponding bidder as well as score or bid ranking of the most current losing bids; and (2) auctions with restricted information availability, in which the bidders are informed only about the standing highest bid and bidder. The experiments indicated that auctions with unrestricted information availability yield higher efficiency than auctions with restricted information availability.

Strecker (2004) analyzed the impact of preference revelation schemes on the efficiency of multi-attribute English and Vickrey auctions. He concluded that English auctions with revealed preference structure of the buyer are more efficient than Vickrey auctions, and English auctions with hidden preferences. Chen-Ritzo, Harrison at al. (2005) introduced a multi-attribute English auction, where only partial information about the buyer's utility function was revealed. They showed that this variant performs better in terms of efficiency than a single attribute (price-only) auction. This outperforming of the multi-attribute over the single attribute auctions holds even though the bids in the multi-attribute auction were far away from those predicted by the solution predicted by theory. Notably, complexity in the auction mechanism consumes some of the efficiency gains over price-only auctions. This observation however, contradicts with the findings reported by Bichler (2000).

2.2 Multi-attribute negotiations

One of the main questions of the research in multi-attribute negotiation is how the representation of multi-attribute preferences affects the negotiation outcomes.

Davey and Olson (1998) compared a value-based negotiation system that used AHP with its pairwise comparing of criteria and alternatives with a goal-based NEGO system that asked users to set aspiration levels for criteria. This research confirmed the suggestion that conventional decision-making is goal-oriented and negotiators preferred to use goal-oriented method.

Lim (2003) conducted an experiment involving executives and managers in Singapore and found that the acceptance of negotiation support systems mainly depended on the subjective norm and perceived behavioural control. Several experiments were conducted using the e-negotiation system Inspire. The experimental research (Vetschera 2007) conducted using Inspire confirmed the theoretical assumption that knowledge about counterpart's preferences contributes to the achievement of better outcomes. Negotiation Assistant (Rangaswamy and Shell 1997) was used for the research on the effect of negotiation support on the results of negotiations. Experiments showed that using NSS in structured negotiation settings yields better outcomes for the negotiators as compared to face-to-face or email negotiations. Experiments with the negotiation support system called Negoisst (Köhne, Schoop et al. 2004) led the authors to formulate five main challenges for computer-aided negotiations. They are the general limitations of preference elicitation due to problem complexity, the dynamics of preferences, the dynamics of the problem structure itself and its understanding, and the necessity for integrated decision support systems to deal with issue-by-issue negotiations.

3. Experimental studies and mechanism comparison

Formal comparisons of auctions and negotiations are difficult because of the significant differences in the assumptions underlying each mechanism. Auctions assume that bidders know the buyer's valuation (price) of the good and follow strict and fixed protocol. Negotiation mechanisms have significantly weaker assumptions; the key assumption is that the parties negotiate in good faith and that the parties have preferences allowing each to compare the alternatives. There are no limitations on communication and no assumptions about the sellers' knowledge of the buyer's valuation. Because there are only a few assumptions for negotiation mechanisms it is possible to add additional ones so that the mechanism can be easier compared with an auction mechanism.

3.1 Single attribute comparisons

Bulow and Klemperer (1996) who have shown in one of the first formal comparative studies that simple English auction with N+1 participating bidders (buyers) always yields higher revenue than a scheme they call "negotiation with N participants".

Bulow and Klemperer did not compare English auctions with anything that resembles negotiation as discussed in social science literature. The basis for their comparison was an exchange mechanism designed so as to maximize revenue of the seller. This mechanism is a type of an auction inasmuch as it does not allow for free interaction among the parties and requires the sellers to compete among themselves.

Kirkegaard (2004) revised Bulow and Klemperer's theory (1996) and included non-cooperative bargaining but also with very limited communication protocol. Manelli and Vincent (1995) showed that the effects of auction and negotiation would vary according to the situations; it is difficult to judge the effect of these two mechanisms on a given transaction without the consideration of the overall context, including the goods, participants, market, and so on. They also proposed a methodology for the mechanism selection. An important conclusion in this study was that auction mechanisms are frequently inefficient in a procurement environment, which contradicts the two previous studies.

In addition to theoretical comparisons, several experimental studies were conducted to compare auctions with negotiations. Thomas and Wilson (Thomas and Wilson 2002; 2005) conducted two studies in a laboratory settings. The first study (Thomas and Wilson 2005) compared first-price auctions to multi-bilateral negotiations in a procurement scenario. They found that with more sellers (four sellers) the transaction prices in multi-bilateral negotiations were not significantly different from those in first price auctions. The transaction prices in multi-bilateral negotiations were higher than in first-price auctions when the number of sellers was reduced from four to two. Moreover, these two mechanisms were equal in terms of efficiency.

In their second study, Thomas and Wilson (2002) compared second-price auctions to multi-bilateral negotiations with verifiable offers. They found that prices were lower in verifiable multi-bilateral negotiations than in second-price auctions. However, the efficiency of these two mechanisms was found to be statistically equivalent. By comparing these results to the first study, they ordered the four mechanisms in terms of yielded transaction prices, from highest to lowest: second-price auctions, verifiable negotiations, non-verifiable negotiations, and first-price auctions.

Bajari, McMillan and Tadelis (2009) conducted empirical analysis of auctions and negotiations in the construction industry. They observed that the use of the exchange mechanism depends on the knowledge and complexity of the context and task (product). Negotiations have advantages, if the specifications of the product to be traded are not well-defined a priori, which is often the case in this industry. Negotiations, unlike auctions allow for the discussion and clarification of the specifications. Not surprisingly, their empirical analysis also reveals that auctions perform poorly in terms of efficiency when changes in the product design need to be made after the transaction took place.

3.2 Single and multi-attribute comparisons

Chen-Ritzo (2005) conducted laboratory experiments on three-attribute auctions to compare the case when all three attributes were subject to price only bidding. In common sense multi-attribute auction should be at least as effective as the single-attribute ones. Their result was empirical proof that using multi-attribute auctions improves both buyer and seller's utilities.

Engelbrecht-Wiggans et al. (2007) experimentally compared buyer-determined and price-based multi-attribute mechanisms in order to determine the conditions under which a buyer-determined mechanism increases the buyer's surplus as opposed to a price-determined (PD) mechanism where the buyer commits to awarding the contract to the lowest bidder. They consider an IPV auction in which quality $Q = C + \gamma X$ where C (cost) is uniformly distributed on (0, 100), X is uniformly distributed on (0, 1), and γ is a constant, so that C and Q are positively. They observed that the "buyer-determined" mechanism increases the buyer's welfare only as long as enough suppliers compete (more than 4). If the number of suppliers is small and the correlation between cost and quality is low, the buyer is better off with the "price-based" mechanism.

3.3 Comparisons of multi-attribute auctions and negotiations

We know of no experimental research in which multi-attribute auctions were compared with multi-issue multi-bilateral negotiations when no preference information of one side is disclosed to the other side.

4. Overview of the Imaras and Imbins systems

Earlier experimental comparative studies of exchange mechanisms dealt with single issue auctions and negotiations (price in most cases) (Thomas and Wilson 2002; Thomas and Wilson 2005). If multiple issues are involved, the weighing of different issues should reflect the preferences of the business. However, the requirement that the auctioning or negotiating sides inform each other about their respective preferences seems unrealistic. The procedure that is embedded in the proposed auction system does not require disclosure of preference information.

We used two systems: (1) Imaras (InterNeg multi-attribute reverse auction system) to conduct auctions; and (2) Imbins (InterNeg multi-bilateral negotiation system) to conduct negotiations. Both systems have been developed in the InterNeg virtual integrated transaction environment (Invite). This section briefly reviews Invite, discussed in detail by Strecker at al. (2006), and the two systems.

4.1 Invite development environment

The Invite environment incorporates at its core process, modeling elements that allow system designers to implement various exchange mechanisms. Using abstractly defined set of elements, including activities, outcomes, and transitions, designers can implement a variety of mechanisms, ranging from simple message-based negotiations and single-issue auctions to multi-bilateral negotiations and multi-issue auctions. Bidding and offer-making are primary examples of activities. In the design of Invite environment activities are represented as web pages and page transitions.

An activity results in a concrete outcome that is recorded by the system (e.g., sending a message). In order to achieve such an outcome the user may need to perform several acts (e.g., read two previous messages and assess one offer). This led us to associate activities with pages and page components with acts. For example, the activity corresponding to the page shown in Figure 3 describes bid submission. This activity has several acts, including assessment of previous bids (shown in the table and graph), specification and generation of bids, and finally, the choice of a single bid.

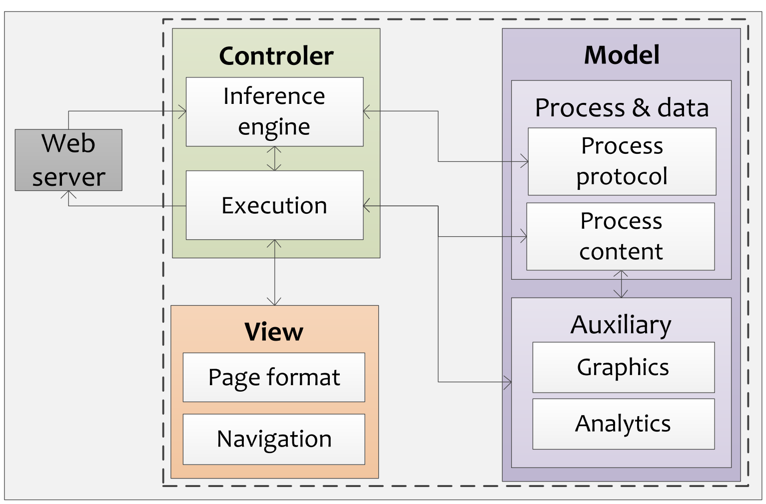

Figure 1. Logical design of Invite is based

The Invite platform is based on a three-tier software architecture built on a Fusebox framework, which enables the model-view-controller (MVC) design. The three types of components and their main subcomponents are depicted in Figure 1.

Invite generates e-negotiation or auction system instances based on the specifications of exchange mechanism designer. A user can request a particular type of an existing mechanism. This request is processed by the controller that extracts the negotiation protocol (process model), which corresponds to the requested type of negotiation or auction. The protocol and other complementary models determine the type of negotiation/auction and the type and content of information exchanged between the parties via the system and between a given user and the system's modeling components. The view-type components are used to compose web pages according to given layout and insert navigation links (Figure 1).

Invite is based on a three-tier architecture depicted in Figure 2. It is a web application based on an application server in the business logic layer and web browser technology in the presentation layer.

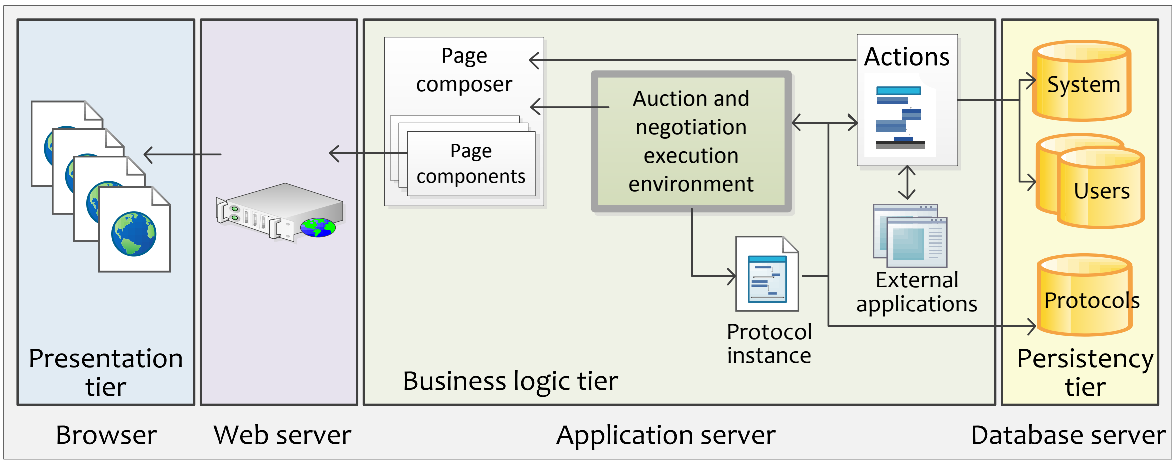

Figure 2. Invite architecture

The business logic layer separates the execution environment, protocol instances, actions and external applications. Actions are invoked by an auction and negotiation execution environment (a runtime engine) which runs instances of auctions or negotiations. The context, in which each instance runs, is the state in which the participants are at a given point in time and it is defined by the activities undertaken so far. It is stored in the persistency layer during and after a negotiation or an auction and managed by the runtime engine.

The execution environment selects and activates the appropriate actions according to the respective user's protocol instance. Protocols specify and control the activities undertaken by the participants, and, on the other hand, those activities performed by the system. They are stored in the database and their instantiation corresponds to the run-time construction of a particular system, for example, Imbins or Imaras.

4.2 Imaras and Imbins user interface

Both systems adopt the model-view-controller (MVC) design principle (Figure 1), which allows separating the different auction and negotiation protocols from the user interface. Imaras supports several types of auction settings, including:

- Disclosure of bids to bidders: only the bidder's own bid is displayed, or both own and winning bids are displayed, or all bids are displayed;
- Bidding process: continuous (asynchronous bidding) or round-based (synchronous bidding); with rounds being defined by time (e.g., number of minutes or hours) or defined by a rule (e.g., number of submitted bids).

Imbins supports multi-bilateral negotiations in which the parties negotiate on the same or similar subsets of issues by exchanging offers consisting of one or more issues (attributes) and free text messages.

MVC used in Invite allows for decoupling of the interface from the engine. This helps us to conduct experiments with systems employing different mechanisms but having very similar user interfaces. To show the similarity we present screenshots from each system.

Imaras's main screen is shown in Figure 3; it is the bidding screen of a round-based auction in which the bidder can see his or her own bids as well as the winning bids. Imbins's main screen is shown in Figure 4; it is the message and offer submission screen in which the negotiator can see his or her own and offers and messages as well as those of the counterpart. Both interfaces have four main components. The clock (A) shows time from the beginning of the auction and the time left to the deadline. The systems' navigation bars are located on the right-hand side (B) where links to active pages are listed. For auctions the round number and clock are also given. The clock is reset at the beginning of every round.

Section C of both bidding and offer screens contains the most recent winning bids and offers made by the seller (who sees this screen) and by the buyer. In auction, only winning bids and bids made by the bidder who sees this screen are shown. In negotiation only offers made by the buyer to all sellers or to the seller who sees the screen are shown.

The most recent bids and offers are shown in both tabular and graphical forms. (The complete list of bids and offers can be seen on separate pages: Auction history and Negotiation history pages are accessible from the menu in Section B.) In this section there is a difference between the auction and negotiation pages. In the auction page, the auction round is given as well as the bidder who submitted the winning bid. In the negotiation page messages sent by a counterpart can be accessed (they are expandable). Bids and offers are constructed and submitted in Section D.

The two main differences between auction and negotiation are in the limit sets for the former and messaging facility for the latter. In Section D of the offer screen in Imbins there is a message box that allows the user to write and send a message to the counterpart.

The limit sets are determined by the multi-attribute auction procedure (Kersten, Wu et al. 2010; Kersten, Pontrandolfo et al. 2012). They are bounds imposed on the attribute values and they assure that the bid in one round is not worse for the bid-taker than the winning bid in the previous round. Because there may be several limit sets (three are shown in Figure 3), the bidder can select one set (table row) and then select admissible attribute values for the given set. Then in the next table the selected values will appear. This table shows the auction bid or negotiation offer.

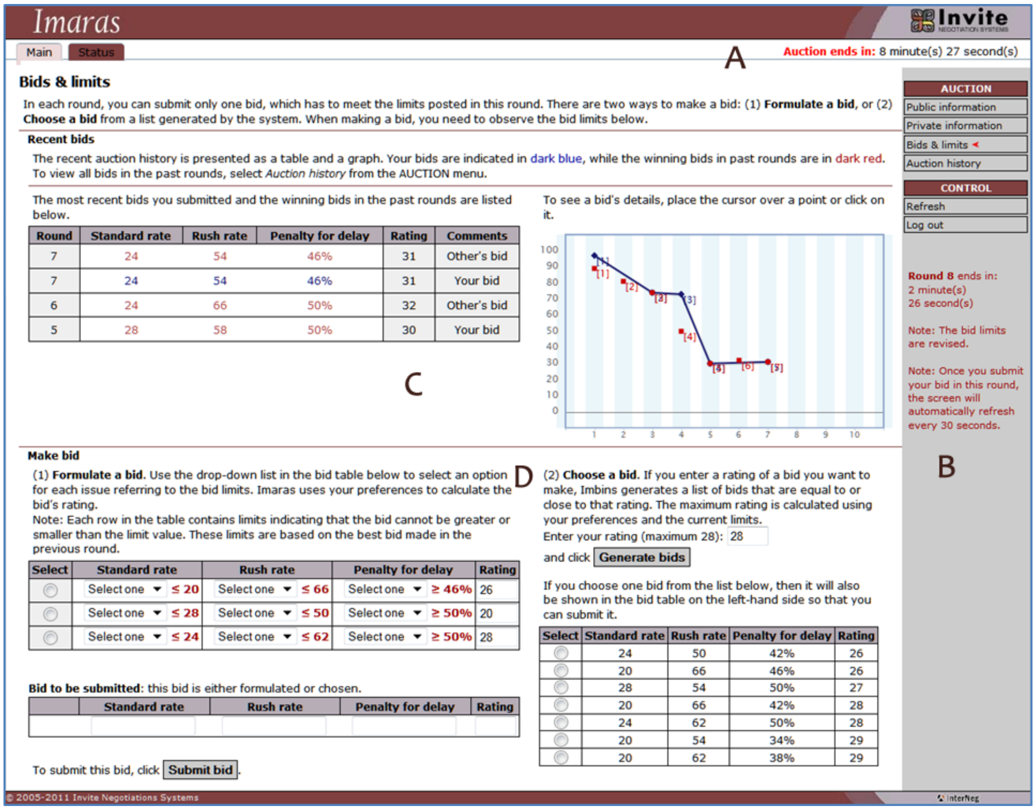

Figure 3. Bid construction and submission screen

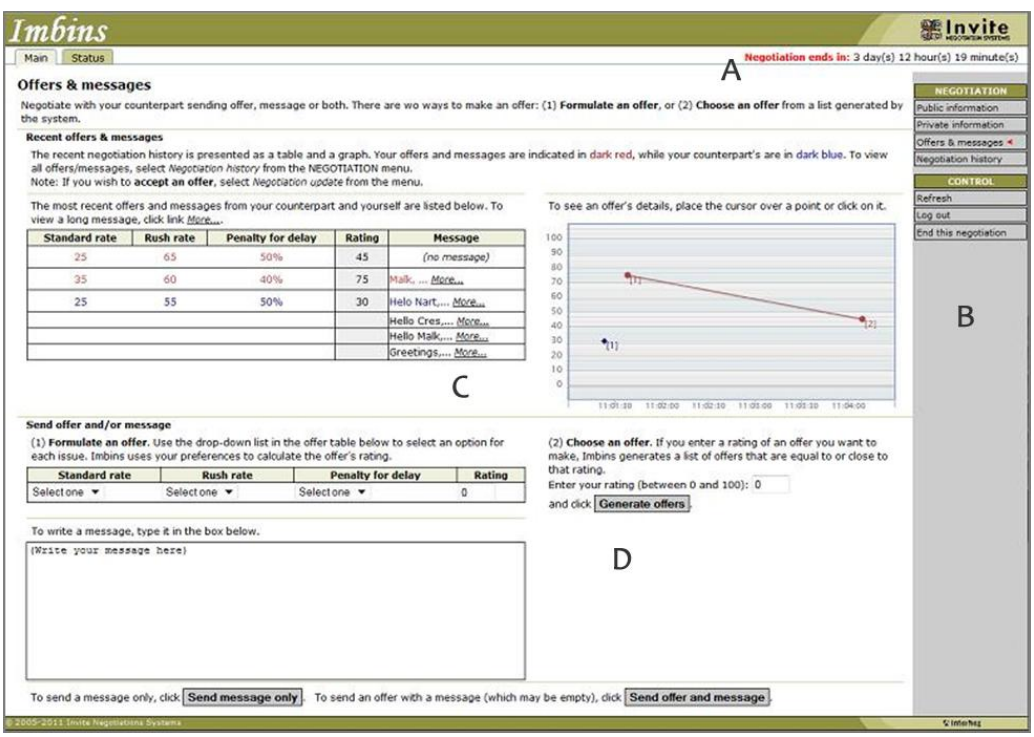

Figure 4. Offer with/w-out message construction and submission screen

There are two ways to input the values into the bid and offer tables. In addition to the one described above, the user may generate bids (offers). In order to do so, he or she has to enter the preferred value of rating (utility) and click on “Generate bids” (“Generate offers”) button. Subsequently a table (not shown) will appear below the button with up to ten bids (offers) with a rating which is equal to or close to the selected rating value.

5. Auction and negotiation comparison

In this section we describe results obtained from the experiments involving the two systems described above.

5.1 Auction and negotiation business case

We used the same procurement case in both auctions and negotiations.

A producer of perishable goods (the buyer) is seeking a logistic service provider who would transport goods from a single depot to a large number of customers. The buyer wants to sign a contract with a single provider for one year with a possibility of renewal. The buyer assures the minimum quantity of goods to be transported. There are five attributes: (1) standard rate of transportation; (2) the amount transported above the minimum quantity without additional charges; (3) rush rate for unexpected delivery; (4) penalty for delay in providing customers with the requested goods on time; and (5) penalty for the non-delivery or delivery of spoiled goods. The possible ranges for each attribute are known to every participant.

There are six providers with a proven record who are invited to the auction or negotiation.

Participants are told that the company they represent estimated a revenue function based on the problem attributes. For each configuration of attribute values, revenue value can easily be calculated using a simple calculator which is embedded in the case description. In order to simplify comparison of different offers or bids, the revenue is represented as ratings between 0 and 100 interval. Ratings are secret and the higher the rating is, the better the contract will be for the participant.

Every participant is also given a breakeven rating and cannot accept a contract below this value because the firm he represents would incur losses. Every participant is also given reservation values for the attributes.

The above parameters are indicative. There may be three or more logistic providers seeking the contract which can have between two and five attributes (clauses). Also the revenue formulae and reservation and breakeven values may be different.

5.2 Experiment 1

The first experiment involved students from a Canadian University. The auctions and negotiations were conducted in the lab and, together with the preparation time they lasted two hours. They were also conducted online and the participants had one week to complete the process. The participants were first year undergraduate students; they were playing the role of the sellers.

One of the key differences between auctions and negotiations is the buyer's involvement in the latter. The buyer may follow different strategies and tactics, making comparison of the two processes difficult. Therefore, we selected buyers from graduate and senior undergraduate students and gave them detailed instructions regarding their behavior. Some of the buyers were asked to follow an integrative strategy, while others—a cooperative strategy.

Selected information about the results is given in Table 2.

Table 2. Experiment 1 results (sellers only)

	Auction		Negotiation*			
	Lab	Online	Lab-In	Lab-Cp	Online-In	Online-Cp
No. of instances	21	15	31	32	7	8
Agreement (%)	—	—	93.5	93.7	100	100
No. of offers (w & w-out msg.)/bids	5.6	3.2	6.3	6.5	2.8	2.9
Seller's profit	-9.5	16.3	13.9	7.7	9.1	4.7
Buyer's profit	80.5	53.3	63.6	69.8	60.4	65.3
No. of dominating alternatives	0.1	2.9	1.7	1.0	3.6	3.4
Overall satisfaction (1-7)	4.7	4.8	5.2	5.3	4.6	4.7
Time (hrs.)	0.24	61.4	0.35	0.36	37.4	45.0

* In – integrative; Cp - competitive

In the lab setting negotiations took longer on average than auctions (35 and 36 min vs. 24 min.). This is understandable because the negotiators-sellers were interacting with the buyers and they needed time to write and read messages. This can be contrasted with much longer time used in online auctions than in negotiations. In this case, however, the likely reason is the auction protocol bidder had to follow: the time allocated to each round was fixed and equal to one day. The number of bids (offers) made significantly differs between the lab and online condition; for online settings it is significantly lower. The difference is much smaller when auctions are compared with negotiations. This may suggest that making offers is not much more difficult than constructing bids. If confirmed, this findings is interesting because negotiators' workload is heavier (they need to consider buyer's offers and messages and also write messages).

In our experimental settings the outcome of every auction is an agreement. This is because the initial auction reservation levels are very favorable for the sellers. This is not the case for the negotiation in which the buyer has to accept an offer. Therefore, the percent of agreements is generally lower in negotiations than in auctions. Interestingly, the sellers reached worse agreements in lab auctions (-9.5) than in negotiations (13.9 and 7.7). In the negotiations, the sellers who negotiated with integrative buyers reached better deals than those who negotiated with competitive ones. For the buyers the results were somewhat opposite: lab auctions yielded the best deals, followed by the deals when buyers were competitive, while the worst deals were achieved by cooperative buyers.

The situation was very different in online settings. Online buyers negotiated better deals through auctions than through negotiations. (Again, this may be due to the way the auctions were set up.) However, the deal-making ability of integrative and competitive negotiators did not change: competitors achieved more. Overall satisfaction levels were similar across all cases, with the participants in the lab settings reporting slightly higher values.

5.3 Experiment 2

The second experiment involved students from an Italian University. The auctions and negotiations were conducted in the lab and, together with the preparation time they lasted two hours. The participants were third year undergraduate students; they were playing the role of the sellers. In negotiations, the buyers were junior researchers who were trained to follow integrative or cooperative strategies.

The main difference between Experiment 2 and the lab portion of Experiment 1 is that in this experiment two versions of the case were used. The three-attribute case used here was the same as the case used in Experiment 1. In addition we also used two-attribute case (one attribute was dropped from the initial case).

Selected information about the results is given in Table 3.

Table 3. Experiment 2 results (sellers only)

	Two attributes			**Three attributes**		
	Auction	**Integrate**	**Compete**	**Auction**	**Integrate**	**Compete**
No. of instances	11	7	7	11	7	7
Agreement (%)	—	100	100	—	100	100
No. of offers (w & w-out msg.)/bids	2.6	3.5	3.5	4.9	3.1	3.1
Seller's profit	-4.91	21.8	3.3	-9.2	9	2.3
Buyer's profit	76.7	55.0	65.4	77.3	60.3	67.8
No. of dominating alternatives	0	0	0	0.8	7.1	3.6
Overall satisfaction (1-7)	5.4	5.7	5.2	5.3	5.3	5.4
Time (hrs.)	0.9	0.15	0.12	0.22	0.15	0.11

As seen from the table, in this experiment the agreement rate was 100%. In a two-attribute case the average number of offers was higher for negotiation instances than the number of bids in an auction. In a three-attribute case, however, the situation is reversed; perhaps, due to the increase of the negotiation task complexity and the required cognitive effort. Sellers' profits were lower in auctions as compared to negotiations. Sellers made more profit in integrative, vs. competitive settings. Again, for the buyers the opposite was true: they made more profit using auctions, followed by competitive, and then integrative approaches. In a three-attribute case there were some cases of the existence of dominating alternatives to the agreements (implying non-Pareto optimality). This especially applied to negotiation cases, with integrative settings being the worst in this respect.

6. Conclusion

In this paper we have described the exploratory experiments aimed at investigating the differences between multi-attribute auctions and negotiations. The results indicate that there may be important differences between the two types of mechanisms in terms of process and outcome variables. One of the major lessons learned from the experiments is that participants need more time to learn and understand the procedure, system and case. These lessons should be taken into account in the design of future experiments to enable a more rigorous and conclusive analysis.

Observation of the negotiation and bidding processes and comments from the experiment participants led us to treat the experiments as extensive testing rather than a research experiment. The earlier system and usability testing did not show the participants' lack of good understanding of the problem and process. During the two experiments, we observed that some participants were lost and/or uninterested.

We received both positive comments ("positive overall experience", "fun to use", "enjoy the challenge", and "good learning experience") as well as negative ones ("not clear process", "difficult construction of bids", "no guidance"). The latter comments and the results of the experiments, in particular the losses that the winners "brought in" to the firms they represented, led us to realize that multi-attribute auctions are difficult and that we need to provide more and better tools for learning about the system, its use and the specifics of the bidding process. To this end, we have prepared several training materials.

Participants in our experiments are students who differ in their motivation and interest to learn the system and the case. In order to provide a more even field so that every participant knows the basics of the system and the bidding process, we are developing a demo followed by a short quiz which will test students' understanding of the system and its use. Students will watch the demo and will be asked to take the quiz about one week before the experiments. The next step aiming at increasing students' understanding of the process is breaking up the process into two separate phases. One phase will be preparation which will take between three days during which students will log in to the system and learn about the case. Before moving to the next phase, which involves bidding, students will need to pass a test.

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