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AN ELEMENTARY INTRODUCTION TO AUCTIONS

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AN ELEMENTARY INTRODUCTION TO AUCTIONS

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Abstract. This paper introduces the questions an auction designer must face and the different academic disciplines that have had something to say about auctions. The first part of the paper discuses the questions that someone deciding to hold an auction must answer, points out their possible significance, and mentions some of the kinds of answers that have been used. The second part of the paper describes the history of the academic disciplines that have studied auctions and the kinds of concerns and approaches that they have used.

1 Introduction

Because of deregulation and the rise of the Internet, many people who have had little to do with auctions are trying to figure out auction related issues. The purpose of this paper is to introduce such people to the questions an auction designer must face and to the different academic disciplines that have had something to say about auctions. This paper is not a survey of the academic literature (although it references some surveys) and it does not develop any auction theory. Rather, it is an attempt to put thinking about auctions into context.

The first part of the paper is a discussion of the questions that someone deciding to hold an auction must answer. It doesn't try to answer them, but it does point out their possible significance and mention some of the kinds of answers that have been used. The second part of the paper describes the different academic disciplines that have dealt with auctions. It describes the history of their involvement and the kinds of concerns and approaches that they have used.

2 What Decisions Define an Auction?

When someone has decided to hold an auction, they have already rejected a number of important alternatives to auctions. They are not going to post a price and wait for someone to come and buy. They are not going to negotiate. They are not going to hold an unstructured Request For Proposal (RFP) process. They are not going to hold a lottery. (Shubik 1970 has a discussion of additional alternatives to auctions.) Deciding to hold an auction means deciding on a relatively formal process for a sale or purchase.

2.1 What is to be Sold?

Perhaps the first decision in deciding to hold an auction is deciding precisely what is to be sold (or purchased). Is the antique chandelier included with the house? Is the product sold as is or with a warranty? If the Federal Communication Commission (FCC) has 30 MHz of spectrum covering the entire country to sell, how should it divide up the country into geographical regions and how should it divide the spectrum into bands? Should it sell 30 MHz licenses in each region, two 15MHz licenses, a 20 MHz license and a 10 MHz license, or three 10 MHz licenses? And what uses should the license authorize. The FCC has auctioned off licenses for different purposes of different bandwidth and different geographical extent—national, regional, metropolitan area, and local area. In addition, technically it does not sell a license, but rather the right to be the sole applicant for the license. A winning bidder still has to prove that it is legally qualified—e.g., with respect to foreign ownership restrictions—and competitors can object and delay the award of a license even to a successful bidder who ultimately proves to be qualified.

The decision about what is to be sold can involve some important but subtle issues as well as the need for careful definition. For example, one of us once witnessed a "retail" auction of the unsold condominiums in a building. The auctioneer did not auction off each condominium separately. Instead, he grouped all of the available one-bedroom condo's into a pool and sold the right to choose any condo in the pool. After that right had been sold and exercised, he repeated the auction with the reduced pool.

This was a clever choice. It induced bidders wanting different condos to compete with each other. Privately, the auctioneer said he had a general idea which condos a winner would choose —the higher floors and better views tended to go first—but that sometimes he was surprised. He reported asking a woman who had chosen a condo on a lower floor with an inferior view why she had chosen the one she selected, and said her answer was, “It’s next door to Mary.”

Another example of the subtleties of defining what is to be sold involves the Federal government’s sale of coal leases. The winner of the auction is likely to have to negotiate with a railroad that has significant market power and perhaps as well with an electric utility with market power. After it has paid the government the bonus it has bid for the coal lease, that money is a sunk cost. The coal company (and the government) would be much better off if what was sold was an option to sign the coal lease. Then the bonus payable upon exercising the option would not be a sunk cost, and the coal company would be in a much stronger negotiating position. (See Rothkopf and Engelbrecht-Wiggans 1992 for a fuller discussion of this.)

2.2 Who May Bid?

A second decision someone holding an auction must make is who may bid. Will anyone be allowed to bid? If not, what qualification will be required? A license? Certification? Registration? A deposit? A bond? Citizenship? An affidavit asserting that you are a citizen? Membership in an organization? An invitation? Will a joint venture of competitors be allowed to bid? Some auctions of repossessed automobiles are open to the public and some are just for licensed car dealers. If you are selling an inexpensive item at a county fair, you may not need any limitation on who may bid. If you are contracting for the construction of a complicated chemical plant, you may want to invite bids from only the best chemical construction companies. A government may want only its own citizens to control or benefit from certain assets. An auctioneer may require registration in order to have a mailing list for announcing future sales.

2.3 Entry Fee

Another related decision is whether there will be an entry fee for participation in the auction. If participation is tightly limited or highly entertaining, this could be a source of funds. Conversely, if bid preparation is expensive, the “entry fee” could be negative; that is, the bid taker may subsidize participation. The military sometimes awards several design contracts before a competitive procurement of a weapon system.

2.4 What Kinds of Payments and Which are Biddable?

Two related decisions are what kinds of payments will the winner make and what will the bid variable be. When the Federal Mineral Management Service sells an offshore oil tract lease, it usually collects money for it in three different ways: a fixed, up-front bonus payment, a percentage royalty payment on oil produced and an annual rental. Typically, the royalty and annual rent are fixed, and the bonus is the bid variable. That is, the bidder offering the highest bonus wins the lease. However, there have been oil tracts leased in which the royalty rate was the bid variable, and there have been oil tracts leased on a profit share basis. (The results of the latter kind of sale are mentioned in Rothkopf, Dougherty and Rose 1986.)

2.5 How will the Bids Be Compared?

The next issue is how will the bids be compared in order to select the winner. If there is only one bid variable, this is simple. However, if there is more than one bid variable, the bid variables need to be reduced to a single number. This can be done with a scoring rule that may be simple or complicated. The red-letter warning for bid takers using a scoring rule is that such rules must be constructed with great care because bidders will optimize against them. A scoring rule that is inadequate in even one small way can give a bad result. If quality is important, it must be defined, measured, and probably constrained.

One particular kind of scoring rule that is used in both road construction and Federal timber leasing involves the use of unit prices. In these auctions, the bid taker has a list of items or activities—construction steps such as cubic yards of earth moving in road construction and board feet of timber of different tree species in the timber leasing. The bids are unit prices for each item. The single winner is selected by multiplying each unit price by the estimated quantity and adding up the products. The payment, however, involves the actual quantities, not the estimates. This leads to gaming by some bidders that is called unbalanced or skewed bidding. For example, a timber bidder who thinks that the Forest Service estimate for the number of board feet of incense cedar on a timber tract is too high may bid a very high unit price on that species and relatively low prices on other species. If she wins, it may turn out, in retrospect, that her bid with the actual measured quantities was lower than another bid that bid unit prices in proportion to value. Furthermore, if she wins, there may well be a moral hazard problem, since she will lose money on every board foot of incense cedar she harvests. (What the Forest Service is selling is the right **and duty** to harvest the timber on the tract by a given date.) The Forest Service, in response to concerns about these problems has taken various steps to limit the range of allowable unit prices. (See for example US General Accounting Office 1983 and US Forest Service 1983, 1984, 1985a and 1985b). Road construction auctions are gamed not just for quantity estimates, but also because progress payments on large projects are based upon unit prices. Hence, the present value of the winning bidder's cash flow will be improved if she has bid relatively high unit prices on early activities such as marshalling equipment and cutting to grade and compensated with relatively lower prices on later activities such as painting and installing signs. (For theoretical discussions of unbalanced bidding see Stark 1974, Diekmann, Mayer and Stark 1981, and Wood 1989.)

A related concern is how responsive must a bid be. What will be done if a bidder says, "You specified A but B is just as good as A, and I am offering you B instead." Suppose B is in fact better than A or suppose the offer of B is an option that will lower the bid and not a substitution. How will these possibilities be handled? The line between an RFP process and an auction is not a clear one.

2.6 How will it be Decided if a Transaction Occurs?

Another question that the auction design must answer is how it will be determined if a transaction takes place. Will there be a reserve price? A publicly announced one? A sealed, private one? If multiple items are being offered, will the reserve price on each item be independent of the price on the others, or will there be some dependency, perhaps an overall budget constraint? Or will the bid taker have unlimited discretion to reject all bids.

2.7 How will the Price be Set?

If there is to be a transaction, how will the price be determined? Will it be the amount of the winning bid? This is called standard sealed bidding. Will it be the amount of the best losing bid? This is called a second-price (or Vickrey) auction. Second-price auctions were proposed and first analyzed by William Vickrey (1961). The pricing rule, which can seem silly at first glance since the winning bidder has indicated a higher willingness to pay, affects bidders' incentives. If the auction is considered in isolation, it is in a bidder's interest to bid her true value or cost regardless of how her competitors behave. (If she bids more aggressively and wins because of doing so or bids less aggressively and loses because of doing so, she is worse off. Bidders in standard sealed bid auctions normally bid less than their value or more than their cost.) If all bidders behave this way, then the auction will have the desirable property that it awards the item to the bidder with the highest value or lowest cost. Furthermore, Vickrey proved a "revenue neutrality theorem" that says that under certain circumstances the second-price auction results in the same average revenue for the bid taker as would a sealed bid auction. More modern treatments such as Milgrom and Weber 1982 identify circumstances in which it can be expected to be even better for the bid taker. However, considering the auction in isolation may not be appropriate. The auction requires the winner to reveal her willingness to pay, and that can be highly disadvantageous to the winner in subsequent negotiations. Awareness of this will affect bidder strategy. (See Rothkopf, Teisberg and Kahn 1990.) In addition, bidders may worry about the ability of the bid taker to cheat by getting insincere bids that lower the payment to the winner. (See Rothkopf and Harstad 1995.)

Similar questions arise if several identical items are for sale. Will each winning bidder pay what he offered? Or will the price for all items be the least attractive bid accepted for any? (Treasury bills have been auctioned using both rules.) Or will the price be a market-clearing price as determined by a mathematical programming calculation (as is done in the New York Independent System Operator's daily electricity supply auction)?

2.8 Single Round vs. Multi-Round Bidding

Another decision is whether there will be a single round of bidding or an auction in which the price changes until the item is sold. If there is to be a changing price, will it be the commonly-used increasing asking price (i.e., an English or progressive auction) or a decreasing asking price (i.e., a Dutch auction where the first bid wins) as used in the

Dutch flower markets. The decisions about the dynamics of a Dutch auction are fairly simple. The main question is how fast should the price decline. However, in a progressive auction, there are a number of issues that must be resolved. How will the minimum bid increments be determined? Will they be constant, preset or variable at the discretion of the auctioneer? Will they be variable at the discretion of the bidders, i.e. will jump bids or bid increases smaller than the auctioneer seeks be allowed? How much time will be allowed before the auctioneer ends the auction? eBay ends auctions at fixed times. Amazon.com allows extra time after each bid made after the scheduled end of an auction. (See Roth and Ockenfels 2000 for a discussion of the significant effect this difference has on how bidders behave.) What will bidders learn about the bids of others during the auction? Will they learn who made them? Their exact amount? Or will they merely know the bid the auctioneer is seeking?

2.9 Precommitment vs. Flexibility

Controlling the speed of the auction is one of a general class of issues involving the tradeoff between flexibility and precommitment. The bid taker's precommitment to a set of rules for the auction may be what induces bidders to participate. However, the bid taker needs some flexibility to deal with unexpected developments like a slow bidder or a bidder who claims to have made a mistake in a bid. Not all such claims are sincere. Bidders have been known to submit two bids—secretly wearing different organizational hats--in a sealed bid auction and then try to with draw an unnecessarily aggressive winning bid due to an "error." (See Rothkopf 1991.)

2.10 Selling Multiple Items

The sale of multiple items raises a host of additional issues. Will the items be sold simultaneously or sequentially (or in some sequence of small simultaneous sales)? If they are to be sold sequentially, in what order? It can matter. Different orders can favor different bidders. For example, if I only want item B if I win item A, then if item B is sold first, I may not know whether or how much to bid for it, but if A is sold first, my decision on B will be clear. Other bidders may have the reverse preference.

If the items are sold simultaneously, will bidders be able to bid on combinations of items? Any possible combination or just certain ones? If just certain ones, how are the allowable combinations to be determined? (See Rothkopf, Pekec and Harstad 1998 for a discussion of some of the issues of allowing bids on combinations, and see Park and Rothkopf 2000 for a further discussion of the process of determining which combinations can be bid on.) Will bidders be able to bid on alternatives, e.g., $100 for A or $110 for B, but not both? Will bidders be able to submit bids subject to a budget constraint (e.g., $100 each for A, B, C, D, E and F, but not more than $300 in total)? If so, how will it be decided which of the bids to honor? For example will the items be considered in some pre-specified sequence (Selected how?) until the budget is exhausted or will the auctioneer try to maximize his revenue subject to the bids and budget constraints of the bidders. If the items are identical, like Treasury bills, will bidders be able to submit demand curves as bids (e.g. 100 at up to $1,000 and 20 more at $990)?

If multiple items are sold in a progressive, multi-round simultaneous auction, how will the auctioneer keep the bidding moving along at an acceptable pace? Will there be "activity rules" as in the FCC's simultaneous progressive auctions. Will bidders be able to get waivers of these rules? If so, how often? (See McMillan 1994 for a discussion of the activity rules in the FCC auctions.)

2.11 Handling Defaults

A critical and sometimes overlook question is the default penalties for bidders who fail to carry through with bids. A few years ago the Australians held a sealed bid spectrum auction with no default penalties. After the bids were opened, the high bidder defaulted. The next highest bid and the one after that were by the same bidder and were also defaulted. The bidder continued to default on its bids until it got to a bid that was just higher than the next highest bid by someone else. Not surprisingly, no one thought the process was fair. If the auction process is to be taken at face value, then some appropriate (and enforceable) penalty for failure to perform as promised is needed. However, excessive penalties may be unwise. Indeed, a case can be made for withdrawable bids with modest penalties. (See Rothkopf 1991 and Harstad and Rothkopf 1995.)

Policies in the event of default are also important. If the high bidder in a progressive auction defaults, can the bid taker accept next to last bid or must she start the auction all over again? If there were other active bidders until right near the end of the auction, is the answer the same as it would be if there were only two bidders and the price is far beyond the initial starting price? (See New York Times 1984 for a discussion of the auction of a repossessed ship in which this happened.)

2.12 What Information will be Revealed and When?

Finally, what information will be revealed after the auction? This can be important. Consider Federal sales of offshore oil leases. The value of a lease can be high, as much as $100 million, but it is extremely uncertain. It is normal for half of the amount of a high bid on a tract to be "money left on the table," i.e., for the high bid to be twice the second high bid. The government discloses losing bids. Put yourself in the position of an oil company vice president preparing a bid for an offshore oil tract. You have two worries. If you don't bid high enough, you will not win, and if you bid too high, you will leave a lot of money on the table. Your boss, the company president, will not like either bad outcome. Suppose, however, that the government decided to reveal only the winning bid. Now there is only one thing will make your boss unhappy—if you lose. Will you bid more aggressively? Do you think your competitors, who are in the same situation as you are, will bid more aggressively?

When there is a sequence of auctions involving the same bidders, promptly revealing losing bids may help bidders collude by taking turns. On the other hand, keeping the bids secret forever, could help cover up collusion. Hence, the relevant issue may well involve not just what to reveal, but when to reveal it.

2.13 Details Matter

Before leaving the topic of the decisions that define an auction, we emphasize our strongly held view that context and details matter. It will not do to blithely assume that what is true for a single isolated auction is true for an actual one imbedded in a steam of commerce. Seemingly small auction design details can have major effects. Several examples of this were discussed above, and they are not the only ones. The devil is truly in the details.

3 Ways to Think about Auctions

Auctions have existed for thousands of years. During that time, auctioneers and bidders have thought about auctions and auction forms have evolved. Academic literature on auctions appears to date back less than 50 years, but it is now massive and involves several different disciplines. This part of our paper discusses this literature. It points out the disciplines that have participated and discusses how they have approached the problem.

3.1 Economics

The first academic discipline that comes to mind when one thinks of auctions is economics. While it was not the first discipline to write about auctions, the economics literature on auctions is now clearly more massive than that of other disciplines. Economics brings to bear several ways of thinking about auctions. The early literature was descriptive. Cassady (1967) wrote an early and entirely descriptive book on auctions. Other early work by economists such as Christiansen (1965) and Dam (1976) was both descriptive and analytical, but often did not develop formal models of auctions.

In 1961, Vickrey wrote the pioneering game-theoretic paper on auctions cited above, but the game-theoretic economic literature on auctions did not take off until about 1978. Now, it is the predominant economic paradigm for thinking about auctions. Game theorists build analytical models of auctions, usually of single isolated auctions. In these models, they calculate a Nash equilibrium. A Nash equilibrium in an auction model is a set of strategies for each bidder such that no bidder has anything to gain by *unilaterally* changing her strategy. Since auctions involve uncertainty and bidders usually have private information, these strategies are not bids, but functions of the bidder's private information, which usually is her estimate of her value or cost. In 1987, McAfee and McMillan compiled a survey of the literature of game-theoretic models of single isolated auctions. The game theoretic literature began to include in its focus auctions of multiple items after 1994 when game theorists became involved with design of the FCC auctions. Paul Klemperer (1999, 2000) has recently compiled a survey paper on game-theoretic models of auctions and a two-volume collection of papers on that topic.

Game-theoretic models of auctions are very difficult to solve mathematically. Hence, a lot of the game theory models make extremely strong simplifying assumptions. This can limit their direct usefulness. What is true in the model may not be true about a particular auction of interest. However, the game theory models often can be used as metaphors or analogies (that must be used with care).

One of the assumptions almost always made by game theory models is that all of the bidders know the game that they are all playing and that they all know that they know this. Another almost universal assumption is that rules of the auction will always be followed. Most auction models assume that there is a fixed group of bidders rather than a group of potential bidders who decide whether to participate in the auction. Most auction models assume that bidders are indistinguishable before they get their private information. Such models can be quite misleading for situations in which one bidder is known to have an advantage or a disadvantage. Until recently, almost all game theory models of auctions were of single isolated auctions. Thus, situations involving repeated auctions, auctions followed by negotiations, or sales of related items were not well handled. Indeed, a single isolated auction is, almost by definition, not an important part of commerce.

Economists have taken to running laboratory experiments, often involving auctions. These experiments can check whether bidders behave in the rational way that the game theory models assume. (See for example Kagel and Levin 1986.) They can also be used to try out new proposed auction forms for which solvable game theory models have not been found. (See for example Banks, Ledyard and Porter, 1989.) Lucking-Reiley 1999 found a way to run experiments on the Internet with real buyers rather than laboratory subjects.

Finally, some economists analyze data from auctions. This econometric work is difficult because auctions are seldom exact or even random repetitions of each other. This makes it hard to draw valid statistical inferences.

3.1 Operations Research/Management Science and Engineering

Operations research/management science involves decision-oriented modeling. The first Ph.D. in operations research was granted for a dissertation that presented a model to help bidders decide how to bid in a sealed bid auction. (See Friedman 1956, 1957.) The model was a decision theory model. To use it, a bidder had to estimate the probability distribution of the best competitive bid. Given this distribution, she could calculate the bid that maximizes her expected profit. Generally, bidders find it easier to estimate the probability distribution of the best competitive bid directly than to try to use game theory. Using game theory would require them to try to estimate the game that they and all of their competitors think that they are playing, and then to assume that the competitors will all behave rationally with respect to this game. (Auction designers, as opposed to bidders, have more use for game theory.)

Unlike game theorists, operations researchers do not feel compelled to limit their analytical models to ones in which all bidders behave exactly optimally. They may use decision theory, exact or approximate game theory (e.g., a game model in which bidders' strategies are restricted to a limited class), or control theory (e.g., Oren and Rothkopf 1975). They tend to pay more attention to details. Rothkopf and Harstad 1994 give an operations research/management science view of auction modeling.

The early literature on auctions included a lot OR/MS-like work by engineers. Civil engineers were involved with highway contracting, and petroleum engineers, with oil lease bidding. Stark and Rothkopf's 1979 bibliography contains about five hundred papers, many of them from the engineering literature. One of the most notable ideas to come out of bidding theory, the "winner's curse" comes from the petroleum engineering literature. The pioneering paper by Capen, Clapp and Campbell 1971 put the phrase "winner's curse" into the academic literature. The basic idea of winner's curse is that while bidders may make unbiased estimates of value (i.e., estimates that are right on the average), they are much more likely to win an auction if they have overestimated value than if they have underestimated it. Thus, even though their value estimates are right on the average, their estimates of the value **of the items they win** are quite optimistic. A statistician would call this "selection bias." Whatever it's name, it is often a real and important phenomenon that bidders must correct for.

Recently, electrical engineers have been involved in the design of electricity auctions and transmission rights auctions. The economics of electricity generation and, especially, the physics of electricity transmission involve complications that are inconvenient for auction designers.

3.3 Sociology

There is not a large literature on auctions in sociology, but sociology present a key point of view for thinking about repeated auctions involving the same people. People involved in such repeated auctions often behave in ways better predicted by the ideas about social behavior of sociologists than by models of economic man. Smith 1990 is a key and easy to read book that develops this point of view.

3.4 Computer Science

In the past few years, computer scientists have become interested in auctions. The popularity of auctions in computer science has at least three causes. First, auctions provide concepts that can be used in designing computer systems. Second, electronic auctions allow for computer programs, called auction agents, that bid. Finally, cryptography has a role in auction design.

In computer-system applications, auctions are often used for optimizing some global measure subject to constraints. Solving optimization problems using auctions may have advantages over centralized optimization methods when the information required at each step in the optimization process is distributed in a system. Bertsekas 1991 developed an auction algorithm for network optimization. Agorics Inc. 1994 designed an efficient climate-control system for a building with multiple office rooms in which each room is represented as a buyer or seller. Gauntt 1998 described several companies' efforts on dynamic, usage-based Internet bandwidth pricing, a couple of which were based on auctions. (The idea of using auctions for Internet bandwidth pricing was first proposed by MacKie-Mason and Varian 1995.) There are research proposals on using auctions for various other purposes including mobile usage management (Mullen and Breeze 2000), power load management (Ygge 1998), and distributed multi-commodity flow problems (Wellman 1993).

The work on auction agents is, in some ways, a polar opposite of game theory. Computer scientists discard the assumption that agents are perfectly rational optimizers and instead design agents that use simple but plausible rules-of-thumb. While bidders in game theory models behave optimally within their simplified model, auction agents try merely to do well. However, they do deal with all the complications of the world in which they find themselves. Game theory is limited for some purposes by strict assumptions that necessitate simplified settings.

Gmytrasiewicz and Durfee 1995 developed an agent that recursively models other agents (i.e., what they think about what I think, and so on). The recursive modeling method assumes that agents build a finite nesting of models (compared to the infinite belief hierarchy used in game theory); a 0-level agent who does not know that there are other agents; a 1-level agent who models only the other agents' actions, a 2-level agent who has an insight into the other agents' internal reasoning process, and so on. Auction agents can be learning agents. Wellman and Hu 1998 combined the recursive modeling method with reinforcement learning in designing agents for a double auction. Cliff 1998 designed agents using an evolutionary process that learns the best bid based on occasional rewards.

The abandonment of optimality has risks; heuristic agent strategies can be exploited. For example, a simple heuristic strategy, such as "waiting in the background" that has worked well (See Rust, Miller and Palmer 1993.), does so only if other agents do not also use it. Adding adaptivity so that an agent can alter strategies can limit such exploitation to some degree. Park, Durfee and Birmingham 1999 used a heuristic exploration function to allow an agent to adapt its bidding strategy to its changing environment. The agent can *explore* and switch strategies in run time. Vidal 1998 showed that thinking more deeply with higher-level recursive modeling is not always beneficial, and used price volatility to quantitatively predict the benefits of deeper models.

Computer scientists are studying the system-wide properties of auctions with heuristic agents. They try to understand properties of agent societies and characterize the types of environments and agent populations that foster social and anti-social behavior. Studies on system-wide properties can be found in Kephart, Handson, *et al.* 1998, Wellman and Hu 1998, Ygge 1998, and Vidal 1998.

Finally, computer scientists bring with them cryptographic methods (such as secure distributed computation protocols), which have the potential to control information flows creatively. Nurmi and Salomaa 1993 show how cryptography can prevent undesirable information revelation in Vickrey auctions. Franklin and Reiter 1996 present a protocol for a sealed-bid auction that prevents a single auctioneer from altering a bid. It uses a distributed set of *m* auctioneers all of whom are needed to open a bid. Kikuchi *et al.* 1998 also used a distributed set of *m* auctioneers. Unlike Franklin and Reiter's protocol, theirs keeps the bids secret even after the auction.

4 Conclusions

This paper has been an introduction to the questions one must face in order to design or evaluate an auction and to the ways academics have of thinking about auctions.

What should you do if you are faced with a problem involving designing an auction? First, we recommend you start with a broad view before you get involved with a detailed analysis. Think about the issues in the broadest possible terms. Why an auction? What are the key underlying economic, technical, social, and political issues? When you narrow your scope down to particular issues, try to see which of the different schools of thought discussed above is most relevant. Finally, when you think you have an answer, try to game it. If you have designed an auction, try to put yourself into the position of a bidder. What would you do if you were in her situation? How could you take advantage of the rules or of the system? If enough is at stake, try to get professional help. In addition, you may wish to run some experiments to see how it would work in sample situations.

Although we haven't discussed auctions from the point of view of a potential bidder, we also recommend that potential bidders start with a broad view before deciding what bids to make. She should consider whether she has alternatives to participating in the auction. Can she get the rules or timing of the auction changed? Can she legally avoid head on competition? Can she anticipate her competitors' actions? Can she legally affect them?

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