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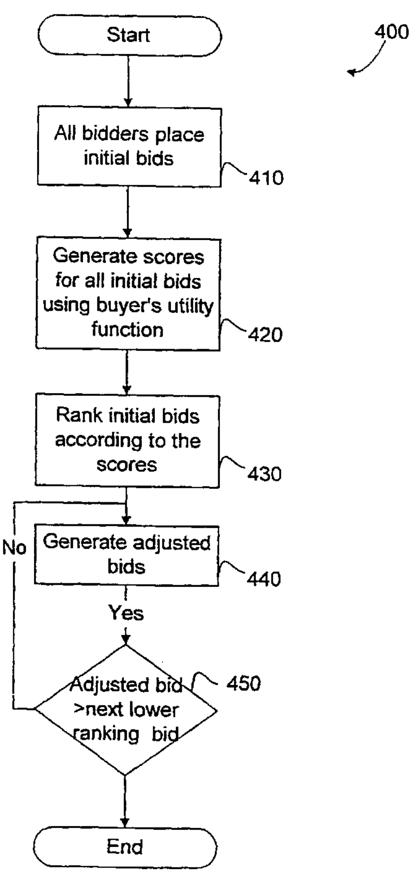

(57) Abstract: An improved multidimensional auction is provided which simplifies the bidder's bidding strategy by performing an adjustment of the initial bids. This adjustment is designed to reduce bidder's incentives to make bids dependent on competitor's expected bids. This is accomplished by the following. A utility function is generated based on the buyer's preferred terms for purchasing a product. The utility function is then applied to initial bids received from one or more sellers of the product to generate a ranking of the initial bids. Finally, the winning bid selected based on the ranking is adjusted to generate an adjusted bid. The adjusted bid is higher than the second highest bid, but lower than the winning bid. As a result, the improved multidimensional auction of the present invention allows for a faster auction process that takes into account buyers' preferences and performs at least as well or outperforms Vickrey and English auctions. It provides fewer incentives to find out the competitor's bids, thus simplifying the optimal bidding strategy. In some embodiments, all of the initial bids -- not just the winning bid -- are adjusted in such a manner as to preserve the ranking of the initial bids. In some embodiments, the adjusted bids are presented to the buyer using a unique format for all bids in a given rank class. Finally, in some embodiments, the initial ids are adjusted using predefined business rules.

WO 01/57621 A2

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MULTIDIMENSIONAL AND REVERSE E-COMMERCE AUCTIONS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to business methods and, more particularly, to business methods for conducting multidimensional and reverse auctions.

Related Art

One of the most widely used forms of auctions is the English auction. In the English auction, bidders openly announce binding bids to all other bidders and the auctioneer. A valid bid must be higher than the previous highest bid by at least an increment defined by the auctioneer. The auction ends if no new offers have been made for a certain period of time. The bidder who placed the last bid wins. He pays the amount of this last bid. While English auctions work quite well for live auctions, they require a substantial amount of interaction amongst bidders.

A different type of auction, the Vickrey auction, approximates the results of an English auction, but does not require interaction amongst competing bidders. In a Vickrey auction, each bidder privately tells the auctioneer the highest bid he is willing to make. There is no interactive bidding process. The auctioneer simply finds the bidder who was willing to make the highest bid. This bidder wins the auction. However, he only has to pay the price of the second highest bid.

If bidders were to decide their maximum bids in advance and always made minimum bids, the English auction and the Vickrey auction would yield very similar outcomes. The final prices in both auctions, in fact, would differ by at most one bid increment.

For example, consider the following auction situation:

I. Bidder A is willing to pay a maximum of $5

II. Bidder B is willing to pay a maximum of $7

III. Bidder C is willing to pay a maximum of $10

IV. Bidding starts at $3

V. Minimum Bid increment is $1

An English auction would yield the results shown in Fig. 1. In fact, A, B and C would each start bidding at their minimum bid (stages 110, 120 and 140, respectively). Thereafter (stages 130 and 160), each would increase its bid only by a bid increment ($1 in the example of Fig. 1) and stop bidding once their maximum bid was reached (stages 130, 150 and 160, respectively).

At stage 160, both A and B will have stopped bidding, as they have reached their maximum bids ($5 and $7, respectively). As a result, bidder C wins the English auction with a winning bid of $8, rather than his maximum bid of $10.

A Vickrey auction would produce a similar result: C has the highest bid ($10) so he wins. However, he only has to pay the price of the second highest bid ($7) plus the increment ($1), so C would win the Vickrey auction with a bid of $8 (adjusted down from $10).

Current Internet auction sites such as EBAY (http://www.ebay.com) and others have a "proxy bidding" feature where the user can enter the maximum price he is willing to bid. This saves the users from having to place a large number of bids themselves, because the system can place the bids for them. If all bidders in EBAY used this feature, the result would approximate the result of a Vickrey auction.

For computer processing, the Vickrey auction is more efficient than the English auction, because there are fewer steps to follow, and the computation time is proportional to the number of bidders. It is also trivial to implement.

The Vickrey auction also has important advantages over traditional sealed tenders in terms of the strategic analysis that is required for optimal bidding. The reason is that optimal bidding in a sealed tender depends on each bidder's predictions of how others will bid. A computerized implementation of such a system would require learning rules that interact with and make predictions about one another, which would be very complicated and probably impractical to implement. In sharp contrast, an optimal bid in a Vickrey auction is equal to the value of the item to the bidder. This bid is optimal regardless of the strategies adopted by other bidders and can be implemented by practical algorithms.

The Vickrey auction does, however, require the bidders to trust the auctioneer. An auctioneer who is favoring a seller could simply lie to bidder C in the example above and say that the second highest bid was actually $9. In that case C would have to pay $10.

So far we have discussed auctions in which buyers are competing for a seller's products. However, other auctions are conducted where seller's are competing for a buyer's business. These auctions are referred to as reverse auctions. In a reverse auction, the bidders are sellers competing for the business of a buyer. The buyer corresponds to the seller in the traditional auction.

Finally, in the Vickrey and English auctions, bids are simply rational, positive numbers. Numbers have the advantage that they can be compared: $10 > $8. This property is essential for the auction processes: The English auction has to decide whether a new bid is higher than the current bid, and the Vickrey auction has to find the highest and second highest bid.

If bids are not numbers, but more complex pieces of data, the ranking problem is more complicated. In order to compare them, a "scoring rule" f can be used that assigns a number to each possible bid. Scoring rules are common in business-to-business RFPs. For example, a bidder's technical competence, proposal quality, and price might all be weighted in determining the winning bid.

The auction can then take place in terms of scores; a bid A beats a bid B if $f(A) > f(B)$, that is, if it has a higher score.

A multidimensional auction is an auction where bids are expressed in terms of vectors in an n-dimensional vector space. A scoring rule f() is used to map vectors to real numbers. The vectors represent attributes of the bid that is being made.

Scoring rules have traditionally been used only in high value business-to-business or government-to-business contracting, because they have been complex to administer. Also, scoring rules have only been used in connection with standard sealed-tenders, and not in connection with Vickrey or English auctions.

Thus, there is a need for a method of conducting auctions that approximates or improves upon the results of the English and Vickrey auctions and that can be used in reverse and multidimensional auctions.

SUMMARY OF THE INVENTION

The method of the present invention provides an improved multidimensional auction which simplifies the bidding strategy for the bidders by performing an adjustment of the initial bids. This adjustment is designed to reduce bidder's incentives to make bids dependent on competitor's expected bids.

This is accomplished by the following. A utility function is generated based on the buyer's preferred terms for purchasing a product. The utility function is then applied to initial bids received from one or more sellers of the product to generate a ranking of the initial bids. Finally, the winning bid selected based on the ranking is adjusted to generate an adjusted bid. The adjusted bid is higher than the second highest bid, but lower than the winning bid. As a result, the improved multidimensional auction of the present invention allows for a faster auction process that takes into account buyers' preferences and performs at least as well or outperforms Vickrey and English auctions.

In some embodiments, all of the initial bids -- not just the winning bid -- are adjusted in such a manner as to preserve the ranking of the initial bids. In some embodiments, the adjusted bids are presented to the buyer using a unique format for all bids in a given rank class. Finally, in some embodiments, the initial bids are adjusted using predefined business rules.

<u>BRIEF DESCRIPTION OF THE DRAWINGS</u>

Fig. 1 is a flow diagram of a prior art English auction amongst three bidders.

Fig. 2A shows exemplary multidimensional bids.

Fig. 2B shows an exemplary scoring rule used to evaluate the multidimensional bids of Fig. 2A.

Fig. 2C shows the results of applying the scoring ruled of Fig. 2B to the bids of Fig. 2A.

Fig. 3 is a flow diagram of an improved multidimensional reverse auction, in accordance to an embodiment of the invention.

Fig. 4 is a flow diagram of a multidimensional auction where each bid can be adjusted, in accordance to an embodiment of the invention.

Fig. 5 is a diagram illustrating an exemplary presentation of bids generated by the auction of Fig. 4.

DETAILED DESCRIPTION OF THE INVENTION

The multidimensional auction of the present invention improves the auctions described above, and further does not require buyers to commit to accepting either the highest (winning) or any other bid.

In some embodiments, the multidimensional auction of the present invention, is a reverse auction where sellers bid for a buyer's business. Each bid includes values for each term of the offer. A scoring rule is used to allow comparison of bids. This scoring rule is referred to as a "utility function" U(), generated from preference information obtained from the buyer. The utility function can be different for each buyer. The utility function is applied to each bid by "plugging" the values for each term of the bid into the utility function for the buyer and calculating the value of the utility function, as shown in Figs. 2A-2C.

Fig. 2A shows exemplary bids 210 and 220 for an hypothetical apple juice auction. Fig. 2B shows an exemplary scoring rule 230 for comparing bids 210 and 220 of Fig. 2B. Finally, Fig. 2C shows the results produced by applying formula 230 to bids 210 and 220. Thus, in the example of Figs. 2A-C, bid 210 would have a higher score than bid 220.

The utility function reflects how much a buyer likes a particular bid. Ideally, U(A) > U(B) if and only if a buyer prefers a bid A over a bid B. In practice, however, the utility function approximates the requirements of the buyer based on one set of assumptions, but the buyer may want to modify his/her utility function to account for any changes in his/her preferences. As a result, in some embodiments, the buyers' utility function can be adjusted/updated by the buyers.

Fig. 3 illustrates the process 300 of running a reverse Vickrey auction using a utility function, as described above. First, bidders A and B submit their maximum offers, a and b, respectively, in stages 310 and 320. The utility function U() is then applied to bids a and b in stages 315 and 325. Stage 330 then compares the utility functions U(a) and U(b). If U(a) > U(b), a becomes the winning bid in stage 340. Otherwise, b becomes the winning bid in stage 350. Depending on the outcome of stage 330, the winning bid (a or b) is then adjusted in stages 345 or 355 to generate an adjusted winning bid (a' or b') and operation 300 terminates.

In the example of Fig. 3, the winning bid (e.g., a) is simply adjusted to equal the next highest bid (e.g., b) plus a bid increment, since the buyer can only accept the winning bid.

By contrast, in some embodiments of the present invention, the list of final offers from all bidders is presented to the buyer (only the winning bid is adjusted). However, the buyer can accept any of the bids and is not bound to accept the winning bid.

Thus, if the winning bidder in the example of Fig. 3 were to adjust his bid to closely to the next higher bid, the buyer would be less likely to accept the adjusted winning bid. Similarly, if the winning bidder were to adjust his bid only slightly, or not at all, the result would be similar to a sealed tender auction.

The multidimensional auction of the present invention allows the winning bidder to adjust winning bid x to any bid x' that satisfies the condition $U(x') > U(y)$, where y is the next highest bid.

By allowing the winning bidder to adjust his/her offer, the optimal bidding strategy is simplified and bidders are encouraged to make their best offer. Bidders no longer have to worry about making an offer that is better than necessary to win, as the winning bidder is given a chance to adjust his/her bid.

The underlying assumption is that the probability that an offer with a given utility is chosen by a buyer depends partially on how the offer ranks among other offers. The highest-ranking offer has a significantly higher probability of being accepted. At one extreme, in an auction with commitment from the buyer, the probability of the winning bid being accepted by the buyer is 1, independent of the utility function of the bid.

A natural generalization of this rule is that for all bids, not just the highest one, the probability of being chosen also depends on the rank of the bid, not just on the utility of the bid.

For example assuming that bidders A, B and C in a reverse auction would be willing to make best offers having a utility function of 90, 85 and 80, respectively.

If bidder B knew that any bid over 80 would assure him the second rank, he might want to bid less than his best bid (e.g., 83). B has an incentive not to make his best offer, but instead to try to find out what bid will be required to keep second rank. In other words, it would not be the optimal bidding strategy to simply make the best offer.

To solve this problem, in some embodiments of the invention, all bidders are allowed to adjust their offer in a way that will not affect the ordinal ranking of the bids. This process (400) is illustrated by the flow diagram of Fig. 4.

In Fig. 4, initial bids are first placed by the bidders in stage 410. Scores are then generated for each initial bid by applying a utility function for the buyer to each bid in stage 420. In stage 430, the initial bids are then ranked based on the scores generated in stage 420. Each bidder is then allowed to adjust his/her bid in stage 440. Stage 450 then determines whether the adjusted bids comply with a set of predefined rules for the auction. If the adjusted bids comply with the auction rules, operation 400 terminates. Otherwise, step 440 is repeated until all adjusted bids comply with the auction rules.

This adjustment can be fixed (for example to the middle or bottom of the interval) or seller-dependent, for example as part of a business rule used to automatically adjust a bidder's bids. At the other end of the spectrum, if bidders were allowed to adjust their bids in a way that alters the ranking of the bids, bidding strategies would become very complicated.

In some embodiments, the presentation of the auction results to the buyer does not include value scores, but only an ordinal ranking. In these embodiments, the optimal strategy may be to adjust to the bottom of the interval. Adjusting to utilities below that interval would encourage sellers to make bids on which they would lose money, in order to obtain a higher rank, knowing that they may adjust their bid downward after the fact. Since the customer also sees attributes of the final offer and takes them into consideration, adjusting all the way down may not be the optimal strategy.

One benefit of this approach is that it becomes harder for sellers to reverse-engineer their competitors' business rules.

There is an additional benefit to this approach. Sellers generally prefer an auction process that does not show their best possible offer to the buyer. If all initial offers can be adjusted downward, sellers can make offers that are more favorable for them than their initial offer, as long as the best offers are significantly far apart from each other. Something similar could be accomplished artificially by simply adding an additional margin to the seller's offers, but it would be nicer to have a non-artificial solution.

The presentation of the auction results to the buyer can strongly influence the buyer's purchase decision.

It is desirable to present the offers in a way that maximizes the probability that the buyer accept one of the offers. At the same time, the presentation should make it easy for the buyer to make a good decision; e.g. one she feels comfortable with in the long run. Also, the presentation can be used to strengthen or soften competition among sellers, for example by altering the prominence of the highest bidder's offers or adjusting the number of offers presented to buyers.

However, the presentation can affect the optimal bidding strategy in the auction described above.

Fig. 5 illustrates a possible presentations of the bids (offers) generated by an auction, in accordance to an embodiment of the invention.

The top 12 offers generated by the auction of fig. 4 are shown in Fig. 5. The top three offers 510 are presented as being "best," without further discrimination. The next four offers 520 are presented as being worse, but better than the last five offers 530. If buyers were to base their decision primarily on which of the groups each offer is in, the optimal bidding strategy would be to try to bid the minimal utility required to be placed in each of the three categories. In such case, the exact ranking of each bid would not affect the likelihood of acceptance of the offers: rather, the category of each offer would determine the likelihood of acceptance of that offer.

An auction in accordance to some embodiments of the invention addresses this problem by defining an adjustment rule that depends on the presentation of the results to the buyer.

According to some embodiments of the invention, an adjustment round can be added to the auction method. Prior to the auction, it is predetermined how the offers resulting from the auction will be presented to the buyer. Based on this presentation, the possible ranks are classified into a sorted list of classes, so that all bids with ranks within the same class are presented the same way.

For example, in the example described above, the rank classes shown in Table 1 below would be assigned:

Table 1

Rank	Utility	Rank Class
1	93.0	1
2	90.0	1
3	89.0	1
4	88.0	2
5	85.0	2
6	82.0	2
7	82.0	2
8	80.0	3
9	78.0	3
10	77.0	3
11	65.0	3
12	45.0	3

After obtaining and sorting the initial bids, all bids are adjusted in such a way that each bid's rank class remains unaffected. There are several ways this adjustment can be done.

For example, all of the initial bids could be adjusted to the highest utility encountered in the next lower rank class. This would be the optimal adjustment in cases where the decision for a particular bid in a chosen category is made at random, without further comparison of the bids' attributes.

If the buyers are presumed to compare bids based on their attributes, the sellers could choose to make any adjusted offer that would still have ended up in the same category.

In other words, the seller could make any offers with a utility that is higher than the highest utility of the initial bids in the next lower class, but no higher than his initial bid. For example, bidder#2 could make any offer that generates a score higher than 88.0 based on the buyer's utility function.

The bidder's decision about the adjusted offer might also depend on which of the rank classes his bid is in. For that reason the classes are marked with ordinals numbers and provide the class's number to the bidder when he makes the adjusted offer.

In some embodiments, the rank classes could contain just one element each, for example, in a presentation that shows a sorted list of bids.

In some embodiments, the auctions use predefined business rules to generate bids dynamically. In such embodiments, actions described above as being performed by the seller are actually performed on the seller's behalf by a business rule provided by the seller.

The present disclosure describes but does not limit the invention. Embodiments other than the ones described herein are within the scope of the invention as set forth in the following claims.

CLAIMS

We claim:

1. A method of conduction a multidimensional auction, the method comprising:

receiving preference information from a buyer indicating the buyer's preferred terms for purchasing a product;

generating a utility function for the buyer based on the preference information received from the buyer;

receiving initial bids from one or more sellers of the product;

applying the utility function to the initial bids to generate a ranking of the initial bids;

selecting a winning bid based on the ranking; and

adjusting the winning bid to generate an adjusted bid, wherein the adjusted bid is higher than a second highest bid, but lower than the winning bid.

2. The method of claim 1, wherein the winning bid is adjusted using a predefined business rule.

3. The method of claim 1, wherein the initial bids are generated using a predefined business rule.

4. The method of claim 1, further comprising:

presenting the adjusted bid and at least one of the initial bids other than the winning bid to the buyer; and

determining which bid, if any, is accepted by the buyer.

5. The method of claim 1, further comprising:

adjusting the initial bids to generate adjusted bids, wherein each adjusted bid is higher than a next lower bid in the ranking of initial bids, but no higher than the corresponding initial bid.

6. The method of claim 5, wherein all the initial bids are adjusted to generate adjusted bids.

7. The method of claim 5, wherein the initial bids are adjusted using predefined business rules.

8. A method of conduction a multidimensional auction, the method comprising:

receiving preference information from a buyer indicating the buyer's preferred terms for purchasing a product;

generating a utility function for the buyer based on the preference information received from the buyer;

receiving initial bids from one or more sellers of the product;

applying the utility function to the initial bids to assign each of the initial bids to a rank class; and

adjusting each initial bid to generate an adjusted bid, wherein the adjusted bid is higher than a highest bid in a next lower rank class, but lower than a lowest bid in next higher rank class.

9. The method of claim 8, further comprising:

presenting the adjusted bids to the buyer, wherein all bids in a rank class are presented in a similar format; and

determining which bid, if any, is accepted by the buyer.

10. The method of claim 9, wherein the adjusted bid in a first rank class are presented in a different format than the adjusted bids of a second rank class.

11. The method of claim 8, wherein the initial bids are adjusted using predefined business rules.

12. The method of claim 8, wherein the initial bids are generated using a predefined business rule.

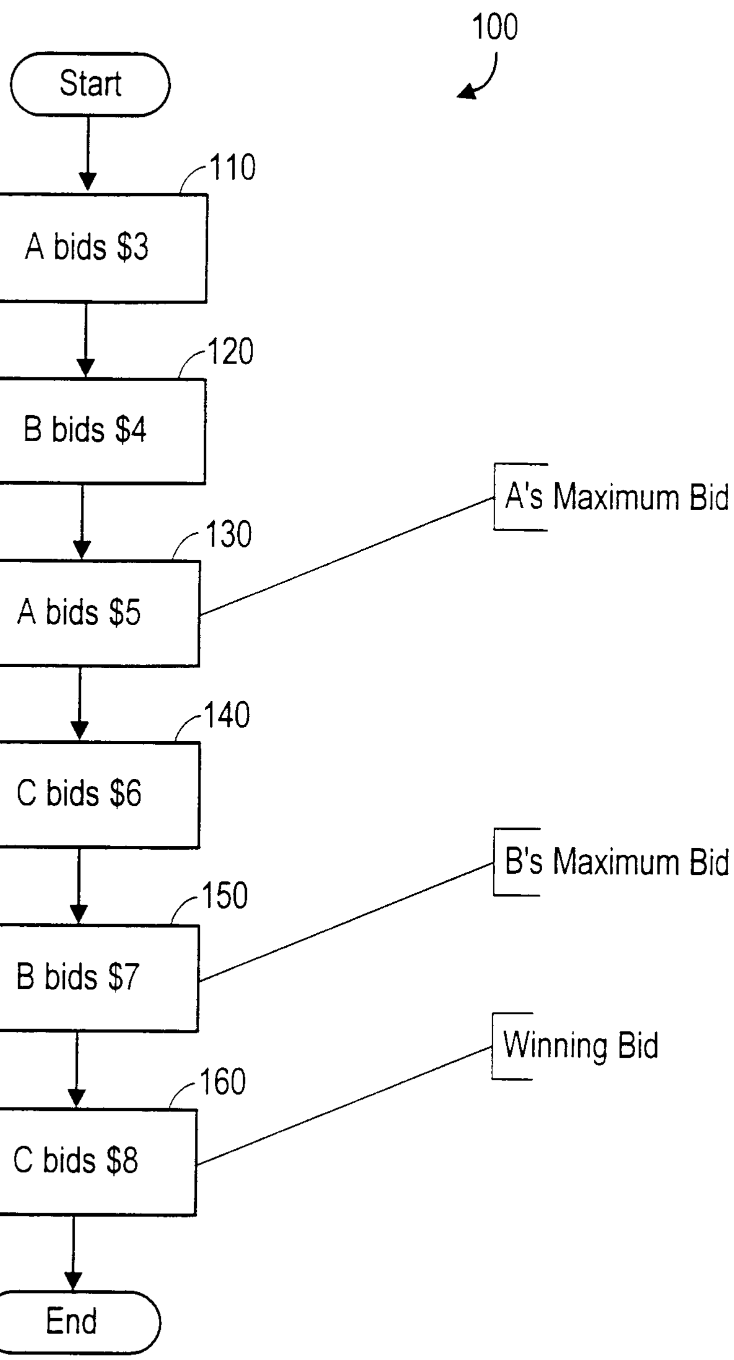

Fig.1 (Prior Art)

A = (80% pure, 1 gallon, $1.20)

B = (100% pure, 1 gallon, $1.50)

Fig. 2A

f(purity, amount, price) =
purity * amount - 1.2 * price

Fig. 2B

A = (80% * 1) - (1.2 * 1.20)
= 0.8 - 1.44
= -0.64

B = (100% * 1) - (1.2 * 1.50)
= 1 - 1.80
= -0.80

Fig. 2C

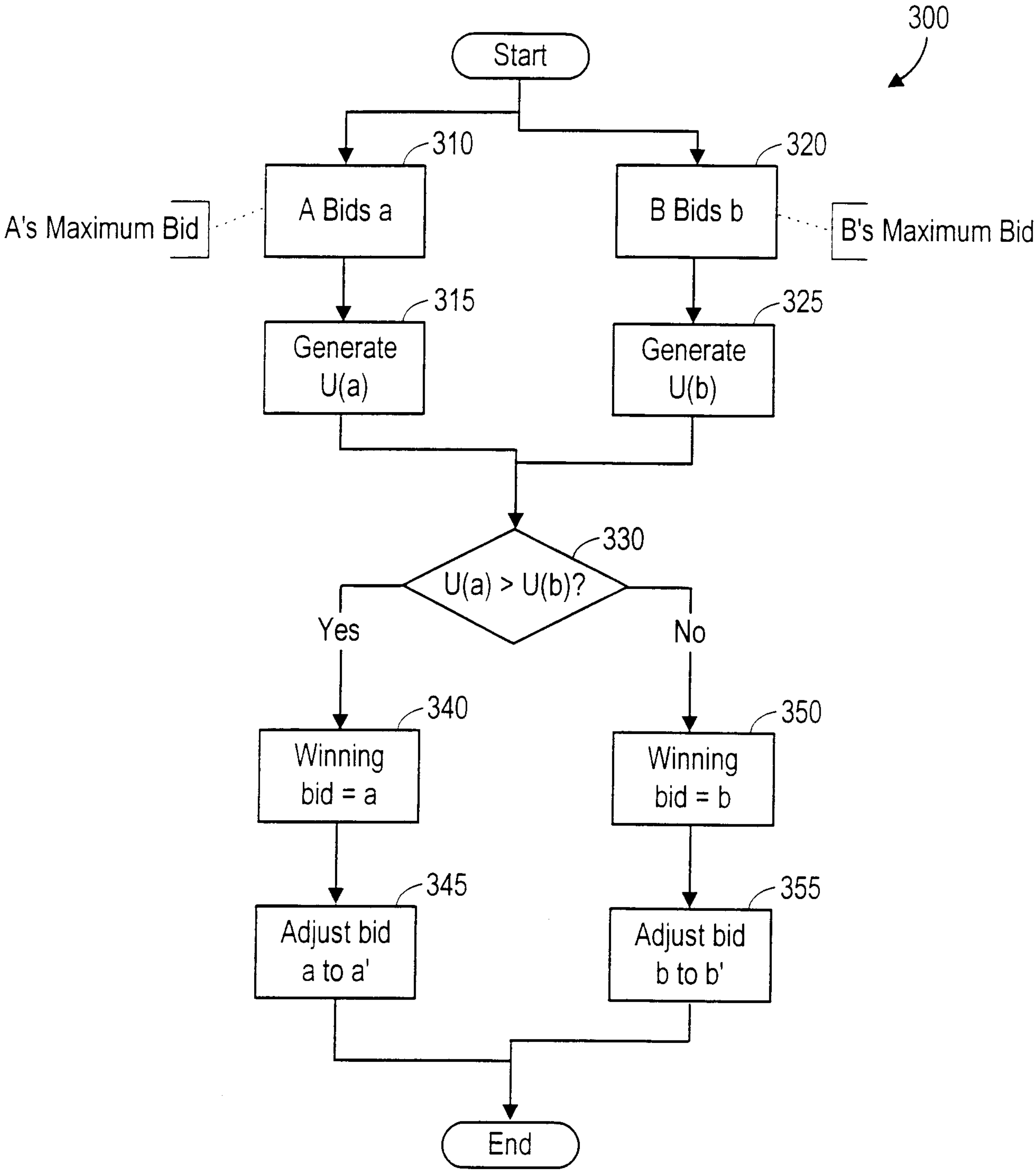
300
Start
310
A Bids a
A's Maximum Bid
320
B Bids b
B's Maximum Bid
315
Generate U(a)
325
Generate U(b)
330
U(a) > U(b)?
Yes
No
340
Winning bid = a
350
Winning bid = b
345
Adjust bid a to a'
355
Adjust bid b to b'
End

Fig. 3

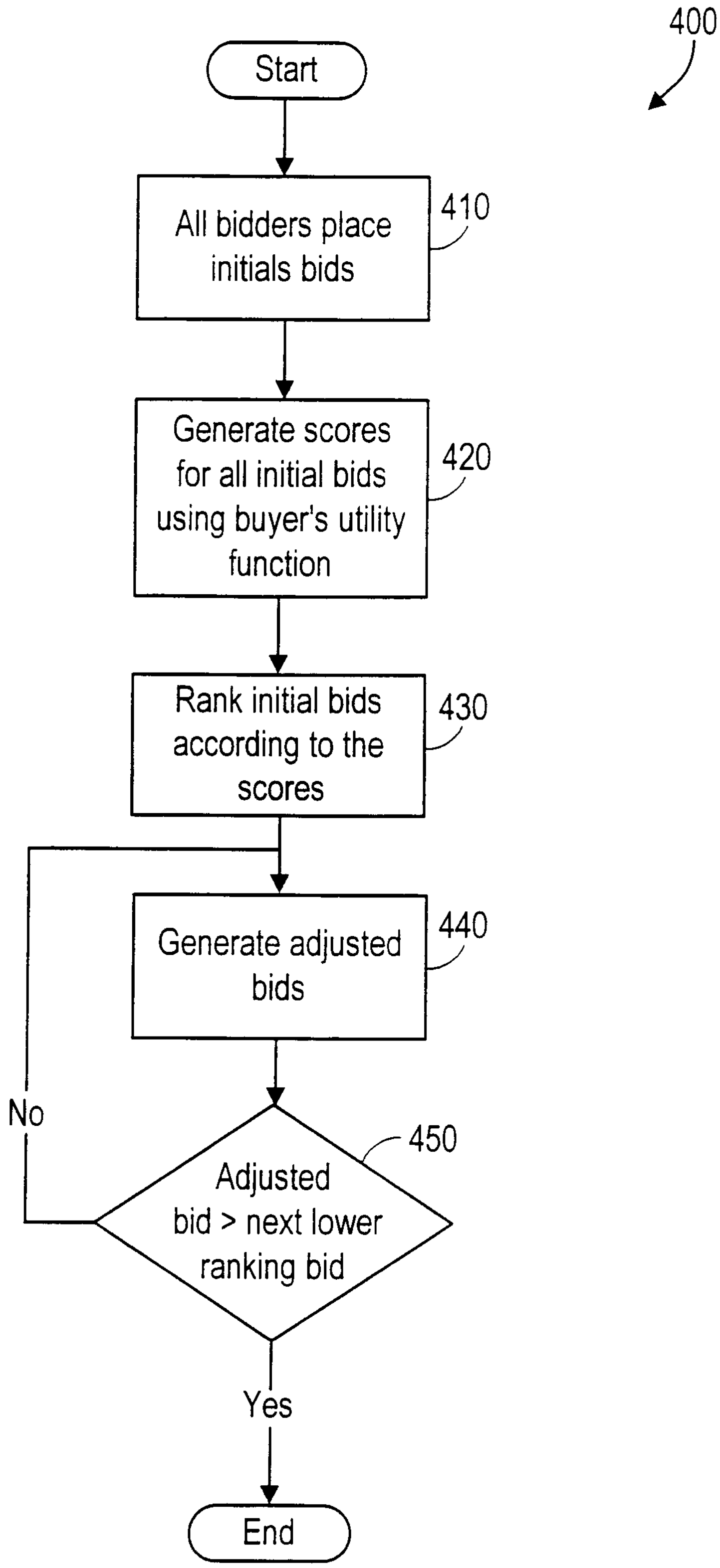
400
Start
All bidders place initials bids
410
Generate scores for all initial bids using buyer's utility function
420
Rank initial bids according to the scores
430
Generate adjusted bids
440
No
Adjusted bid > next lower ranking bid
450
Yes
End

Fig. 4

Best 3 offers:
1 2 3

510

Good alternatives:
4 5 6 7

520

Also worth considering:
8 9 10 11 12

530

Fig. 5