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Overview of Dynamic Mechanism for Online Auction System

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Abstract: ***Many real environments are dynamic, such as in a stock exchange where participants are arriving and departing at different times, Selling seats on an airplane to buyers arriving over time, selling adverts on a search engine to a possibly changing group of buyers and with uncertainty about the future supply of search terms and allocating tasks to a dynamically changing team of agents. In above mentioned environments at least one of the following is true: either agents are dynamically arriving or departing, or there is uncertainty about the set of feasible decisions in the future. The existing solutions for static settings are inappropriate in the dynamic settings.***

Keywords- Dynamic Mechanism, Dynamic Environment, Online Auction System, Vickrey Auction, Double Auction

I. INTRODUCTION

Mechanism design is the discipline of designing mechanisms that lead to sociallydesirable outcomes in a context in which individuals are self-interested[1]. Traditionally, mechanism design has focused on static settings inwhich all private information required for future decisions is known to the mechanism(or the decision-maker) at the start, and normally decisions are made at asingle point in time. For instance, the Vickrey auction is designed for static environments,where there is one item for sale, each buyer submits his or her willingpayment (or valuation) for the item and the buyer who is willing to pay the highestprice is awarded the right to purchase the item at the price offered by the secondhighestbidder [2]. The Vickrey auction requires that all buyers haveto be available at a specific time so that the auctioneer is able to collect sufficientinformation for its decision-making, otherwise the desired properties of the auctionwill not hold. However, auctions in many environments are dynamic; for example,at the Stock Exchange participants are arriving and departing at varying times andthe market owner (or the mechanism) has to make a sequence of decisions overtime rather than at a single point in time.

Properties For well Designed Auction Scheme:

A well-designed auction scheme should preserve the most critical property:

(i) *Truthfulness* – It means that the bidders should reveal the true value for the item for which they are bidding. True valuation of the item can be obtained by spectrum capacity and availability. It may be possible that the particular bidder can misreport its bid value for the particular spectrum. It should be noted that by misreporting this factor, neither buyer nor seller will get higher utility.

(ii) *Individual Rationality*: In this, we consider theutility of both the buyers and the sellers individually. Here, thewinning seller is paid more than its bid and the winning buyerpays less than its bid so that both the buyers and the sellersgain some utility.

(iii) *Budget Balance*: In this, the profit obtained by the third party i.e in our case, auctioneer, is taken into consideration and that will always be a non- negative value. This profit is equal to the amount paid by the buyers which will be less than its true valuation minus the payment made to the seller more than its true valuation.

II. DYNAMIC ENVIRONMENT

To understand the dynamic environment, we take an example. For instance, a seller is selling a car, and each buyer comes at adifferent time with a willing payment to buy the car and a waiting period duringwhich the seller has to decide whether or not to sell the car to this buyer. In thissituation, the Vickrey auction does not work properly, because the seller does notknow if the willing payment of a buyer is the highest until all buyers have arrived.Unfortunately, the seller also cannot wait until all buyers have arrived, as the buyerwith highest willing payment might have already left at that time. The challengeposed by the uncertainty about participants, the decision-making of a mechanismin a dynamic environment is also challenged by participant's strategically play withtheir arrival and departure. For example, a participant arriving at time t1 might notreport to the market until $t_2>t_1$ if it is in his or her interest to do so. Existingsolutions for static settings cannot handle this kind of manipulation considering thedynamic nature of arrivals and departures. The methods of the mechanism design inthe static environment are to be extended in the dynamic environments whereagent types are revealed online. So, in the sense of online algorithm the decisionmust be made without the knowledge of the future. The decision problem in manymulti-agent problem domains is inherently dynamic rather than static. The environmentwhere the agents appear and departs dynamically [3] could bewell addressed by interesting field of mechanism design (MD) that is called OnlineMechanism Design (OMD). The private information of each participant is changingover time. The main challenge in online mechanism design is that decisions ofan online mechanism have to be made dynamically, without knowledge of futureparticipants.

Dynamic Auction

An agent has to report his or her (henceforth his) arrival time, departure time, and the valuation price for the transaction. Let us call all these information the ***type***of an agent.

Formally the type of an agent i∈ {1,2,3,….N} can be written asγ_i={a_i, d_i, v_i} where a_i is the arrival time (first time he is in the market), d_i is thedeparture time (up tod_i, he is in the market and after that he will no longer be inthe market), and valuation v_i for an allocation of a single unit of the item in someperiod t∈[a_i, d_i]. The utility v_i– p when the item is allocated in some t∈ [a_i, d_i].and payment p is collected from the agent.

III. VICKREY AUCTION

Let's consider the Vickrey auction for dynamic environment:

1. Collect the bid from the agents of its type γ_i={a_i, d_i, v_i} and in each period t ∈ T run the auction.
2. Allocate the item to the highest unassigned bid, in each period t

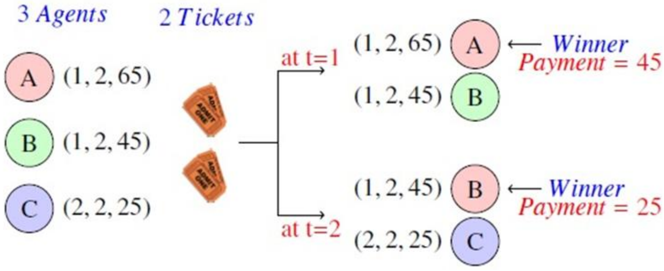

Figure 3.1: Vickrey auction for dynamic environment

In figure 3.1, the type information of agents are:A = (1, 2 , 65), B = (1, 2, 45), and C = (2, 2, 25) for the available number of items (in ourCase - tickets). At t = 1, only agents A and B are present in the market, with agent A as the winner (highest bid value). The payment of the agent A is: 45. Similar is the case for timet = 2, with agent A out of the market.

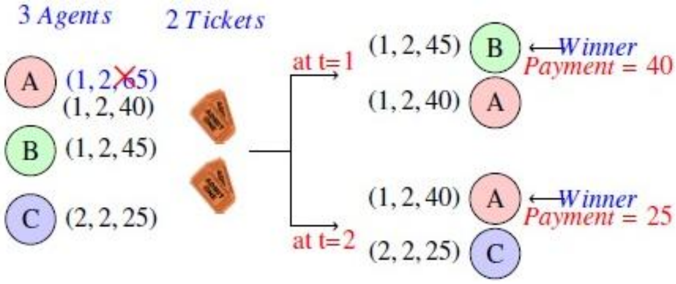

Figure 3.2: Failure of Vickrey auction in dynamic environment:

In figure 3.2, the type information ofagents are: A = (1; 2; 40) (A manipulates its bid value from 65 to 40), B = (1; 2; 45), andC = (2; 2; 25) for the available number of items (in our case tickets). At t = 1, only agentsB and C are present in the market, with agent B as the winner (highest bid value). Thepayment of the agent A is: 25. Similar is the case for time t = 2, with agent B out of themarket.

3. Every allocated agent pays the bid price of the second-highest unallocatedagent in this time period.

Let say three agents (A, B, C) are present with their type information as follows γ_A= (1, 2, 65), γ_B = (1, 2, 45), γ_C= (2, 2, 25) indicating arrival, departure and value.

Two tickets are available and one ticket is to be sold in each time period. Supposeall agents bid truthfully, then agent A wins in period t = 1 and his payment will be45 as shown in **Figure 3.1**. He stops bidding. Agent B wins in period t = 2 for 25Agent A can do better by manipulation (not revealing his true information). AgentA can report its type as.γ_A = (1, 2, 40), This is represented in **Figure 3.2**.In thiscase agent B will win in period t = 1 with payment 40 as shown in **Figure 3.2**. Butagent A will win in period t = 2 with payment 25. By manipulation agent A canpay 25 instead of45. Therefor direct adaptation of the concept of Vickery auction isnot sufficient to achieve the truthfulness in this online environment [3].

If this algorithm is used, manipulation is possible and by manipulation agent A cangain (45 - 25) = 20 more.

IV. MODIFIED VICKREY AUCTION

Let's consider the Modified Vickrey Auction for dynamic environment:

1. Collect the bid from the agents of its typeγ_i={a_i, d_i, v_i}and in each period, t∈T run the auction
2. Allocate the item to the highest unassigned bid, in each period t.
3. Every allocated agent pays the critical-value payment, collected upon its reported departure.

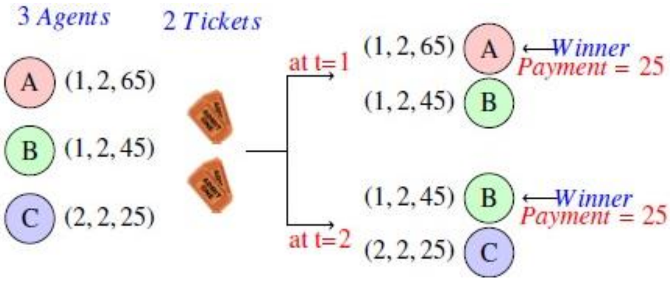

Figure 4.1: Modified Vickrey Auction for dynamic environment:

In the figure 4.1, the type information ofagents are: A = (1; 2; 65), B = (1; 2; 45), and C = (2; 2; 25) for the available number of items (in our case tickets). At t = 1, only agents A and B are present in the market, with agent A as the winner (highest bid value). The payment of the agent A is: 25 (critical value for his arrival-departure window (1, 2)). Similar is the case for time t = 2, with agent Aout of the market.

The critical value of the winning bidder $\gamma_i=\{a_i, d_i, v_i\}$ is $v^c(\gamma_{-i})$which is theminimal value v_i, such that.$a_i \geq a_{-i}$and $d_{-i} \leq d_i$. We define $\gamma_{-i} = (\gamma_1, \ldots\ldots \gamma_{i-1}, \gamma_{i+1} \ldots\ldots)$ i.e. excluding γ_{-i}. Three agents (A, B, C) are present with their type information as follows, γ_A = (1, 2, 65), γ_B = (1, 2, 45), γ_C= (2, 2, 25) indicating arrival, departure and value. Two tickets are available and one ticket is to be sold in each time period. Suppose all agents bid truthfully, then agent A wins in period t = 1 and his payment will be payment is 25 because this is the critical value for his arrival-departure window (1,2), given the bids of other agents. Agent B wins in period t = 2 for 25 (the critical value for his arrival-departure window (1, 2)).

V. DOUBLE AUCTION

Consider double auctions in which there is one item in the market with multiple buyers and sellers each submitting a single bid to either buy or sell one unit of the item [4]. The applications of double auctions in electronic commerce, including stock exchanges, business-to-business commerce, bandwidth allocation, etc have led to a great deal of interest in fast and effective algorithms. In a typical double auction market, buyers submit bids (to buy the item) to the central auctioneer (CA) (the market maker) offering the highest prices they are willing to pay for a certain item, and sellers submit asks (to sell the item) to set the lowest prices they can accept for selling the item. The auctioneer collects the orders and tries to match them using certain market clearing policies in order to make transactions.For double auctions, the auctioneer, acting as a broker, is faced with the task of matching up a subset of the buyers with an equal-sized subset of the sellers. The auctioneer decides on a price to be paid to each seller and received from each buyer in exchange for the transfer of one item from each of the selected sellers to each of the selected buyers. The profit of the auctioneer is the difference between the prices paid by the buyers and the prices paid to the sellers.

For the online double auction (ODA), N sellers and M buyers are available. The sellers and buyers are synonymously called agents. The sellers are the agents thatare present in the market with multiple items, to sell. There are several agents who can buy the item. They are termed as buyers. The set of sellers is denoted by S = {1,2,3,. . . . N} and the set of buyers is denoted by B ={1,2,3,. . . .M}. Each of the sellers and buyers can appear and depart dynamically [5]. All the sellers and the buyers are not present simultaneously. If we divide the total duration of the ODA into some discrete time periods T = {0, 1, ...}, in each discrete timet $\in$T some subset of the buyers and some subset of the sellers will be present. In each discrete time t $\in$ T, the ODA tries to match the buyers with the sellers with a condition that one buyer is matched with one seller only. The matching of a buyer with a seller is called a transaction. Because of the online nature of the problem, an agent has to report his or her (henceforth his) arrival time, departure time, and the valuation price for the transaction [6]. Let us call all these information the type of an agent. Formally the type of an agent can be written as $\gamma_i=\{a_i, d_i, x_i, v_i\}$where $a_i \in T$ is the arrival time (first time he is in the market), $d_i \in T$ is the departure time (up to di, he is in the market and after that he will no longer be in the market), $x_i \in \{b, s\}$indicates that whether an agent is a buyer (b) or a seller (s) and v_i is the valuation, for the buyer $v_i$defines its value for receiving one unit of an item while present and for the seller v_i defines its value for sellingone unit of an item while present.

VI. CONCLUSION AND DISCUSSION

Without knowing who will arrive or what will happen after a decision has beenmade, it is very difficult for a mechanism to make decisions that satisfy some overall goals such as efficiency (that is, maximizing social welfare). To understand the difficulty, let us consider a simple example of ranking a set of numbers in an online fashion; that is, the numbers come one by one and on the arrival of each number a final position has to be assigned to this number without knowing what numbers will come afterwards. The algorithms designed to solve this kind of online problem are called online algorithms. In general, certain goals achievable in a static trading environment cannot be achieved in a corresponding online case, because the uncertainty about traders who have not yet arrived [7]. Therefore, in order to measure the performance of an online auction, we need to compare the result of an online auction with the optimal (offline) solution. The optimal solution is the best solution with regard to the goals an auction can achieve, given that all future inputs are known to the auction before it makes any decision, that is, there is no uncertainty about the information required for the decision-making. As the type of an agent depend on three parameters namely arrival time, departure time, and valuation for the item instead of the valuation only the nature of the problem in Online Mechanism Design

(OMD) environment has not only been fundamentally different from the (Offline) MD but also has made it challenging to design Incentive Compatible Mechanism (ICM) [8]. The new considerations that have been explored in the OMD environment are as the agents have to be allocated the item without the information about agent's types that are yet to be explored, the main difficulty in designing the ICM due to the fact that an agent can decide the other agents with whom they will compete by misreporting the arrival time, departure time, and valuation and only limited misreports of type may be available, for instance it may be impossible for an agent to report earlier arrival than its true arrival and also it may be of no sense for an agent to report a late departure as it might allocate the item to the agent by the time it has left the place of competition.

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