

# Auctions and Mechanism Design

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In this talk, I will present an introduction of Auction theory and Mechanism Design (MD) theory. Auction theory is a kind of the central example of the MD theory, and the best introduction about MD theory. Thus I will present mainly Auction theory in this talk. The most important concept of MD theory is "truthfulness" (that is called as also "incentive compatible"). I will explain how truthfulness is defined and realized in several auction settings. Also, it is important to consider the computational issues in mechanism design. It is well-known that the winner determination in the combinatorial auction is an NP-complete problem however it is possible to compute approximately the winner with preserving truthfulness. Such computational consideration is required to realize the mechanism work in the real world, and we call it Computational Mechanism Design (CDM) theory.

## 1 Introduction

Mechanism design (MD) is a field in microeconomics and game theory. It deals with problems in which multiple selfish agents are to be organized in a way that the global outcome meets socially designed goals. Auction can be seen as one of the mechanisms, where people buy and sell goods or services by bidding, allocation (awarding), and pricing. Auction theory deals with how people act in auction markets and investigates the properties of auction markets. Auction design can be seen as a subset of MD.

The following four auctions are thought as the basic designs of auctions.

- First-price sealed-bid auctions,
- Second-price sealed-bid auctions (Vickrey auctions),
- Open Ascending-bid auctions (English auctions), and
- Open Descending-bid auctions (Dutch auc-

tions).

Vickrey Auction is the Second price auction where the winner is the bidder who submitted the highest bid and the price he pays is the second highest bid value. It is known that it gives bidders an incentive to bid their true value. Namely, the dominant strategy in Vickrey auction with a single, indivisible item is for each bidder to bid their true value of the item. This is because the winner can not manipulate its payment price, since the payment price is not determined by the winner's bid price.

## 2 Combinatorial Auctions and Vickrey Clark Groves (VCG) Mechanism

The above basic auctions are basically handling a single good. It has been widely studied combinatorial auctions (CA) where multiple distinguished goods are sold and bidders can submit bids to some combinations of the goods. For example, there can be three goods, A, B, and C. A bidder can submit a bid like USD40 for {A,B} and USD30 for {A}. The auctioneer awards to the combination of the submitted bids that maximizes the total revenue. This process is called the winner determination and is known as an NP-hard problem. VCG mechanism is the mechanism that makes the combinato-

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オークションとメカニズムデザイン

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rial auction truthful with a sophisticated payment scheme. In VCG, the payment of the winner is determined as how much he reduces the social surplus of the other agents.

### 3 Generalized Second Price Auctions (GSP)

Internet advertisement business started from well-known “ banner-ads ”, which put advertisement pictures on the web-pages based on, for example, views/month. Overture, Inc., first developed the Pay-Per-Click based Internet advertisement, where advertisers pay the cost based on the number of clicks for its advertisement. This was a very innovative business model but it was not stable in terms of prices because bidders have incentive to maneuver their prices because the payment was determined by what their declarations. Google found that bidders do not want to pay more than the bid of the next position. Thus, in 2002, Google starts the Google AdWords, where each bidder pays the price of its next position. This is called generalized second price auction (GSP)[1] and is based on a very similar idea of Vickrey auction in which bidder’s payment cannot be determined by its own bid. In this sense, GSP is the most widely used Vickrey (like) auction in the world because when someone searches a word by Google, it run one GSP process. (In theory, GSP does not satisfy dominant strategy incentive compatible but it is known that bidders are on locally-envy free equilibrium in the GSP.)

### 4 Computational Mechanism Design

Computational mechanism[2] design brings together the concern in microeconomics and game theory with decision making under distributed private information, uncertainty, and self-interest, and the concern in computer science with computational and communication complexity. The following are a couple of the recent research topics:

Truthful Greedy-allocation Combinatorial Auctions[3]:

As we explained in section 3, CA is one of the NP-hard problems that means much computational power are required. The study tackles this problem in which they build an greedy algorithm that find approximated optimal com-

ination instead of finding the exact optimal combination while keeping truthfulness. To keep truthfulness, a special notion of “ critical value ” that means the minimum value that a winner can still win.

Interdependent Value Auctions[4][5]:

This work considers the problem of auction design with agents that have interdependent values, i.e. values that depend on each others’ private values. The work adopt the contingent bids model allow agents to submit bids of the form “ if player 1 bids  $x$  for good then I will bid  $y$ . ” This work identified a specific linear valuation model for which there exists an efficient auction for a single item, and extend this to provide an approximately efficient CA.

### 5 Conclusion

We briefly explained auction theory and mechanism design. The work presented here has a significant impact because while some results, like the GSP, are theoretically developed well, it has been actually developed and used in the real world.

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