# HETEROGENEOUS USER BEHAVIOR IN MULTIPLE OVERLAPPING ONLINE AUCTIONS

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Using *k*-means clustering algorithm, which is one form of unsupervised learning, we analyze bidder behavior in multiple overlapping online auction market. An interesting aspect of today's online auction market is that often multiple mechanisms exist concurrently or in an overlapping manner for identical items and often these mechanisms are offered at the same website. Online overlapping auction setting is fundamentally different from traditional physical auction environment in which each auction is assumed to be an independent and isolated mechanism. Since bidders can get the signal from other overlapping auctions before the completion of a given auction, the strategic space of bidders could be influenced by the market forces engendered by the overlapping auctions. This interesting environment motivates us to look at a set or a collection of multiple overlapping auctions as a whole, which we call as, *market level perspective* so as to analyze the bidder behavior.

The statistical challenge of our research is to utilize unsupervised learning techniques to transform the inputs regarding bidder entry and bidding behavior into different dimensions which represent bidders' likelihood of winning and the surplus they gain. To carry out this research objective, we use *k*-means clustering algorithm. We classify bidders into multiple sub-groups based on their 'entry behavior' and 'bidding behavior' at both *individual auction level* and *the market level* which comprises a set of multiple overlapping auctions.

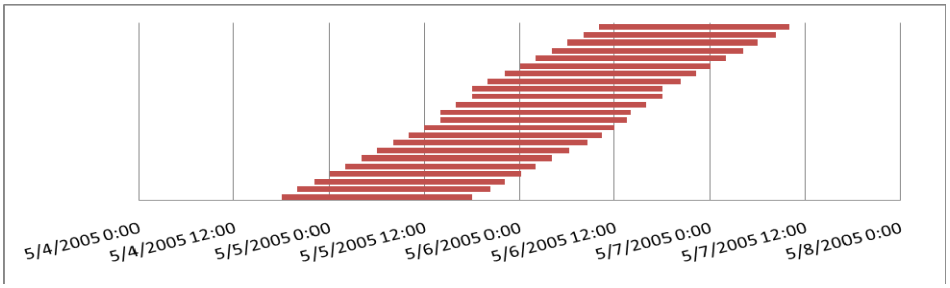


**Figure 1. Overlapping auctions for "TiVo Series2 DVR"**

While heterogeneous bidder behavior has been studied in (Bapna et al., 2004; Steinberg and Slavova, 2005; Zhong and Wu, 2006), their focus of analysis was mainly at the *individual auction level*. Given that multiple auctions for identical items are accessible to bidders at a specific time, the scope of the analysis should be extended to the surrounding market. We shed new light on the impact of market forces induced by the overlap on bidders' strategic space which is critical to understanding the inter-dependency of dynamic pricing mechanisms.

We collected data from the online auction site of Sam's Club which can be viewed as a B2C auction. The dataset includes 932 overlapping auction instances for various electronic goods. There are 24 unique items and each item was sold by multiple overlapping English auctions. In contrast to other C2C online auction sites such as eBay, there is only one seller in Sam's Club online auctions. The benefit of one seller auction is that they do not suffer from bias related to seller reputation, shipping method and cost, and options such as buy-it-now, which are

common to many other C2C online auctions. Therefore, Sam's Club's online auction site is an ideal venue to study the bidder behavior. Figure 1 shows a stylized view of overlapping auctions conducted at Sam's Club's website. Multiple overlapping auctions for the same items are offered during a given time period. Each line segment is an English auction in which a single object is offered and the highest bid becomes the winning price.

At the *individual auction level*, we follow the approach outlined in Bapna et al. (2004) where the bidders' participation pattern and their bid intensity are measured using three variables, namely, Time of Entry (*TOE*), Time of Exit (*TOX*) and Number of Bid Revisions (*NOR*).

To characterize the market level bidding strategy which has not been considered in prior research, we select variables such as total number of auctions each bidder participated (*NOA*), average number of bid revisions made in the auctions they participated (*NOR*), and average quantity each bidder demanded in the auctions they participated (*QNT*). The number of auctions (*NOA*) and quantity (*QNT*) explains the bidders' interest in obtaining multiple identical items and the number of bid revisions (*NOR*) explains the bidding intensity.

We found that, at individual auction level and market level, different bidding strategies yield different outcomes in terms of winning probability and winning price. Applying normalized measure for winning price we examine the relative surplus achieved by a particular strategy. At the individual auction level, active *participators*, who stay in an auction for a long time making multiple bids, have the highest likelihood of winning but their surplus is lower than other clusters. At the market level, the *institutional bidders*, who participate in a large number of auctions, exhibit lower winning probability compared to the other clusters. They however pay significantly less (i.e., they have higher relative surplus) if they win. Although majority of *institutional bidders* participate in many auctions, they do not spend much time in any particular auction. They minimize the auction monitoring cost by bidding in multiple auctions so as to win the objects at a relatively lower price. We further examine how the bidder classification at the individual auction level is mapped into the market level classification.

Recently, Anwer et al. (2006) and Peters and Severinov (2006) studied cross bidding activities among multiple competing auctions. Given that our market level variables represent cross bidding activities to some extent, we also examine potential cross bidding activities of *institutional bidders* in our study.

**References**


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