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A Novel Online Mechanism for Honest Bilateral Bidding Strategies on Ridesharing Platforms

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Abstract—Ridesharing platforms typically use the take-it-or-leave-it trading mechanism, where passengers and drivers can only accept or reject prices offered by the systems. Due to a lack of consideration for user requirements in such systems, system-generated prices do not necessarily reflect different situations of the traders, such as a passenger's urgency degree, the actual running cost, and a driver's expected profit. Since private information related to user requirements is incredibly valuable for determining the reasonable prices of trips, to design a trading mechanism for transport services utilizing such information become increasingly important. In this paper, we introduce a bilateral auction mechanism for cloud-based on-demand transport service markets, where passengers and drivers are allowed to submit their bids independently. Our approach takes both passengers' and drivers' personal valuation of transport services into consideration. When a trip distance is less than a maximum distance determined by the market maker, an initial rate with a fixed fee is applied; otherwise, a passenger must pay by a unit price no less than the price charged by a driver. We consider two rounds of bidding processes: bidding for the initial rate and bidding for the unit price. In either round, we determine trading price p^* that is used by all winners of an auction. For example, in the second round, suppose we have n passengers with bidding prices b_i, i =1, 2, …, n, and m drivers with bidding prices s_j, j =1, 2, …, m. We sort the bidding prices of passengers and drivers into $b_1 \geq b_2 \geq \ldots \geq b_n$ and $s_1 \leq s_2 \leq \ldots \leq s_m$, respectively. Then we find the positive integer k, called the efficient number of trades, that satisfies the requirements of $b_k \geq s_k$ and $b_{k+1} < s_{k+1}$, where $1 \leq k \leq \min(m, n)$. We further define the lower bound price $lb = \max(s_k, b_{k+1})$ and the upper bound price $ub = \min(b_k, s_{k+1})$. The trading price can be determined as $p^* = (lb + ub) / 2$. Since there must be an overlapping between the two ranges $[s_k, b_k]$ and $[b_{k+1}, s_{k+1}]$, it is guaranteed that p^* exists. To support analysis of our approach, we define a *success-oriented bidder* as a bidder who tries his/her best to win an auction with non-negative profit, and a *profit-oriented bidder* as a bidder who tries his/her best to get more profit even at a high risk of losing the auction. Speculative bid of traders will inevitably reduce the trading successful rate of a passenger or a driver when the increase of traders' profit is limited. We proved honesty is a dominant strategy for all passengers and drivers with success orientation, and an approximate dominant strategy for all passengers and drivers with profit orientation when the number of traders tends to infinity. We further performed experiments where passengers and drivers demonstrate their speculative behaviors. For example, by generating random numbers of passengers and drivers in simulated auctions, we show that a profit-oriented passenger may try to increase his/her utility by placing a speculative bid, namely underbid, at the risk of losing the auction. This is consistent with our previous analysis that underbid is not a good strategy for success-oriented passengers. In addition, with multiple speculative passengers and speculative drivers in each auction, we studied how the successful rate and trading price may be affected. The experimental results show that the trading price has no obvious changes for various speculation degrees and percentages of speculative traders. In summary, our proposed bilateral auction mechanism not only satisfies certain desirable properties, such as individual rationality, but also ensures all valuable profitable trades between passengers and drivers be supported. Furthermore, by analyzing speculative behaviors of traders, we show that this trading mechanism encourages traders to provide honest bids, which helps to optimize the resource distribution of the platform.

Keywords—ridesharing platform; bilateral bidding; dominant strategy; honest bid; speculative strategy