Abstract

Basic auction mechanisms can cause serious inefficiencies in situations where bidders demand combinations of items. Such a situation arises when the items are complementary, *i.e.* when the value of a combination of items is substantially more than the sum of the values of the individual items. This demand for a bundle of resources rather than the individual items is quite common, and at the same time critical, in various business domains, like truckload transportation, allocation of airport take-off and landing slots, buying of radio spectrum for wireless communication services, etc. However, there are important issues that need to be addressed before combinatorial auctions can become a practical reality. In a combinatorial auction, a bidder faces an almost impossible task of valuing a large number of bundles. This is known as the *valuation problem*. This discourages bidders from participation, and the current auction schemes do not address the problem adequately. *Iterative combinatorial auctions* which allow bidders to submit multiple bids were devised to address this valuation problem. In an iterative auction bidders get access to information from the auctioneer which helps them to refine the initial estimates of their valuations. Thus they are able to 'discover' the prices of the packages during the course of the auction which addresses the valuation problem. However, the *information feedback* that the auctioneer provides has to be relevant and appropriate to help the bidders reduce their valuation uncertainties. Information feedback is thus one of the most important design issues in iterative combinatorial auctions. As we move into the domain of online combinatorial auctions (a form of iterative combinatorial auction), where the auction state may change after each and every bid, *participation and monitoring costs* of bidders become a serious bottleneck as the bidders have to continuously keep track of a large number of bundles. At the same time, providing relevant information feedback in an online combinatorial auction is a very big challenge which requires resolving the winner determination problem (WDP) after each bid. Since WDP is a computationally intractable problem, developing faster solution to the WDP is not enough because solving the WDP after each bid is not a practical solution. The dynamic programming formulation of the WDP is a fine approach to providing relevant feedback in an online combinatorial auctions but it places a restriction on the number of items that can be handled. However, in an online combinatorial auction, the number of items is expected to

increase manifold. Thus, *solving the WDP without placing any restriction on the number of items* is a major obstacle for the online execution of combinatorial auction.

In this thesis we try to address the issues discussed above. The problem of *valuation* and *information feedback* has been addressed by proposing two new combinatorial auction schemes, *RevalSlot* and *RevalBundle*. These two schemes allow the bidders to participate in the auction without imposing the requirement that bidders have an accurate idea of their valuations. *RevalSlot* uses the concept of varying slot sizes to guide the bidders in their bidding. *RevalBundle* addresses a few limitations of *RevalSlot* and proposes a new information feedback scheme to promote meaningful bidding. We have done experimental simulations to test the efficacy of these two auction schemes. The high *participation and monitoring costs* of bidders in online combinatorial auctions has been addressed by proposing a distributed signal driven combinatorial auction scheme, *PRACA*. This scheme allots a proxy agent to a bidder which then bids on the behalf of the bidder keeping her interests in mind. We have carried out an experimental simulation as well as an experiment with human bidders, which have verified the efficacy of *PRACA* and also proved that *PRACA* can allocate the resources efficiently. We have proposed an algorithm which solves the WDP and provides relevant feedback to the bidders without placing any *restriction on the number of items*. The algorithm is named *CompDL*. It concentrates on updating the relevant information feedback parameters (*DL* and *WL*) of only those packages on which bids have been placed so far, as opposed to the method of dynamic programming where the information about all the possible packages are stored in memory. Thus *CompDL* can operate with limited memory, and solve the WDP to provide relevant information feedback to bidders. We have studied the application of combinatorial auctions to the field of team selection in professional sports. We have analyzed the data from the Indian Premier League (IPL) auction to experimentally verify that combinatorial auctions can make the process of team selection much more efficient. We have used our mechanism, *RevalBundle*, and modified it slightly to devise a new scheme *MRPF*, and deployed *CompDL* to solve WDP in this new scheme. Experimental results indicate that a combinatorial auction scheme is best suited in a situation where a team is to be built from scratch, and where the team requires a blend of complementary skills.