

The goal of the proposed research is to extend the theoretically important idea of a VCG (i.e. second-price, combinatorial) auction to one that is feasible in practice, by developing a mechanism that achieves the full benefits of a VCG auction but eliminates the need for bidders to bid on an exponential number of bundles and simultaneously reduces the computational complexity of the winner- and payment- determination problems.

Auctions have been used for millennia to leverage competition and find market clearing prices. Today, internet auctions are becoming increasingly important negotiating tools for the procurement of goods and services. Such auctions present significant challenges to both the bidders and the auctioneer, however. The bidders must decide how much to bid for each item or service they are willing to provide, and the auctioneer must solve a *winner-determination problem*, determining which bidder wins each contract, and a *payment-determination problem*, determining how much that bidder will be paid. These decisions are particularly challenging in the case of a *combinatorial auction*, where bidders bid on *bundles* of items rather than individual items, so as to take into account potential interactions. Consider, for example, the procurement of long-term contracts for truckload shipments. In such auctions, a shipper places a large number of loads simultaneously up for auction to a group of carriers. The challenge for the carriers is to decide how much to bid for each load, because the cost of transporting a particular load depends not only on the length of the movement, but also on whether the driver will be able to return home from the load's destination with another revenue-generating load (*backhaul*). In a combinatorial auction, a carrier can instead bid on *sets* of loads, thereby taking into account the impact of backhaul opportunities. The success of such an auction depends on the carriers' ability to evaluate and bid on a large (possibly exponential) number of load bundles, with each bid requiring a potentially complex costing decision. The auctioneer also faces the challenge of solving a winner-determination problem over this very large set of bids. Similar difficulties exist in many other applications of combinatorial auctions (for example, the allocation of radio spectrum or airport runway slots) as well.

The **intellectual merit** of this project is in providing a new, mathematical programming (MP) based mechanism that captures the benefits of combinatorial auctions without the need for explicit bidding on all possible combinatorial bundles, nor the solving of an exponentially large winner-determination problem. In developing and investigating this mechanism, the proposed research will address issues that are both theoretical (for example, What are the implications of the mechanism by which the payment is determined? How would the approach change given stochastic input data?) and applied (such as, What other applications are appropriate candidates for this approach? How can the MP's be solved more efficiently?) The **broader impact** of the proposed research takes three forms. First, this research makes VCG combinatorial auctions feasible in practice for many applications by greatly simplifying bidding and winner determination. Second, the diversity of backgrounds and expertise of the three PI's will not only facilitate the research, drawing upon strengths in large-scale and combinatorial optimization, transportation, and auctions and procurement, but will also enhance its dissemination, enabling the targeting of conferences and peer-reviewed publications in these three different areas and the incorporation of the research within courses at the undergraduate and graduate level in both business and engineering. Third, ongoing efforts to ensure the participation of students from URM groups in research will continue. In particular, PI Cohn is actively involved in the ADVANCE project, SWE, and Phi Sigma Rho, and has supervised several female and URM students at the undergraduate, masters, and doctoral level.