Abstract

Collusion-Resistant Cost-Sharing Mechanisms: Design Techniques, Analyses, Trade-Offs

Florian Schoppmann

How can a system be designed so that autonomous self-interested players behave in a "desirable" way? In this thesis, we study this question in the context of cost-sharing problems, where finitely many players have an unknown valuation for some non-rivalrous but excludable service (e.g., network connectivity). The challenge is to design mechanisms that elicit truthful reports of the players' valuations, determine which set of players Q to serve, and decide how to distribute the incurred service cost $C(Q)$. So in particular, a cost-sharing mechanism has to give players an *incentive* to reveal truthful information. Further constraints for cost-sharing problems include *budget balance* (i.e., recovery of the service cost with the prices charged) and *economic efficiency* (i.e., a reasonable trade-off between the service cost and the excluded players' valuations). Practical applications moreover require that cost-sharing mechanisms are computable in *polynomial time*.

Cost-sharing problems are fundamental in economics and have a broad area of applications; e.g., distributing volume discounts in electronic commerce, sharing the cost of public infrastructure projects, allocating development costs of low-volume built-to-order products, etc. Despite this fundamental nature, general techniques for solving cost-sharing problems are rare. When requiring group-strategyproofness—i.e., collusion resistance in a very strong sense—essentially only one technique has been known, the so-called Moulin mechanisms. Unfortunately, there are several natural cost-sharing problems for which any Moulin mechanism inevitably suffers poor budget balance and economic efficiency.

In this thesis, we devise several alternative techniques for designing cost-sharing mechanisms. We demonstrate the benefits of our novel techniques by applying them to various natural cost-sharing problems where the costs $C(Q)$ are induced by combinatorial optimization problems. Moreover, we provide characterization results that contribute towards understanding the inherent limitations of collusion resistance with respect to the other desirable properties of cost-sharing mechanisms.