Title: Approximation in Mechanism Design

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Auction theory (and, more generally, economic mechanism design) describes how protocols for allocating scarce resources to competing agents should be designed to optimize objectives such as welfare or revenue. For example, when each buyer's willingness-to-pay is drawn i.i.d. from a well-behaved distribution then reserve-price-based auctions (like eBay) are revenue-optimal. Unfortunately, the theory of optimal auctions gets complicated when applied beyond such idealistic settings, and furthermore, the complicated auction mechanisms it suggests are rarely seen in practice. In this tutorial, I will motivate approximation as a technique for the design and analysis of simple, practical auctions that approximate the optimal (complicated, impractical) ones. First, I will show that, in auction problems where agent preferences are single-dimensional, e.g., a single value for receiving an abstract service, that often simple reserve-price-based auctions are approximately optimal. Second, I will show that, in auction problems where the agent preferences are multi-dimensional, e.g., distinct values for distinct services, simple posted-pricing mechanisms are approximately optimal. I will also give a succinct description of the prices that should be posted to obtain a good approximation. This latter result is significant as there is no such succinct description of the optimal mechanism in these multi-dimensional settings. Furthermore, both reserve-price-based auctions and posted-pricing mechanisms are commonly used in practice. Third, optimal mechanisms are often parameterized by distributional knowledge, I will show that there is often a single non-parameterized mechanism that simultaneously approximates the optimal mechanism for any distribution. Fourth, I will consider resource allocation problems where the optimization problem, absent strategic interaction of the agents, is computationally intractable. For these problems I will give a general reduction for converting any algorithm (for the non-strategic setting) into an auction (for the strategic setting) that obtains the same expected performance in equilibrium. This result shows that computational constraints imposed by tractability can be considered independently from incentive constraints imposed by agent strategizing.