

Approximation Algorithms for Submodular Allocation Problems

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Various questions tackled in computer science can be formulated as multi-agent allocation problems. These are problems where one or more goods need to be shared among multiple buyers. Another flavor of these problems arises when multiple agents wish to collaborate to accomplish a task. I plan to pursue various problems from this domain in my research.

A major focus in theoretical computer science has been studying problems with linear cost functions. However linear cost functions do not always model the complex dependencies of costs in real world settings. Submodular functions form a rich class of valuation functions which capture the natural properties of economies of scale or the law of diminishing returns. I have studied several fundamental covering problems like vertex cover, shortest path, perfect matching and spanning tree in this setting, and established tight upper and lower bounds of the approximability of these problems. Unlike all the previous work in this area, [1] tackles problems where a combinatorial object is being divided amongst agents as opposed to distinct goods. Apart from being of independent theoretical interest these problems find applications in network design and task scheduling problems. During my PhD, I plan to delve deeper in this area to further understand the hardness of other combinatorial allocation problems.

An intriguing facet of allocation problems is incentive compatibility (truthfulness). While in the previous setting we assumed that the valuations provided by the agents were accurate, here we try to design solutions that are immune to strategic manipulation. i.e. we wish to design mechanisms in which it is most profitable for an agent to report his valuations truthfully. From a commercial viewpoint these problems arise in a myriad settings from ad-auctions to bandwidth allocation markets. From an academic perspective, these problems are also important since they incorporate ideas from approximation algorithms with techniques drawn from game theory and economics. This area presents a rich source of problems which have significant applications. I am particularly interested in the incentive compatible (truthful) submodular allocation problem. In this problem we wish to efficiently allocate indivisible goods among agents who have submodular valuation function for subsets of goods. In the traditional setting this problem (without the requirement of incentive compatibility) has been well studied and optimal constant factor approximation algorithms are known. Very little is known about this problem when the solution is required to be incentive compatible.

Another area of interest to me is that of resource allocation problems that arise in wireless networks. In these problems we wish to allocate resources to satisfy quality guarantees such as latency and reliability. They present a different set of implementation challenges from the aforementioned problems and involve a significant experimental component. For example, in [2] we considered the channel allocation problem for CDMA networks, for maximum throughput. [2] gives a randomized assignment scheme that is optimal and satisfies reliability guarantees with high probability. I plan to pursue similar problems in the future.

References

- [1] Gagan Goel, Chinmay Karande, Pushkar Tripathi and Lei Wang, "Approximability of Combinatorial Problems with Multi-agent Submodular Cost Functions". FOCS 2009.
- [2] Pushkar Tripathi, Pushkar Sachdeva and Mustafa Ammar, "Almost Optimal CDMA Channel Allocation". Manuscript 2009.