



Resource Allocation in Wireless Networks with Strategic Users

September 2010

Introduction

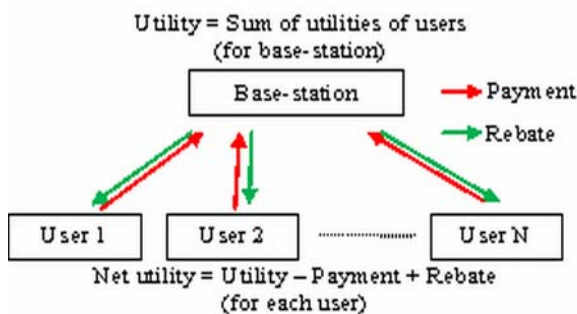
How should we allocate bandwidth in a wireless network among multiple users? An *efficient* resource allocation maximizes the aggregate utility of all the users. Such allocation often depends on information privately held by the users. For example, in the uplink of a packet data cellular system, the base-station will allocate bandwidth using the channel and queue state of each user. While the channel state can be estimated at the base-station, we must rely on the users to feedback the queue state truthfully. Strategic users can misrepresent their queue information to maximize their own utility at the expense of aggregate utility. We address the problem of allocating a single infinitely divisible resource to a number of users.

Incentive Compatibility

Mechanism design theory helps us design a resource allocation algorithm (or *mechanism*) that will induce users to truthfully report their queue information. The base-station collects payments from each user depending on the reported queue information. The net utility of each user is now the difference between her own utility and her payment. Payments are constructed such that the dominant strategy of each user is to report the true value. The *Groves* class of mechanisms, specifically the Vickrey-Clarke-Groves (VCG) mechanism, are *dominant strategy incentive compatible* (DSIC).

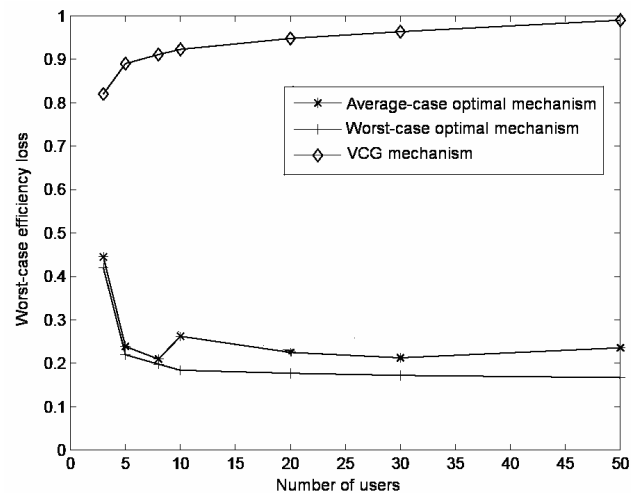
Budget Balance

The VCG mechanism maximizes total payments from users. While this is desirable in some scenarios (like an auction), our interest is in scenarios where the base-station is interested only in truthful feedback and not in the surplus (from payments). In fact, the base-station desires *budget balance*, i.e., sum of payments is zero. Since the Green-Laffont impossibility theorem says that a mechanism cannot be efficient, DSIC and budget balanced, we achieve near budget balance by providing rebates to the users, i.e., by a redistribution of most of the payments back to the users. Moulin and Guo & Conitzer have proposed almost budget balanced mechanisms for the allocation of an *indivisible* resource. We design almost budget balanced mechanisms that are efficient and DSIC for allocation of a *divisible* resource.



Results

We propose two new almost budget balanced mechanisms belonging to the Groves class, both efficient and DSIC. The rebates are linear functions of the reported information and the utility functions are assumed to be concave. The rebates are designed to minimize the worst-case and average *efficiency loss* (defined as the ratio of the sum of payments to the sum of utilities) respectively. We first show that the worst-case and average-case optimal linear rebate functions are solutions to convex optimization problems. The constraint set, however, is determined by an infinite number of half-plane constraints, parameterized by the set of reported values. We then propose a randomized approximate linear program (LP) by sampling the constraints and argue that its constraint set is “near-feasible” with high probability. We finally show that, under a rather general condition on the valuation function, the min-max value for the approximate LP is close to the true value, with high probability.. While the work was motivated by uplink resource allocation, our results apply to any allocation problem where surplus is not desired.



Future Directions

In future, we plan to consider mechanism design with (a) non-linear rebate functions, (b) further reduction in the number of constraints to be sampled in the approximate LP, and (c) more general network resource allocation problems.

References

- [1] A. K. Chorppath, “Resource allocation in communication networks when users are strategic,” M.S. Thesis, IIT Madras, 2010.
- [2] A. K. Chorppath, S. Bhashyam, R. Sundaresan, “A convex optimization framework for almost budget balanced allocation of a divisible good,” Submitted to IEEE Trans. on Automation Sci. & Engg., May 2010. <http://www.ee.iitm.ac.in/~skrishna/>