Network Design: Optimization and Algorithmic Game theory
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Local Peering and Service Contracts in Strategic Network Formation

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Abstract

We introduce a noncooperative game in an effort to understand business relationships between entities (enterprises, ISPs, residential customers etc.) in the Internet. Connection contracts are local (ie bilateral) between two entities and may either be of a peer-peer or a customer-provider variety. Entities bid (or demand payment) for the formation of these contracts, and in the resulting network some traffic is routed and other traffic dropped. As often occurs in practice, we also include a mechanism that penalizes providers if they drop traffic emanating from one of their customers.

Stable solutions to this game have some interesting properties. We first show that every Nash equilibrium can be represented by a flow of utility with certain constraints, helping us to visualize the general structure of stable solutions and providing useful proof techniques. Using a natural objective function, we can show that the price of stability is at most 2. Using the social welfare objective function, the prices of anarchy and stability can both be unbounded, which leads us to focus on inducing good stable solutions using a limited budget. We show that if every payout is increased by a factor of 2, then there is a Nash equilibrium as good as the original centrally defined social optimum. Under stronger conditions, we exhibit factors better than 2. Finally, we show how to find the best Nash equilibrium in polynomial time when the underlying network is a multicast tree, as well as in some other special cases.

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