Two-Stage Myopic Dynamics in Network Formation Games

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January 15, 2008

We consider a network formation game where a finite number of nodes wish to send traffic to each other. Inspired by modern data networks, we restrict our analysis to connected networks. Nodes contract bilaterally with each other to form bidirectional communication links; once the network is formed, traffic is routed along shortest paths. Each contract is endowed with a utility transfer. Cost is incurred to a node from three sources: (1) traffic related costs; (2) maintaining links to other nodes; and (3) payments made to other nodes (from contracts). We consider two models for traffic related costs: one where cost arises from routing packets (inspired by our earlier model in [1]); and another where cost is related to latency (inspired by the model of [2]).

As a solution concept, we define a network to be stable if no single node wishes to unilaterally deviate, and no pair of nodes can profitably deviate together; our technical definition is a variation on the notion of pairwise stability.

The main contribution of this paper is to study such games under a natural form of myopic local best response dynamics. The network evolves in discrete steps, each consisting of two stages. During the first stage, an exogenously designated node u considers all possible unilateral deviations. Then, during the second stage, it considers forming a new contract with a node v in its neighborhood. That contract can be accepted or rejected by the target node. While the designated node u chooses its actions to maximize its payoff at the end of both stages, the target node v chooses a myopic best response to maximize its payoff given the network after the first stage. These dynamics are a natural generalization of those presented in our previous paper ([1]).

We characterize a simple set of assumptions under which these dynamics will converge to a pairwise stable network topology; as an example, our assumptions are satisfied by a contractual model motivated by bilateral Rubinstein bargaining with infinitely patient players. If the routing cost is related to latency, our dynamics always converge to a star network, thus selecting an efficient equilibrium. This is a strong result: as shown by [2], the set of pairwise stable outcomes includes arbitrarily inefficient outcomes. Thus our natural dynamics also yield a desirable equilibrium selection process.

If the traffic cost is related to routing, our dynamics converge to a network where only minimum routing cost nodes route traffic; in this sense our dynamics again select a desirable outcome. We also characterize an important special case, where the dynamics converge to a star centered at a node with minimum cost for routing traffic. In this setting our dynamics select an efficient equilibrium.

References

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