Topology Design of Communication Networks: A Game-Theoretic Perspective

Abstract:

We study the performance of noncooperative networks in light of three major topology design considerations, namely the price of establishing a link, path delay, and path proneness to congestion, the latter being modeled through the "relaying extent" of the nodes. We analyze these considerations and the tradeoffs between them from a game-theoretic perspective, where each network element attempts to optimize its individual performance. We show that for all considered cases but one, the existence of a Nash equilibrium point is guaranteed. For the latter case, we indicate, by simulations, that practical scenarios tend to admit a Nash equilibrium. In addition, we demonstrate that the price of anarchy, i.e., the performance penalty incurred by noncooperative behavior, may be prohibitively large; yet, we also show that such games usually admit at least one Nash equilibrium that is system-wide optimal, i.e., their price of stability is 1. This finding suggests that a major improvement can be achieved by providing a central ("social") agent with the ability to impose the initial configuration on the system.