Abstract

Selfish Routing in Networks

Martin Gairing

In this work, we study the problem of users selfishly routing traffic through a shared network. Users route their unsplittable traffic by choosing a path from their source to their destination with the aim of minimizing their *private cost*, which are defined as their expected latency. This often contradicts the goal of optimizing the *social cost*, which measures the global performance of the whole network. We model such environments by *selfish routing games*, where the network users are assumed to be selfish *players*. In such routing games, a *Nash equilibrium* represents a stable state of the system in which no player can improve its latency by unilaterally changing its strategy. The *price of anarchy* measures the maximum performance degradation due to the selfish behaviour of the players.

In the first model, the network consists only of a single source and a single destination which are connected by *parallel links*. In such a *routing game on parallel links*, link latency functions are linear and the players have complete information about the system and the other players. For this model, we present results concerning the computational complexity of pure Nash equilibria. Furthermore, we prove a multitude of results that are related to the price of anarchy in various sub-models.

In the second model, called model of *weighted congestion games*, there is a set of resources and each player can choose as its strategy a subset of a given set of subsets of resources. The players have again complete information. Weighted congestion games provide us with a general framework for modeling any kind of non-cooperative resource sharing problem – not only that of routing. In this dissertation, we show exact values for the price of anarchy of weighted and unweighted congestion games with polynomial latency functions.

In the third part of this work, we define a selfish routing game with incomplete information that we call *Bayesian routing game*. Here, we again restrict the network to *parallel links* with linear latency functions. However, players do not know each other's traffic. For Bayesian routing games, we prove results on the existence and computational complexity of pure Bayesian Nash equilibria, we study structural properties of certain Bayesian Nash equilibria, and we prove bounds on the price of anarchy for various social cost measures.