Network Routing Games

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13 October 2020

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Network routing games have been studied intensively in the algorithmic game theory literature over the last two decades, especially because of the many applications they have, for example, in road traffic, congested networks, Internet routing, etc. Most studies can be regarded as being "foundational", in the sense that the models considered capture only the most essential aspects of these applications (e.g., selfish route choices, load-dependent latencies, multi-commodity networks). However, many aspects of practical relevance are still unaddressed or poorly understood, mostly because their study is much more challenging. It therefore is timely to provide and study more sophisticated models, incorporating among others the following aspects:

1. Data uncertainty: Input data is often assumed to be given deterministically and fixed adversarially. Studies focus on worst-case analysis.
   - What if the latencies are affected by uncertainties (stochastic, robust, scenario-based, etc.)?
   - What if the demand of each commodity is varying (over time, stochastically, depending on congestion, etc.)?
   - What if the network infrastructure is subject to changes (closure of subnetworks, restricted access, etc.)?
2. Specific network structures: Most studies focus on arbitrary networks, even though the relevant networks often exhibit some structural properties.
   - Can we gain more detailed insights by exploiting specific network properties (planar, geometric, social networks, etc.)?
   - What if we focus on well-established random graph models (Erdős-Rényi, Barabási-Albert, configuration model, etc.)?
3. Representative utility and social cost functions: Player decisions are not always made on purely selfish grounds. Rationality assumption often fails. Expected travel time minimisation as social cost objective mostly.

- What are suitable utility functions to capture the players' decision making accurately (risk attitudes, other-regarding preferences, etc.)?
- How to model the procedure used by the players to arrive at their final decisions (mistakes, bounded rationality, repeated play, learning, etc.)?
- What are good alternatives to the standard social cost function of minimising the overall (expected) travel time (latency fluctuations, mean-variance, etc.)?

4. Limited information: Typically, all input is assumed to be given a priori, players have full information and decisions are taken simultaneously.

    - What if the players have partial information only (network, latencies, demand, etc.)?
    - What if a fraction of the players is controlled centrally, while the others act selfishly (Stackelberg routing)?
    - What if the players arrive sequentially or the input data is revealed in an online manner?

Disclaimer: Some of the above aspects have been addressed in the literature recently. But often new aspects are reduced to variants of "standard" models. Conceptual novelty will be the key here.