Public Signals in Network Congestion Games

SVENJA M. GRIESBACH, Technische Universität Berlin, Germany
MARTIN HOEFER, Goethe-Universität Frankfurt, Germany
MAX KLIMM, Technische Universität Berlin, Germany
TIM KOGLIN, Goethe-Universität Frankfurt, Germany

It is a well-known fact that selfish behavior degrades the performance of traffic networks. Various measures have been proposed in the literature as a remedy for the inefficiency of traffic equilibria (such as road tolls or network design techniques). However, it often seems impractical and/or politically undesirable that these measures get implemented to a substantial extent.

We consider a largely untapped potential of network improvement rooted in the inherent uncertainty of travel times. Travel times are subject to stochastic uncertainty resulting from various parameters such as weather condition, occurrences of road works, or traffic accidents. Large mobility services have an informational advantage over single network users as they are able to learn traffic conditions from data. A benevolent mobility service may use this informational advantage in order to steer the traffic equilibrium into a favorable direction. The resulting optimization problem is a task commonly referred to as signaling or Bayesian persuasion.

Previous work has shown that the underlying signaling problem can be NP-hard to approximate within any non-trivial bounds [1], even for affine cost functions with stochastic offsets. In contrast, we show that in this case, the signaling problem is easy for many networks. We tightly characterize the class of single-commodity networks, in which full information revelation is always an optimal signaling strategy.

Moreover, we construct a reduction from optimal signaling to computing an optimal collection of support vectors for the Wardrop equilibrium. For two states, this insight can be used to compute an optimal signaling scheme. The algorithm runs in polynomial time whenever the number of different supports resulting from any signal distribution is bounded to a polynomial in the input size. Using a cell decomposition technique, we extend the approach to a polynomial-time algorithm for multi-commodity parallel link networks with a constant number of commodities, even when we have a constant number of different states of nature.

The full paper is available at: https://arxiv.org/abs/2205.09823

CCS Concepts: • Theory of computation → Algorithmic game theory; • Networks;

Additional Key Words and Phrases: Algorithmic Game Theory, Bayesian Persuasion, Network Congestion Games, Optimization, Signaling, Wardrop equilibrium

ACM Reference Format:
Svenja M. Griesbach, Martin Hoefer, Max Klimm, and Tim Koglin. 2022. Public Signals in Network Congestion Games. In Proceedings of the 23rd ACM Conference on Economics and Computation (EC ’22), July 11–15, 2022, Boulder, CO, USA. ACM, New York, NY, USA, 1 page. https://doi.org/10.1145/3490486.3538349

REFERENCES
[1] Umang Bhaskar, Yu Cheng, Young Kun Ko, and Chaitanya Swamy. 2016. Hardness Results for Signaling in Bayesian Zero-Sum and Network Routing Games. In Proc. 17th Conf. Econ. Comput. (EC). 479–496.

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

EC ’22, July 11–15, 2022, Boulder, CO, USA
© 2022 Copyright held by the owner/author(s).
ACM ISBN 978-1-4503-9150-4/22/07.
https://doi.org/10.1145/3490486.3538349