SOE 17: Traffic, Urban and Regional Systems I

Time: Thursday 16:00–17:30 Location: GÖR 226

SOE 17.1 Thu 16:00 GÖR 226

Topological universality of on-demand ride-sharing efficiency — •Nora Molkenthin, Malte Schröder, and Marc Timme — Chair for Network Dynamics, Institute for Theoretical Physics and Center for Advancing Electronics Dresden (cfaed), Technical University of Dresden, 01069 Dresden

Ride-sharing has been suggested as a solution to a wide range of challenges in personal transportation, ranging from avoiding traffic jams and pollution in cities to improving the availability of public transport in rural areas. However, the dynamics and scaling of such systems are not yet fully understood and definitions of efficiency of ride-sharing are often conflated with the demand. Here we introduce a demand-independent efficiency measure and use it to evaluate the scaling of the efficiency of ride-sharing with the number of buses for different street network topologies. We find and explain universal behaviour of efficiency with vehicle number.

SOE 17.2 Thu 16:15 GÖR 226

Anomalous Diffusion in Ridesharing? — •Philip Marszal, Malte Schröder, Nora Molkenthin, and Marc Timme — Chair for Network Dynamics, Institute for Theoretical Physics and Center for Advancing Electronics Dresden (cfaed), TU Dresden

A multitude of new transport approaches hold a promise of more flexible and more sustainable mobility. Ridesharing, combining trips to simultanenously share rides of several people on the same vehicle, aims to reduce the number of vehicles on the street and the distance traveled by each individual vehicle. Despite already being offered by service providers, the collective dynamics of ridesharing systems are not well understood. Here we study the spatio-temporal dynamics of ridesharing buses by interpreting their routes as random walks whose properties depend on the system size and load. We identify scaling relations characterizing the area served by a bus and its effective velocity, changing from ballistic trajectories on short timescales to anomalous diffusive motion on long timescales. As differences in scaling drastically affect system performance, these insights suggest a novel path towards optimizing ride-sharing systems.

SOE 17.3 Thu 16:30 GÖR 226

Traffic flow splitting from digital decision support — •David-Maximilian Storch, Malte Schröder, and Marc Timme — Chair for Network Dynamics, Center for Advancing Electronics Dresden (cfaed), Technical University of Dresden, 01062 Dresden, Germany

Digital technology is fundamentally transforming human mobility. Mode and route choices are greatly affected by a variety of smartphone-based trip planning applications. In uncertain or overwhelmingly complex traffic situations such software tools provide valuable decision support to their users. Yet, it is unclear how widespread adoption of digital routing technologies alters the collective dynamics of the population's mode and route choices. Here, we answer this question for the dynamics of urban commuting under digital decision support.

We formulate the commuting dynamics as a repeated congestion game where a fraction of the population relies on, but also contributes to, crowdsourced traffic information. Informational nudges provided by the decision support tool modify the commuters' route choice rationale and their traffic assignment. If the tool simply distributes the crowdsourced traffic information, we uncover a separation of commuter flows into technology and non-technology users, fueling systemic inefficiencies. An alternative class of route suggestion protocols may overcome this problem and promote socially optimal mobility outcomes.

These results highlight new research directions in the field of algorithmic design of mode-route choice decision support protocols to help fight congestion, emissions and other systemic inefficiencies in the course of increasing urbanization, digitization and autonomy.

SOE 17.4 Thu 16:45 GÖR 226

How efficient is ridesharing? — •Robin Maximilian Zech, Nora Molkenthin, Marc Timme, and Malte Schröder — Chair for Network Dynamics, Institute for Theoretical Physics and Center for Advancing Electronics Dresden (cfaed), TU Dresden

Ride-sharing may substantially contribute to make future mobility flexible, fair and sustainable. Recent work (Molkenthin et al., arXiv:1908.05929) proposed a generic measure of ride-sharing efficiency that is based on the intrinsic ride-sharing dynamics and follows a universal scaling law across network topologies. Here we ask how limited passenger capacity of ride sharing vehicles (busses) alters this universality. Using queueing theory, we present an analytic solution to a minimal model with requests served on a two node graph. For more complex street networks, we compute an effective number of busses by considering the probability of one bus having to delay a request due to capacity constraints. We find that for large numbers of busses and a suitably redefined topological factor, universality extends to finite capacity systems.

SOE 17.5 Thu 17:00 GÖR 226

Efficient and resilient ride sharing by stop pooling — •Charlotte Lotze, Malte Schröder, and Marc Timme — Chair for Network Dynamics, Institute for Theoretical Physics and Center for Advancing Electronics Dresden (cfaed), TU Dresden

Mobility faces three main challenges: emissions, social inequality and congestion. One potential solution currently discussed to address these challenges is ride sharing, i.e. the combination of multiple similar trips of customers to the same vehicle.

Here we present basic dynamic implications of stop pooling – a promising modification of door-to-door ride-sharing services. The main idea is to aggregate individual passenger's stop locations (e.g. have passengers walk a short distance to or from their stop) to save vehicle travel and stopping times and to thereby achieve a more efficient service. In a simple model, we quantify how efficiency increases as a function of both stop pooling radius and number of passengers per vehicle to estimate the impact of ride sharing with stop pooling on economic, sustainable, fair and resilient future mobility options. We also discuss potential positive consequences on sharability [1-3] and resilience. In conclusion, stop pooling may further optimize the benefits gained by the novel mobility option ride sharing.

[1] Santi P., et al. (2014) PNAS 111 : 13290-13294.
[2] Tachet R., et al. (2017) Sci. Rep. 7 : 42868.
[3] Molkenthin N., et al. (2019) arXiv : 1908.05929

15 min. break