With the ever-growing traffic demands, the transportation networks are getting more and more congested. While expanding these networks with more roads is both costly and in many cities not even feasible, the rapid development of new sensing and communication techniques has made it possible to perform control of transportation networks in real-time. With the right usage of such technologies, existing transportation networks’ capacities can be utilized better in order to lower the congestion levels. However, the control has to be done robustly, since real-time control and close to maximal utilization also make the networks more fragile and if not, even a small perturbation can have a tremendous impact on the traffic network. In this thesis, a few solutions that lead to better transportation network utilization are presented, designed with said robustness requirements in mind.

In the first part of the thesis, a decentralized control strategy for traffic signals is presented. The proposed policy, which we call Generalized Proportional Allocation (GPA), is inspired by the proportional fairness allocation for communication networks. The original proportional fairness controller does not explicitly take the overhead time needed to shift between different activation phases into account. We, therefore, enhance the proportional fairness so that it adapts its cycle length to the current demand. When the demand is higher, one wants longer signal cycles not to waste too much of the time overhead, while for lower demands, the cycle lengths should be shorter, so that the drivers do not have to wait for a long time. Stability for an averaged version of this control strategy is proved together with throughput-optimality of the controller. This means that no other control strategy can handle larger exogenous inflows to the network than the GPA-controller. Since the traffic signal controllers such as the GPA may allocate service to an empty line, due to the fact that several lanes can receive green light simultaneously, a model that handles this issue is proposed. For this model, the well-posedness of the dynamical system is shown when the traffic signal controller is Lipschitz continuous.

The GPA controller’s performance is also evaluated in a microscopic traffic simulator. In the microsimulations, it is shown how the proposed feedback controller outperforms the standard fixed-time controller for a scenario based on all traffic over the duration of one full day in Luxembourg. The controller’s performance is also compared to another decentralized controller for traffic signals, the MaxPressure controller, for an artificial Manhattan-like network. From these simulations, it can be concluded that the GPA performs better than MaxPressure during low demands, but the MaxPressure performs better when the demand is high. The fact that the GPA does not require any information about the network, apart from the current queue lengths, makes it robust to perturbations. In other words, the control strategy does not have to be updated when the demand or topology of the network changes.

The second part of the thesis is devoted to routing problems. First, the problem of routing a fleet of vehicles in an optimal way for the whole fleet is considered. The objective is then to achieve a minimum delay in average for the entire fleet. The routing algorithm takes into account the presence of regular drivers that are trying to optimize their own traveling time in the network. Conditions are posted for when such a routing assignment exists, and two algorithms to compute it are shown.
At last, a type of dynamic routing policies for multicommodity flows is studied. The routing policies are designed with the objective to avoid congested routes. It has previously been shown that if only one class of vehicles are present, the network is robust to perturbations with these routing policies. A model for multicommodity flows is proposed, and it is shown that the robustness properties for the single-commodity case do not necessarily hold in the multicommodity case. (Less)