Multi-Agent Control of Large-Scale Transportation Networks

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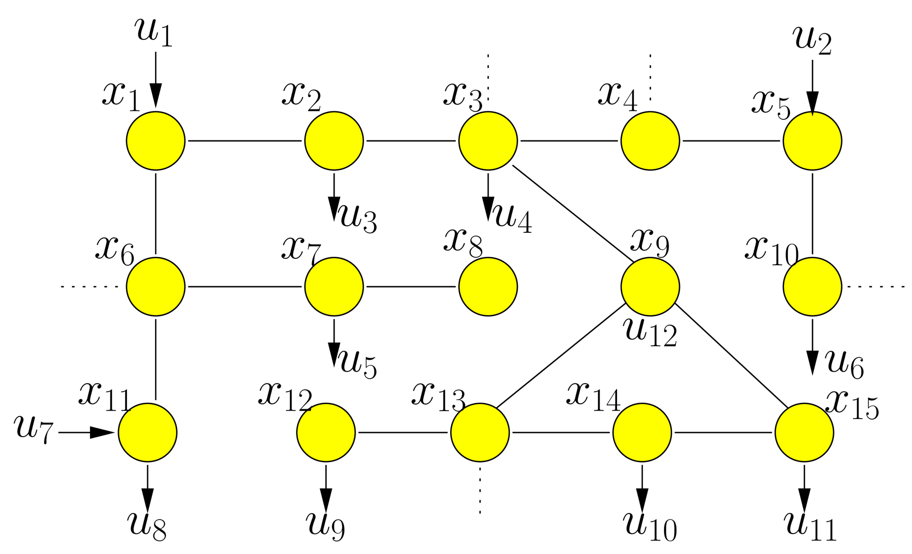
Motivation

Reliable operation of large-scale transportation networks, like traffic, logistic, and water networks, is of crucial importance for our modern society. Due to the large scale of these networks, control by a single, centralized, controller is not possible. In this research we therefore consider multi-agent, distributed, control.

Unified Framework

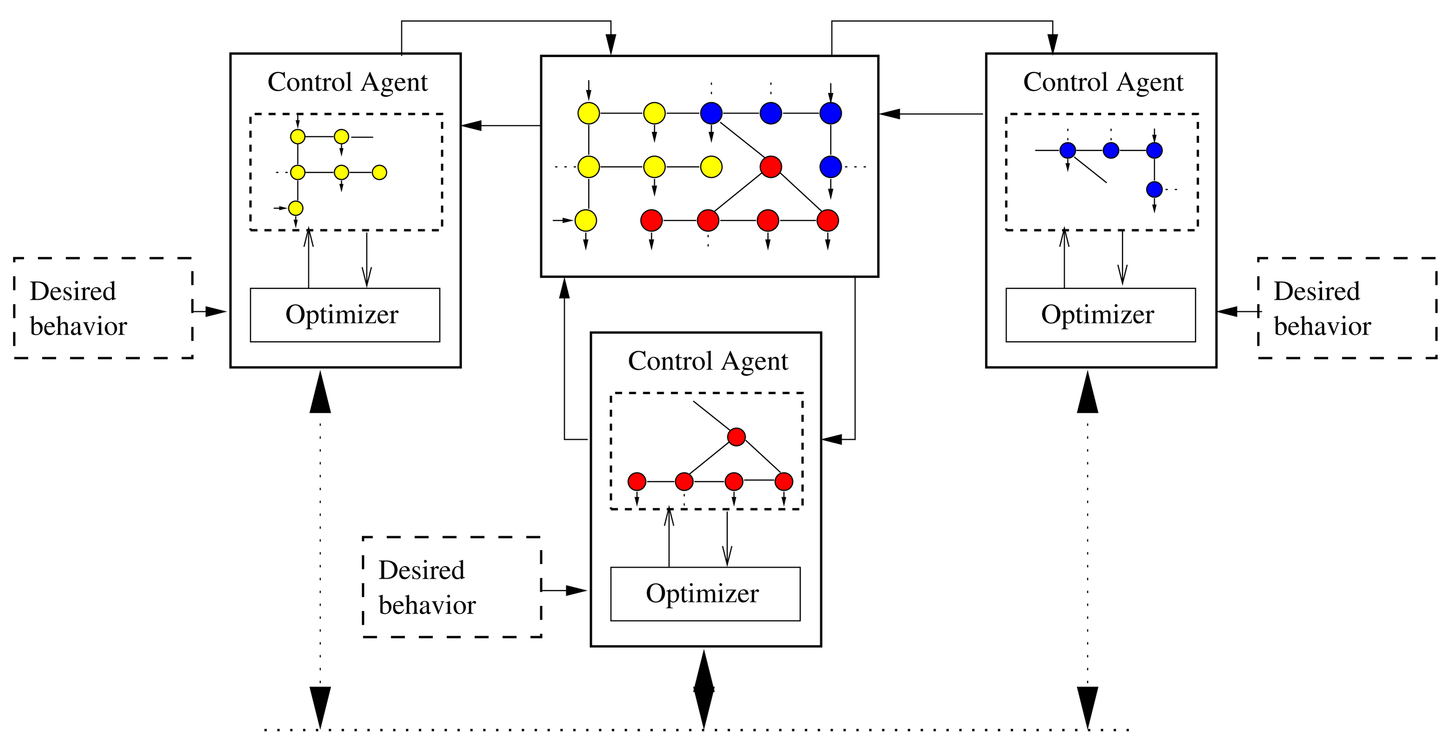
We consider transportation networks in a unified framework, such that we can talk about commodity that enters the network at sources, that flows over links to nodes, and that finally leaves the network at sinks. We may represent such a network schematically as:



where in this case commodity flowing into the network and flowing out of the network can be controlled. Actions have to be chosen such that, e.g., efficient capacity usage, congestion avoidance, or high supply quality are obtained.

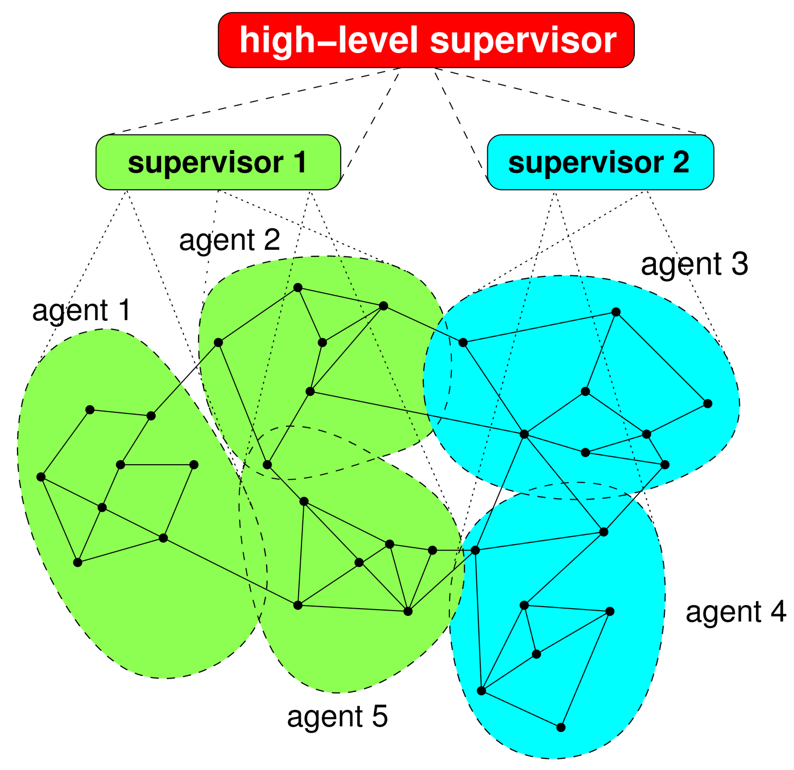
Multi-Agent Model Predictive Control

Due to computational complexity, communication overhead, and lack of scalability, single-agent, centralized, controllers cannot be used. Instead, we consider how multi-agent, distributed, controllers can be employed in a model predictive control setting. Each controller has only local information, can act only locally, although there is communication with other controllers:



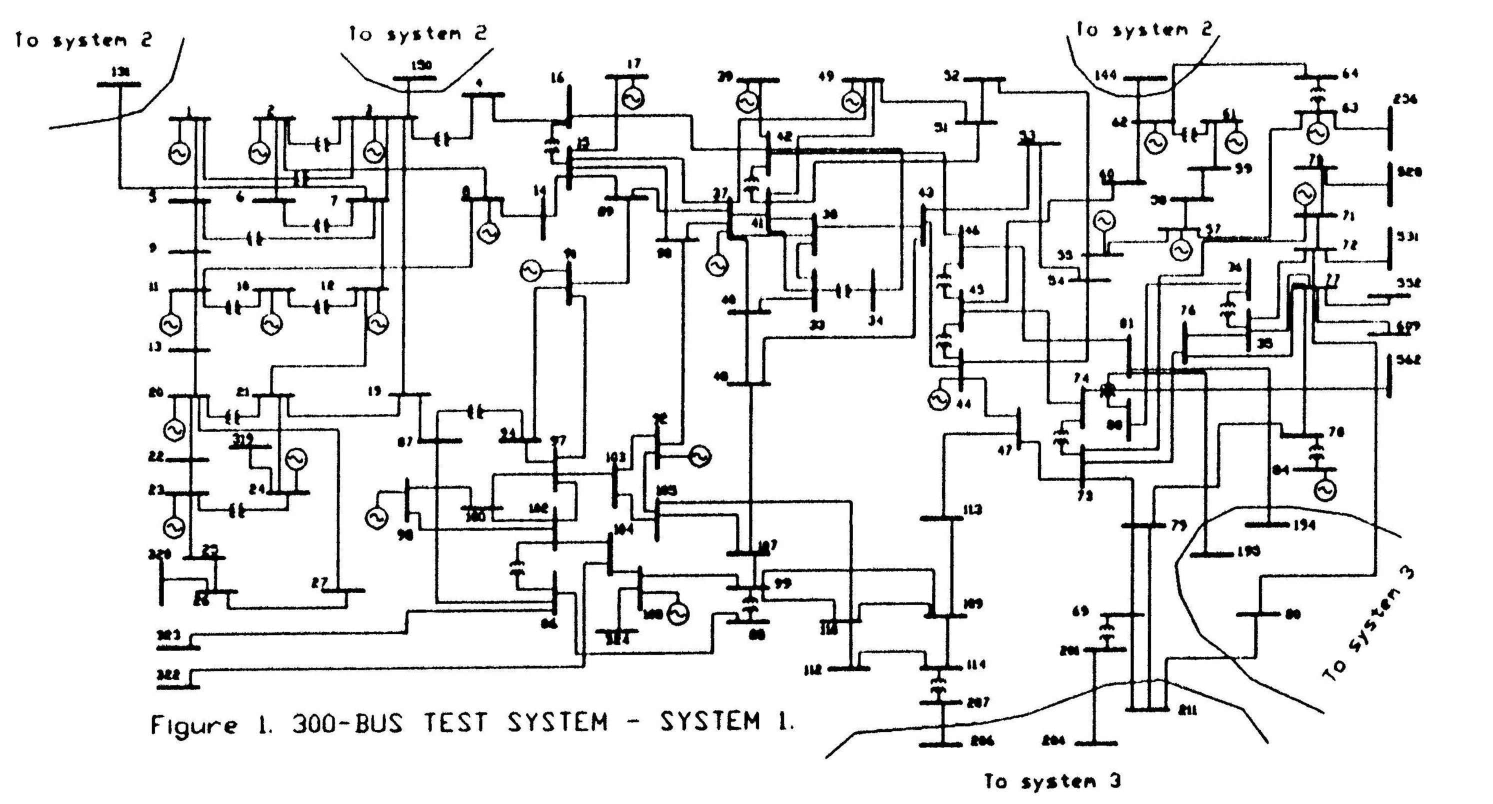
Hierarchical Control

To improve performance, the agents can be organized in a hierarchy, in which agents at the lowest level interact with the physical system, while agents at higher levels instruct lower levels. E.g.,



Power Distribution Networks

To assess the performance and potential of developed techniques in a practical setting we use power distribution networks. Due to the deregulation in power generation and distribution, new distributed control designs are required.



Key Issues

Key issues that are addressed in our research are:

How should a network be divided into subnetworks? And how should agents be assigned to control these regions?

How should the agents communicate with each other to obtain the best performance? And how close is this performance to the performance of an optimal, centralized, controller?

Are multiple levels of control necessary? How should they be designed? And how should communication between levels be organized?