Controller design for flow networks of switched servers with setup times

Erjen Lefeber
Dynamics and Control Group
Department of Mechanical Engineering
Eindhoven University of Technology
A.A.J.Lefeber@tue.nl

1 Abstract

This work is concerned with the controller design for networks of switching servers with setup times, e.g. manufacturing systems or urban road networks (traffic light control). Control of these networks is difficult, since using controllers that are stable for a server in isolation might render the network unstable. Sofar, in literature, most people first propose a policy, and then study the resulting behavior of the network under this policy.

In this work we propose an entirely different way of looking at the problem of controlling a network of switching servers with setup times. Instead of starting from a policy and then analyzing the proposed policy, we start from a priori specified desired network behavior. Using this desired behavior for the network under consideration as a starting point, we look for a policy which guarantees convergence of the system towards this desired behavior.

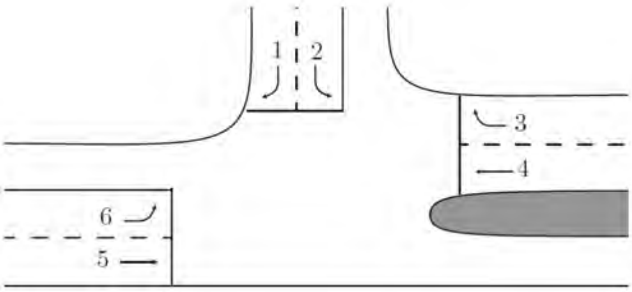

Figure 1: A T-junction

As an example consider the traffic light control of an isolated intersection, see Figure 1.

Before we develop a controller for this intersection we first determine an optimal periodic fixed time schedule using a novel group-based approach. By adding an objective function to the mathematical model of [1], we can obtain a mixed integer programming problem (MIP). Solving this MIP results in a periodic schedule as depicted in Figure 2.

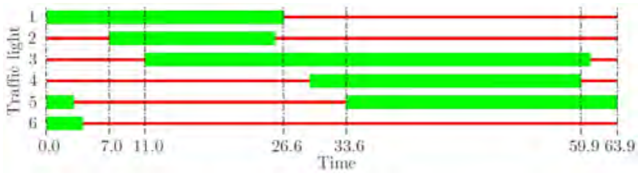

Figure 2: Optimal periodic schedule for the T-junction

Next step is to determine a controller which stabilizes the system towards this given optimal periodic orbit. The proposed controller periodically repeats the phases of the periodic orbit, where each phase is equipped with its phase control rule which determines when a phase ends. Such a phase control rule implies a dynamical operator which maps the state at the beginning of a phase to the state at the end of a phase. The monodromy operator is a similar map for the entire cycle. We propose phase control rules which are such that not only the optimal periodic orbit is a fixed point of the monodromy operator, but also all solutions converge to this fixed point. To that end we use the ideas presented in [2]. This approach can also be applied in a network setting for manufacturing systems where we have control over the service rate.

Future work consists of extending the optimization approach for determining optimal periodic behavior from an isolated intersection to a network of intersections. Also, we are looking for suitable phase control rules in case we have no control over the service rate, as typically is the case in the setting of traffic light control.

References

[1] P. Serafini and W. Ukovich. A mathematical model for periodic scheduling problems. *SIAM Journal on Discrete Mathematics*, 2(4):550–581, 1989.

[2] V. Feoktistova, A. Matveev, E. Lefeber, J.E. Rooda, Designs of optimal switching feedback decentralized control policies for fluid queueing networks, *Mathematics of Control, Signals, and Systems* 24, 477–503, 2012.