State feedback control of switching server flowline with setups

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1 Introduction

We consider the control of flowlines consisting of switching servers, through which different types of jobs flow. Switching from one job type to an other takes time. Examples of such flowlines can be found in manufacturing industry, food processing industry, communication networks, data flow and traffic flow.

The optimal process cycle with respect to work in process (wip) levels for a single switching server with two job types is known from previous work, [1]. This optimal wip level value is an absolute lower bound on average wip levels for flowlines with more than one workstation, since upstream workstation only move wip to downstream workstations, without reducing it. In this study we derive conditions for workstations in a flowline that have to be met in order to achieve the minimal wip level of an isolated workstation for the whole flowline. Based on these conditions, the class of flowlines is characterized that can behave as if it were a single switching server. For an introduction to the topic in more detail, the reader is referred to [2].

2 Example of switching server flowline

Consider the flowline as shown in Figure 1, consisting of two workstations. The workstations process two different job types, which are stored in separate buffers with length x_i^j with $i \in \{1,2\}$ the job type and $j \in \{A,B\}$ the workstation identifier. Jobs arrive with constant arrival rate λ_i and are processed by the servers with maximum rate μ_i^j. Switching from one job type to another job type takes time: σ_{12}^j or σ_{21}^j time units. A process cycle of a server always has the following operations: setup to type 1, process type 1 jobs, setup to type 2, process type 2 jobs, setup to type 1, etc.

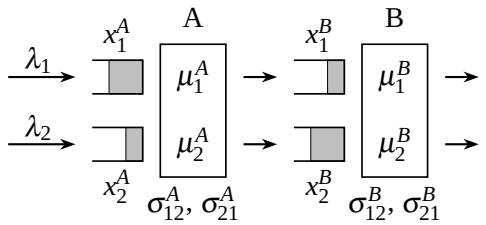

Figure 1: Flowline of 2 switching servers with 2 job types.

3 Desired periodic behavior

From [1] we know the optimal process cycle with respect to time averaged wip levels of a single switching server with two job types and setup times. If it is possible to treat a flowline of such switching servers as a black box which as a whole behaves like the optimal process cycle for a single switching server, then the flowline also has a cycle with this minimal mean wip level. Each server in the flowline has to meet conditions to fulfill this desired behavior:

- All servers have the same period length of a cycle.
- Buffers may never become negative.
- If the most downstream workstation has an empty buffer, all buffers of that type have to be empty.
- All servers process the same number of jobs of each type during a process cycle.

These conditions yield mathematical conditions which have to be fulfilled to make a switching server flowline behave like a single stand-alone switching server. These mathematical conditions completely characterize the class of flowlines for which this is possible.

4 State feedback controller

A state feedback controller is proposed that steers a trajectory to the desired trajectories for all servers in the flowline, from any arbitrary start point (buffer levels and current mode of operation of a workstation). Convergence to the desired process cycles is proven mathematically. Although the analysis is performed with a hybrid fluid model, the controller can successfully be implemented in a (stochastic) discrete event case study.

5 Conclusion

We have derived conditions for flowlines of switching servers with two job types and setup times to behave as if it were a single switching server. A state feedback controller has been proposed, which has been proven mathematically.

References

[1] J.A.W.M. van Eekelen, E. Lefeber, J.E. Rooda, *Feedback control of 2-product server with setups and bounded buffers*, in Proceedings of the 2006 American Control Conference; Minneapolis, United States, 544–549, 2006.

[2] J.A.W.M. van Eekelen, E. Lefeber, J.E. Rooda, *State feedback control of switching server flowline with setups*, accepted for the 2007 American Control Conference, New York, United States, 2007.