Observer design for a class of switching servers

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1 Introduction

Networks of switched servers are all around, e.g. manufacturing systems, supply chains, urban traffic networks, etc. When the layout and policy of the network is known, under certain conditions it is possible for a server to reconstruct the global state of the system. Therefore, we propose to use the idea of observers for deriving distributed policies for switching networks. However, first a criterium for observability of these networks and design of observers for arbitrary observable networks must be considered. We present the design of observers for a specific class of switching servers.

2 System

We consider switching servers as fluid models with constant input and using a clearing policy with a fixed switching order. The server can serve only one flow at a time and switching between serving different flows might require a switching/setup time. When a flow is served by a server more than once we speak of a re-entrant flow. Figure 1 depicts two examples of switching servers with and without re-entrant flows.

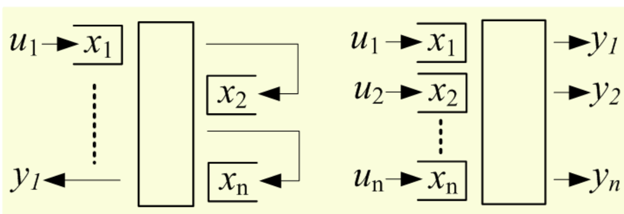

Figure 1: Switching servers with (left) and without (right) re-entrant flows.

The server dynamics can be described by the following linear hybrid model:

$$\dot{x} = B_m u + E_m, \tag{1}$$

$$y = C_m \tag{2}$$

where x and y are the continuous state vector and output vector. The discrete state or mode is denoted by m. Matrices B_m, C_m and E_m are mode dependent. Note that the output vector is piecewise constant and unrelated to the continuous state of the system.

3 Observer design

The observer problem concerns the estimation of unmeasured states of a system using the information of inputs and outputs. For the class of systems under consideration we present a step-by-step approach to derive an observer. First, events are defined. An event is a time-instant where the observable output, i.e. output known by the observer, switches between values. This indicates the beginning or end of a specific mode. Second, the system dynamics are copied by the observer. Third, the switching rules are adapted. A switch to and from modes with observable output is only allowed at the accompanying events. This step entails two extra modes per observable output, which occur during the time that the observer expects a certain event and the actual occurrence of that event. Fourth, the dynamics of these modes are derived. Last, updates of the state vector at events are derived. For example, when an event indicates the end of a mode, the buffer that is served during this mode is known to be zero.

Using this approach an observer is derived which can completely estimate the states of the system if and only if information of all inputs and at least a single output is known.
Furthermore, the time it takes for the observer to completely estimate the states of the system is in finite time and has an upper bound depending on the number of inputs between two consecutive observable outputs.

4 Conclusions

An approach has been developed to derive observers for a class of multi-class switching servers. Also, an observability criterium and the maximal time it takes for the observer to completely estimate the states of the system has been derived.
Interesting future work is expanding this approach to; discrete event systems, systems with stochastically distributed arrival and process times and systems with different policies.

Acknowledgement

This work is supported by the Netherlands Organization for Scientific Research (NWO-VIDI grant 639.072.072).