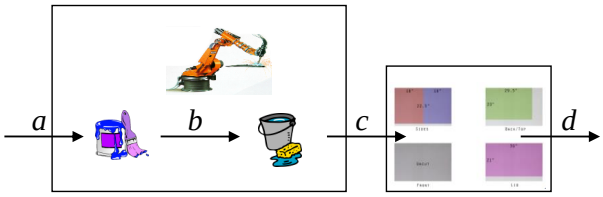
Analysis and Control of Cyber-Physical Systems

Homework 3 — 31 March 2021

Problem 1. A flexible manufacturing cell depicted in the figure below is composed by a paint/polish station P operated by a robot and by a buffer B of infinite capacity.



Station P works as follows. The robot picks up a metal plate arriving on a belt (event a) and paints it. When the painting operation is completed (event b) the robot polishes the plate. When the polishing operation is completed (event c) the plate is deposited in the buffer — stacking it over the other plates eventually there — and the station is now ready to process another plate. The initial and final state of the station is the one where the robot is idle.

The buffer can be modeled by a DFA with two states: empty and not-empty. When the buffer is empty, event c changes its state to non-empty, but this event does not modify the state when the buffer is non-empty. The buffer can be emptied with a "batch" operation (event d) corresponding to the simultaneous removal of all plates; this event can also occur when the buffer is empty, but in this case the state does not change. The initial and final state of the buffer is the empty one.

In the particular process we are considering, plates can be painted with different colors. Stacking in the buffer, one over the other, two plates of different colors their paint may be altered. Thus one wants to control the cell to ensure that at any moment the buffer contains at most one plate. All events arte controllable, except event c.

(a) Model the cell and the buffer by two DFAs denoted, respectively, P and B.

(b) Model the specification by a DFA H.

(c) Construct the DFA G modeling the concurrent behavior of the cell and the buffer.

(d) Show that DFA H is not an *admissible* supervisor for G. Determine a work w *allowed* by the specification which is *weakly forbidden*.

(e) Determine a maximally-permissive supervisor S which can enforce this specification. Construct the closed-loop system S/G. Is it blocking?

(f) Determine, if possibile, a supervisor S' with fewer states than S but such that the behavior of the closed-loop system S'/G coincides with the behavior of S/G.

Problem 2. Given a plant G, assume that there exists a supervisor S that enforces a given language specification K. Discuss under which conditions the following properties may hold.

(a) $L(S/G) = L(G)$;

(b) $L(S/G) = K$;

(c) $L(S/G) = \{\varepsilon\}$.