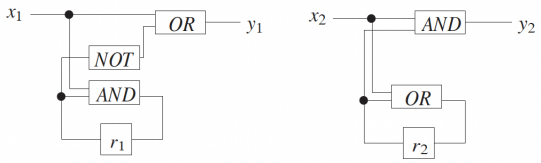
System Specification and Verification
- Seminar - Week 3 -

Spring 2026

1. Consider the following two sequential hardware circuits:



   - Give the transition systems of both hardware circuits.
   - Determine the reachable part of the transition system of the synchronous product of thesetransition systems. Assume that the initial values of the registers are $r_1 = 0$ and $r_2 = 1$.

2. **Handshaking : Railroad Crossing**

   For a railroad crossing a control system needs to be developed that on receipt of a signal indicating that a train is approaching closes the gates, and only opens these gates after the train has sent a signal indicating that it crossed the road. The complete system consists of the three components Train, Gate, and Controller.

   Controller handshakes with the trains (via the actions approach and exit) and the Gate (via the actions lower and raise via which the Controller causes the gate to close or to open, respectively).

   Model the three components and then compute the transition system modelling the handshaking between the three components.

   The Train : Has three states modelling the position where it is with respect to the gate (far, near, in). It approaches the gate, enter the gate and then exits.

   The Controller: When the train approaches, the Controller receives the signal and then he lowers the gate. Then, after the train passes, the controller raises the gate.

The Gate: has two states (up and down) and it is controlled by the Controller.

3. We are given three (primitive) processes P_1, P_2, and P_3 with shared integer variable x. The program of process P_i is as follows:

Algorithm 1 Process P_i

```
for k_i = 1, ..., 10 do
    LOAD(x);
    INC(x);
    STORE(x);
od
```

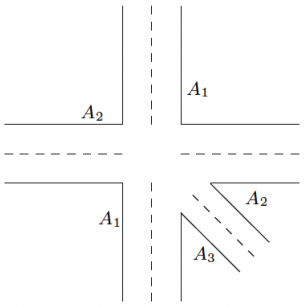
That is, P_i executes ten times the assignment $x := x + 1$. The assignment $x := x + 1$ is realized using the three actions $LOAD(x)$, $INC(x)$ and $STORE(x)$. Consider now the parallel program:

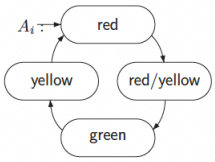
Algorithm 2 Parallel program P

```
x := 0;
P_1 || P_2 || P_3
```

Question: Does P have an execution that halts with the terminal value $x = 2$?

4. Consider the following street junction with the specification of a traffic light as outlined on the right.





(a) Choose appropriate actions and label the transitions of the traffic light transition system accordingly.

(b) Give the transition system representation of a (reasonable) controller C that switches the green signal lamps in the following order: A_1,A_2,A_3, A_1,A_2,A_3, ...
(Hint: Choose an appropriate communication mechanism.)

(c) Outline the transition system $A_1||A_2||A_3||C$.

5. Show that the handshake operator $||$ that synchronizes two transition systems over their common actions is associative. That is, show that

$$(\mathcal{T}_1||\mathcal{T}_2)||\mathcal{T}_3 = \mathcal{T}_1||(\mathcal{T}_2||\mathcal{T}3)$$

where $\mathcal{T}_1$, $\mathcal{T}_2$ and $\mathcal{T}_3$ are arbitrary transition systems.