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Analytical Solutions and Reasoning
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Topic: Transition Systems and Temporal Logic

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Lets consider the two processes P_0 and P_1, which execute the following pseudo code. They both can be in a critical section (crit and crit'), which correspond to the locations with the corresponding label. The processes share a variable `turn`, which is initially set to 0.

P_0:

```
l1   while true do
l2     while turn == 1 do skip end while
crit   turn := 1
l4   end while
```

P_1 :

```
l1'  while true do
l2'    while turn == 0 do skip end while
crit'  turn := 0
l4'  end while
```

Note: 'skip' is an atomic statement that has no effect.

Exercise 1 (Transition System) Find a suitable encoding of the given processes.

1. Develop an encoding for the states of the processes individually
2. Construct a transition system for each of the processes
3. Construct a transition system for both processes running in parallel ($P_0 \parallel P_1$) (Hint: the result is similar to the asynchronous product construction, but there is some synchronization happening via the shared variable.)

Exercise 2 (LTL formulas) Consider the following list of path properties.

I P_0 and P_1 are never in their critical sections at the same time.

II P_0 will eventually enter the critical section.

III If P_0 is eventually in the critical section, P_1 will also be eventually in the critical section.

IV Eventually, `turn` will not change its value again.

V P_1 will be in the critical section infinitely often.

Tasks:

1. Find an LTL formula for each of the properties.
2. Classify the formulas according to the classifications discussed in the lecture.
3. Provide for each formula a path in the transition system from Exercise 1.3 that is a model for the formula and one that is not (if possible).
4. Decide for each of the formulas φ: Does $P_0 \parallel P_1 \models \varphi$?
   (Note: $\mathcal{A} \models \varphi$ iff for all paths $\pi = (q_0, q_1, \ldots)$ where q_0 is an initial state holds that $\pi \models \varphi$)