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Hand in until November 20th, 2019
15:59 via the post boxes
Discussion: November 25th, 2019

Tutorial for Cyber-Physical Systems - Discrete Models
Exercise Sheet 5

Since there was no lecture, we use this exercise sheet to practice again and put together a few concepts we have already seen.

Exercise 1⋆: Bakery 6 Bonus Points

In this exercise, we start from an informal description of a process, and model it as a transition system in order to then be able to formally answer questions about this system.

The following describes a process of every-day life, an interaction between a customer and a baker in a bakery[1].

> In the first step, the baker and customer exchange greetings. They then enter in a question-answer loop:
>
> - The baker asks the customer what baked goods he or she wishes to buy.
> - The customer hears (i.e., receives) this question and either answers by naming a baked good or informs the baker that he or she has selected all the items he or she wishes to buy.
> - The baker hears (receives) the answer.
>   - If a baked good was indicated, the baker packs it into a paper bag, and then asks the customer for the next item (i.e., restarts the loop).
>   - If the customer indicated he or she does not wish to buy more items, the loop ends.
>
> After the loop has ended, the baker tells the customer the price. After hearing the price, the customer pays the baker. The baker then hands over the baked goods.

(a) Model the baker and the customer as separate transition systems. Do not model which specific baked good was selected. The customer should have an atomic proposition indicating whether he or she received the baked goods. The baker should have an atomic proposition indicating whether the customer has paid.

Draw both transition systems. For one of them (of your choosing), also give the definition of the transition system as tuple.

(b) Draw the parallel composition of your transition systems. Do not forget to label the configurations with sets of atomic propositions: A configuration of the composed system is labeled with all atomic propositions that hold in any of its local states.

(c) Using your transition system, argue that it is never possible that the customer receives baked goods without having paid.

[1] Not to be confused with *Lamport's Bakery algorithm*, a solution to the mutual exclusion problem in parallel systems. See `https://en.wikipedia.org/wiki/Lamport%27s_bakery_algorithm`.