Real-time and Probabilistic Systems Verification

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MSc in Computer Science

University of Camerino

Prof. Luca Tesei

Instructions

Do the following tasks using the suggested tools. Prepare a report in pdf in which you describe in details your solutions (possibly using screenshots). Send the report and the UPPAAL/PRISM project files that you generated to the teacher by email.

Real-time Modelling and Verification

Consider the following scenario.

A closed parking place has `NP` parking places and `NE` entrances. There are then `NC` cars (where `NC` $>$ `NP`) allowed to use the parking place. Whenever a car is *away*, it can decide at any moment to try entering the parking place. After this decision, it has 1 minute to select one of the entrances and send to it an approach signal. Then, the entrance has 1 minute to reply: it will allow the car in if there are still free parking places or it will send the car away if the are no free parking places.

If the car gets inside, then it has 2 minutes to park (thus decreasing the number of free places) or to realise that there are actually no free parking places (it checks the same variable checked by the entrance one minute before...). If the latter case occurs, then the car has further 2 minutes to go away, otherwise the car is *parked* and can stay in the parking place as much as it wants before freeing its parking place and going away.

1. Model the scenario in UPPAAL. Instantiate the constant numbers `NP`, `NE` and `NC` with values that permit to execute the following checks in reasonable time.

2. Check that your model is deadlock free

3. Check that the number of parked cars is always between 0 and `NP`

4. Check that it is *not* possible to guarantee that if a car tries to park then it will always find a place

5. Check that it is possible that a car is allowed to enter the parking place but then it actually finds that there are no free places

6. Discuss if and how the previous problem can be avoided

Probabilistic Modelling and Verification (DTMC)

Mr. Brown has got N umbrellas. Some or them are kept in Mr. Brown's office and the others in his home, depending on the policy of Mr. Brown when moving from home to office (and back) that is described in the following. Wherever he is (office or home) if it is raining, with a given probability p, and if there is at least an umbrella then he takes one umbrella to avoid getting wet. Thus, the umbrella is moved to the other place. If it is not raining the number of umbrellas in each place does not change. There is the possibility that the umbrellas are all in one place. In this case, if Mr. Brown is at the other place and it is raining he will get wet.

1. Model this scenario in PRISM as a DTMC. Consider $p = 0.35$ as probability of raining and $N = 4$. Moreover, suppose that at the beginning there is a uniform distribution of probability among the number of umbrellas available (it is not important to model if at the beginning Mr. Brown is at home or at office).
2. Using PRISM, study the steady-state probability of getting wet and that of having at least one umbrella available.
3. Using PRISM, study the transient probability of getting wet within K steps, where K ranges over $[0, 15]$ (draw a graph using PRISM facilities).
4. Determine the expected number of steps before getting wet.
5. Determine the average number of available umbrellas at time instant K, where K ranges over $[0, 15]$ (draw a graph using PRISM facilities).

Probabilistic Modelling and Verification (CTMC)

Model in PRISM the following chemical reactions with the given species and kinetic constants:

- Species: A (initially 3 elements), B (initially 3 elements), AB (initially 1 element).
- Reactions: $A + B \rightarrow_{k_1} AB$, $AB \rightarrow_{k_2} A + B$, $B \rightarrow_{k_3}$.
- Rates: $k_1 = 2$, $k_2 = 1.5$, $k_3 = 1$.

Then:

1. Study the transient probability of having at least 2 AB elements in the time range $[0, 2.5]$
2. Study the steady-state probability of having no more B elements
3. Study the average number of reactions occurring in the time range $[0, 3.5]$
4. Study the transient probability of reaching 0 B elements in the time range $[0, T]$ where T varies from 0 to 4.

   Hint: Use three different PRISM modules for the three species and one special module only to specify the kinetic constants k_1, k_2 and k_3. Then use the names of transitions to synchronise the modules on the same reactions. For each reaction in each module specify the appropriate guards and rates. In this way possible states with rates that sum to zero can be avoided.