Dipartimento di Elettronica, Informazione e Bioingegneria
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Software Engineering 2 – Pre-exam example

November 2024

Last name, first name and Id number (matricola):

Number of paper sheets you are submitting as part of the exam:

Notes

A. This file contains the description of the problem that you are asked to model in Alloy. The solution must be provided through the following Microsoft form: https://forms.office.com/e/at76ZC21Gt
B. You must use the Alloy Analyzer (version 6.1.0) to create the file with your proposed solution.
C. Follow the instructions provided in the form to submit your Alloy model (which you need to provide through various text boxes).
D. If the signatures, combined with the facts and predicates of Part 1, do not compile and do not produce reasonable instances, the rest of the exam (Part2 and Part 3) will not be evaluated.

E. Total available time: 2h and 30 mins

Note that we will not grade your solution to this example, but we encourage you to upload your solution through the form for two reasons:

- **you can get accustomed to the form we will use for the exam;**
- **after submitting your solution, you will get the link to our proposed solution.**

Question – Alloy (16 points)

Model the elements and features of a system monitoring traffic accidents in a city.
Consider that the network of roads of a city can be described as a graph, where its nodes are the intersections (crossroads), and the arcs are the roads. Since some roads are one-way, while others are two-way, each arc represents a permitted direction from one intersection to the next; hence, one-way roads are represented through single arcs, while two-way roads are represented through two arcs.
Vehicles are present in the road network (for simplicity, consider that the only kind of vehicles that are present in the city are cars, so from now on we will use the terms "vehicles" and "cars" interchangeably). Vehicles can be at intersections or on roads between intersections. For simplicity we assume that the capacity of roads and intersections is infinite (i.e., there is no maximum number of vehicles that can be at the same intersection or on the same road).

Part 1

1. Define suitable Alloy signatures (and related constraints) that capture the road network and the vehicles in them.
2. Define and execute a predicate that shows instances of the network that include at least a one-way road and a two-way road.

NB: We are interested in modelling the road network of a single city, so you can consider that the intersections and roads all belong to the same network.

Part 2

Vehicles move through the road network. The exact time it takes for a car to travel between intersections is not relevant for this exercise. Notice that if intersections *I1* and *I2* are connected by a road *R* (going from *I1* to *I2*) and a car moves from *I1* to *I2*, then the car first takes the road *R*, and then arrives at intersection *I2*.

1. Define suitable constraints that capture how vehicles move around the city. Notice that vehicles can overtake one another so, if they leave and arrive at the same intersections, they do not need to arrive in the same order in which they left.
2. Define a predicate that shows an evolution of the network in which there are at least 3 cars, which start at different intersections, and after 5 steps are at the same intersection; in addition, at least one of the three vehicles moves in the first three steps. Execute the predicate to show that the behavior is feasible in your model.

Part 3

We now want to represent the fact that accidents can occur at intersections (but, for simplicity, not on roads connecting them). When an accident occurs at an intersection, the traffic stops at the intersection; that is, cars cannot leave the intersection, and no new cars can reach it.

1. Introduce suitable elements to represent the occurrence of accidents in the road network, and the corresponding constraints.
2. Define and check an assertion that states that, as long as there is an accident at an intersection, then all cars that are on roads arriving at the intersection are stuck in traffic (i.e., they cannot leave the road).