UPPAAL Modeling Exercises: Time-critical systems

Luís Soares Barbosa

Exercise I.1

A trivial system. Model the following system described in the lectures:

1. Set the stopwatch to 0
2. When the stopwatch measures 10, action a can occur. If a occurs go to 1., if not idle forever.

Exercise I.2

Rail-Road Cross. Build a UPPAAL model of a *rail-road cross* as depicted in Fig 2.
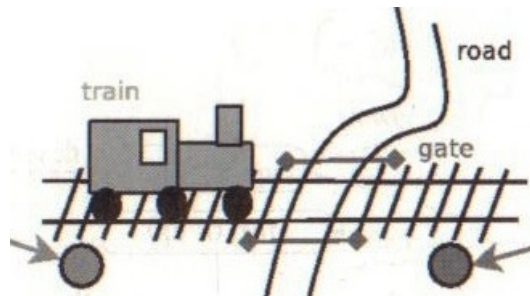

Figura 1: A rail-road cross

Your starting point is the parallel composition of the 3 untimed processes in Fig 2. Consider the following time require-
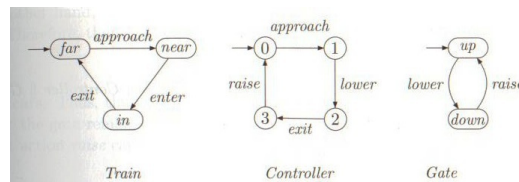

Figura 2: Suggestion for an untimed model

ments:

- There is a time interval lasting for at least 2 minutes between the detection of train approaching and its entering in the cross.
- 1 minute delay between the controller sensing the train approaching and giving order to lower the gate
- The gate goes down in less than 1 minute.


Exercise I.3

An elevator. Consider an autonomous elevator which operates between two floors. The requested behaviour of the elevator is as follows:

- The elevator can stop either at the ground floor or the first floor.
- When the elevator arrives at a certain floor, its door automatically opens. It takes at least 2 seconds from its arrival before the door opens but the door must definitely open within 5 seconds.
- Whenever the elevator's door is open, passengers can enter. They enter one by one and we (optimistically) assume that the elevator has a sufficient capacity to accommodate any number of passengers waiting outside.
- The door can close only 4 seconds after the last passenger entered. After the door closes, the elevator waits at least 2 seconds and then travels up or down to the other floor.

Suggest a timed automaton model of the elevator. Use the actions up and down to model the movement of the elevator, open and close to describe the door operation and the action enter which means that a passenger is entering the elevator.

Exercise I.4

QoS of a media stream. Consider the following requirements for a media stream channel and model a possible representation in UPPAAL.
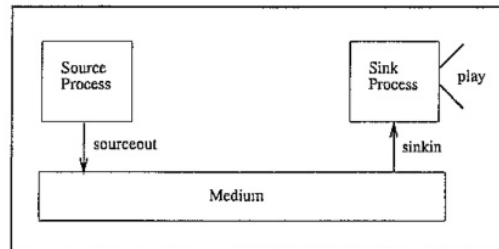
- Source emits a message every 50ms (ie, 20 messages per second)
- Channel latency is between 80ms and 90 ms
- Channel may loose messages (no more than 20%)
- A message is considered lost if it does not arrive within 90 ms
- Sink end receives messages and takes 5ms to process each one
- An error should be generated if less than 15 messages per second arrive at the sink end

Exercise I.5

Gossip Girls. A number of girls, say G_1 to G_n, for $n \geq 2$, initially know one distinct secret each. You can assume that the secrets are subsets of $\{1, ..., n\}$, and that initially girl G_i knows $\{i\}$, for each $i \in \{1, ..., n\}$. Each girl has access to a phone that can be used to call another girl to share their secrets. Every time two girls talk to each other they always exchange all of the secrets they know. Thus, after the phone call, they both know all secrets they knew together before the phone call. The girls can communicate only in pairs (no conference calls are allowed), but it is possible that different pairs of girls talk concurrently.

- Model the problem as a network of timed automata in UPPAAL, and use it to find the smallest number of phone calls needed for four girls to know all secrets.

- Refine your model so that each phone call lasts exactly 60 seconds (for simplicity this time duration is independent of the number of exchanged secrets). Find the minimum time needed to solve the gossiping girls problem for four girls.

- Experiment with the UPPAAL search options breath-first and depth-first search and with the diagnostic trace settings fastest and shortest. Try to solve the problem for five girls.

Hints.

- Design a single template for all girls. For each girl, remember the currently known secrets in a local integer variable. (Use a binary encoding such that if a girl knows the secrets of, for instance, girls 1 and 3 but does not know the secrets of girls 2 and 4, the value in the integer variable will be 0101 in binary; that is, 5 in decimal representation. You might find the operation |, for a bitwise OR, useful.)

- How to model value passing when two girls make a phone call? (check the UPPAAL tutorial)

Exercise I.6

UPPAAL Demos. read the UPPAAL tutorial [Behrmann, David & Larsen, 05] available from the tool web page and run all demos included in the distribution. Explain the problems and corresponding modelling solution; try out a few variants.