

Cyber-physical systems and their verification(2.8.2)

TD n° 2 : Timed regular languages

Reminder : two Alur's theorems

1. Given a timed automaton A one can compute a finite automaton B such that $L(B) = \text{Untime}(L(A))$
2. Universality problem “Does a timed automaton A accept all the timed words?” is undecidable

Exercise 1 – Four languages

Are the following timed languages over $\{a, b\}$ timed regular? Build a timed automaton or prove that it is impossible.

1. L_1 : timed words with the number of a being a prime integer.
2. L_2 : timed words with the duration being a prime integer.
3. $L_3 = \{tatb\}$. (with t staying for delay between events).
4. $L_4 = \{ta1asb \mid t + s = 2\}$. Also, is it recognizable with a one-clock automaton?

Exercise 2 – Folk's theorems — S. Tripakis

Prove that no algorithm given a timed automaton A

- answers YES or NO whether $\overline{L(A)}$ is timed regular;
- and if the answer is YES builds a timed automaton B such that $\overline{L(A)} = L(B)$.

Hint : suppose that such an algorithm exists and use it to decide Universality.

Remark : (O. Finkel) deciding whether $\overline{L(A)}$ is timed regular is also impossible.

Exercise 3 – Modeling and verification — easy exercise

Romeo wakes up between 6 and 7 o'clock, learns Timed automata for 6 to 8 hours, then swims for 2 to 3 hours, makes jogging for 2 to 4 hours (altogether he makes sport for less than 6 hours), and goes to “Chez Uppaal” bar for the rest of the day. He goes to bed at 22 hours.

Juliet is awake from 7 to 21, and during all that time she alternates 3 hours of learning Hybrid systems and 1 hour of hanging at “Chez Uppaal”.

The **specification** says that they should never meet “Chez Uppaal”.

1. Model Romeo and Juliet behaviors by timed automata.
2. Represent the verification of the specification as emptiness checking for an intersection of timed regular languages. **Hint** : you will need a special event for their rendezvous.