Priced Timed Games and infinite diagnostic

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Introduction

Due to the increasing use of computers in potentially dangerous or highly consuming tools, the analysis of such systems is a hot topic. In particular it allows one to address the problems of optimisation of the cost of such systems and the detection of the occurence of faults within them. In order to tackle those issues this ARPE focused on the two following problems:

- the synthesis of controllers for timed systems;
- the diagnosis/prediction of probabilistic infinite-state systems.

Context

- Priced Timed Games (PTG) were mostly studied with positive prices only and an EXPTIME algorithm was given for One-Clock PTG. With negative prices only one subclass (where only two prices among -1,0 and 1 are possible) was solved with a corner abstraction method.
- Diagnosis/prediction of probabilistic systems was studied for finite systems where PSPACE/NLOGSPACE algorithms where given. Infinite state systems were studied through pushdown automata but without probabilities.

Diagnosis of infinite systems

Diagnosis is a critical task in monitoring systems and it has recently led to theoretical developments related to its complexity w.r.t. both its decision problems and the synthesis of diagnosers.

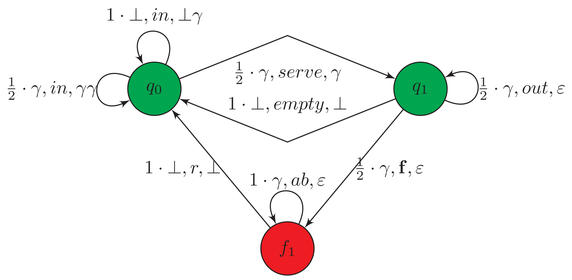

Figure 3: A probabilistic pushdown automaton

Pushdown automata are automata where transitions can read the top of a stack, replace it, remove it or add another letter on the stack. Adding probabilities decide which transitions is taken. When a transition is taken, the controller does not necessarily knows it. A visibly probabilistic pushdown automaton warns when the height of the stack changes. We wish to detect a particular transition called the fault.

Results:

- Diagnosis/prediction of probabilistic pushdown automata is undecidable;
- Diagnosis/prediction of visibly probabilistic pushdown automata is decidable in EXPSPACE/PSPACE;
- Diagnosers/predictors may need infinite memory.

Priced Timed Games

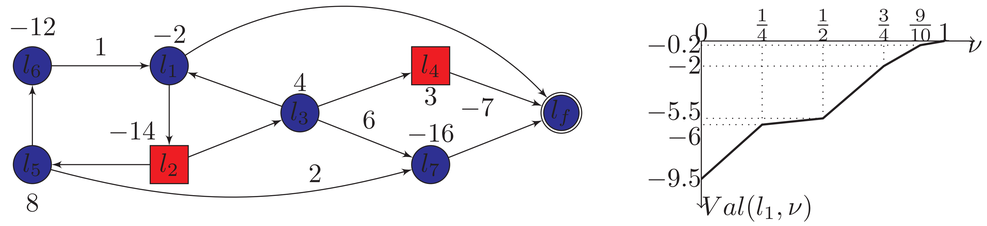

Figure 1: A PTG and its value function

PTG are two-player zero-sum games played on priced timed automata (whose locations and transitions are labeled by weights modeling the costs of spending time in a state and executing an action, respectively). The goals of the players are to minimise and maximise the cost to reach a target location, respectively.

Results:

- Simple one-clock PTG with positive and negative prices can be solved in EXPTIME;
- One-clock PTG are determined;
- Reset-acyclic priced timed games (with arbitrary weights and one-clock) can be solved in EXPTIME.

Future research

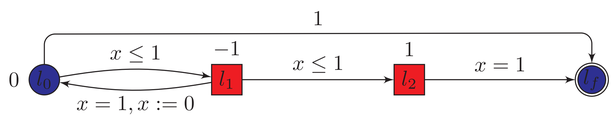

Figure 2: A PTG where the number of resets in optimal plays can not be bounded a priori.

- How to solve the whole class of one-clock PTG? How to replace the bound on the number of resets in our algorithm ?
- Does there exists a one-clock PTG which function value has an exponential number of pieces?
- Can we approximate multiple-clocks PTG with a one-clock PTG?
- Better algorithm for the diagnosis of visibly probabilistic pushdown automata? Or tight lower bound?
- Which sub-class has finite memory diagnosers/predictors?
- Are other specifications interesting to study?

References

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[2] Thomas Brihaye, Gilles Geeraerts, Shankara Narayanan Krishna, Lakshmi Manasa, Benjamin Monmege, and Ashutosh Trivedi. Adding Negative Prices to Priced Timed Games. In *Proceedings of the 25th International Conference on Concurrency Theory (CONCUR'13)*.

[3] Thomas Brihaye, Gilles Geeraerts, Axel Haddad, Engel Lefaucheux, and Benjamin Monmege. Simple priced timed games are not that simple. Research Report 1507.03786, arXiv, 2015.