Nondeterministic Bigraphical Reactive Systems for Markov Decision Processes*

Paulius Dilkas[0000−1111−2222−3333] and Michele Sevegnani[1111−2222−3333−4444]

University of Glasgow, Glasgow, UK

Abstract. The abstract should briefly summarize the contents of the paper in 150–250 words.

Keywords: First keyword · Second keyword · Another keyword.

1 Introduction

Definition 1 ([2]). *For any finite set X, let* $\mathrm{Dist}(X)$ *denote the set of discrete probability distributions over X. A* Markov Decision Process *is a tuple $(S, \overline{s}, A, P, L)$, where: S is a finite set of states and $\overline{s} \in S$ is the initial state; A is a finite set of* actions*; $P : S \times A \to \mathrm{Dist}(S)$ is a (partial) probabilistic transition function, mapping state-action pairs to probability distributions over S; $L : S \to 2^P$ is a labelling with atomic propositions.*

Definition 2. *A* reward structure *for an MDP $(S, \overline{s}, A, P, L)$ is a pair (ρ, ι), where $\rho : S \to \mathbb{R}$ is the* state reward function*, and $\iota : S \times A \to \mathbb{R}$ is the* transition reward function*.*

Definition 3. *A* bigraph *is a tuple $(V, E, \mathrm{ctrl}, \mathrm{prnt}, \mathrm{link}) : \langle k, X\rangle \to \langle m, Y\rangle$, where V is a set of nodes, E is a set of edges,* ctrl *is the* control map *that assigns controls to nodes,* prnt *is the* parent map *that defines the nesting of nodes, and* link *is the* link map *that defines the link structure.*

The notation $\langle k, X\rangle \to \langle m, Y\rangle$ indicates that the bigraph has k holes *(sites) and a set of inner names X and m* regions*, with a set of* outer names *Y. These are respectively known as the* inner *and* outer *interfaces of the bigraph.*

Reaction rule definition [1]
Stochastic bigraphs [3]
PhD thesis [4]
Define NBRS
Lemma: any MDP can be expressed as an NBRS
Changes from PBRS: each reaction rule annotated with an action name (probabilities normalised over each action separately) and an integer reward/-cost, predicates get a reward/cost, too.

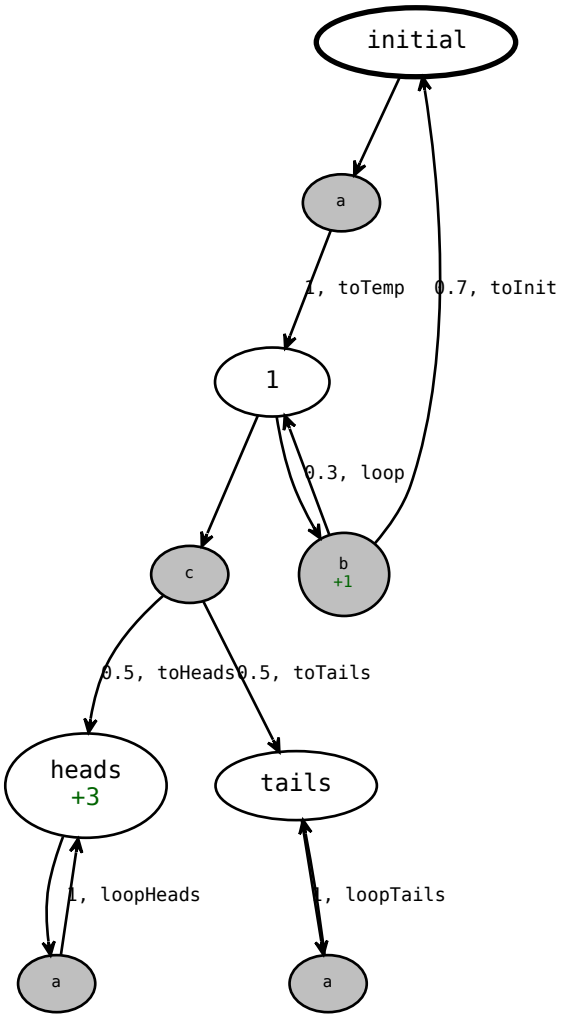
initial
a
1, toTemp
0.7, toInit
1
0.3, loop
c
b
+1
0.5, toHeads
0.5, toTails
heads
+3
tails
1, loopHeads
1, loopTails
a
a

Fig. 1. ...

2 Example

Listing 1.1. asdf

```
atomic ctrl S0 = 0;
atomic ctrl S1 = 0;
atomic ctrl S2 = 0;
atomic ctrl S3 = 0;

big initial = S0;
big heads = S2;
big tails = S3;

action a
  react toTemp = S0 -[1.]-> S1;
  react loopHeads = S2 -[1.]-> S2;
  react loopTails = S3 -[1.]-> S3;
end

action b[1]
  react toInit = S1 -[0.7]-> S0;
  react loop = S1 -[0.3]-> S1;
end

action c
  react toHeads = S1 -[0.5]-> S2;
  react toTails = S1 -[0.5]-> S3;
end

begin nbrs
  init initial;
  rules = [ {toTemp, toInit, loop, toHeads,
  toTails, loopHeads, loopTails} ];
  preds = { initial, heads[3], tails };
end
```

Example 1. Consider an MDP $(S, \overline{s}, A, P, L)$, where... Look at Figure 1.

3 Exporting to PRISM

Transitions, state rewards, transition rewards

* Supported by organization x.

4 Case study in autonomous agents

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