Model-checking invariant properties of resource-bounded MAS with discounting

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Discounting has been introduced to calculate the accumulated utilities of infinite repeated games [3]. It was applied in [2] for multi-agent systems to compute *realistic* agents' accumulated payoffs over infinite computations. This allows one to formulate state or path properties over accumulated payoffs based on arithmetic constraints. To this end, we introduce the logic dRB±ATL as an extension of RB±ATL [1] where discounting is used in invariant properties.

Let Agt be a set of n agents, Res a set of r resources, Π a set of propositions and $B = \mathbb{N}_\infty^r$ a set of resource bounds where $\mathbb{N}_\infty = \mathbb{N} \cup \{\infty\}$. The syntax of dRB±ATL is as follows: $\varphi ::= p \mid \neg\varphi \mid \varphi \vee \psi \mid \langle\langle A^b \rangle\rangle \bigcirc \varphi \mid \langle\langle A^b \rangle\rangle_\beta \Box \varphi \mid \langle\langle A^b \rangle\rangle \varphi \,\mathcal{U}\, \psi$ where $p \in \Pi$ is a proposition, $A \subseteq Agt$, $b \in B$ is a resource bound, and $\beta \in [0, 1]$ is a *discount factor*. Here, $\langle\langle A^b \rangle\rangle_\beta \Box \varphi$ means that A has a strategy to make sure that φ is always true, and the accumulated cost (with the discount factor β) of this strategy is at most b. We note that our approach is different from that of [2] in (i) discounting is for accumulated costs rather than accumulated payoffs and (ii) discount factors are attached to formulas at the syntax level rather than models at the semantics level.

Formulas of dRB±ATL are still interpreted on resource-bounded concurrent game structure (RB-CGS) as RB±ATL [1]. However, the accumulated cost with a discount factor β of a computation λ is defined as $\sum_{j=0}^{\infty} \beta^j \times cost(\lambda[j], F_A(\lambda[0, j]))$. Note that the above accumulated cost always exists if $\beta < 1$.

The model-checking problem for dRB±ATL is the question whether for a given RB-CGS structure M, a state s in M and an dRB±ATL formula ϕ, $M, s \models \phi$. We show that the model-checking problem for dRB±ATL is decidable.

References

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