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Protocol of on-line discussion during November, 1997
about the following research article:

Paolo Liberatore:

The Complexity of the Language $\mathcal{A}$

Q5. **Anonymous reviewer** (21.11)

Section 6 in the article addresses domain descriptions in which some states are not reachable from the initial state. I think the modification of the semantics of $\mathcal{A}$ as proposed in that section does not allow to solve the problem of unreachable states. Consider the situation where you replace the observation that H and L are initially both false by what you observe after two steps, i.e. replace the two 'initially' propositions by

$$H \text{ after } I; I$$
$$\neg L \text{ after } I; I$$

Intuitively, the model should be the same. But the reachable states semantics now considers $\{H, L\}$ to be a possible initial state. This is because $\Psi_D(I, \{H, L\})$ is undefined there, hence both value propositions are weakly true. I.o.w., you get back to the orginal $\mathcal{A}$ semantics you wanted to avoid.

Generally, my feeling is that in order to solve the problem that your example highlights (and I think it is a problem) you cannot do in the language of $\mathcal{A}$. What you need is a notion such as "action A is executable if ...".

Also, on page 5 you write:

> *"to prove that D entails $\ulcorner F$ after $A_1; ...; A_m\urcorner$ it suffices to prove that $\ulcorner D \cup \neg F$ after $A_1; ...; A_m\urcorner$ is inconsistent."*

This reduction seems not to go through for your modified semantics of section 6.

The rest (i.e. the main part of the paper) is just perfect as far as I can see. And it was a pleasure to read the paper.

A5. **Paolo Liberatore** (24.11)

You wrote:

> *Section 6 in the article addresses domain descriptions in which some states are not reachable from the initial state. I think the modification of the semantics of $\mathcal{A}$ as proposed in that section does not allow to solve the problem of unreachable states. Consider ...*

You are right. In this case, the semantics does not capture the intuitive meaning of the domain description.

You also wrote:

> *Generally, my feeling is that in order to solve the problem that your example highlights (and I think it is a problem) you cannot do in the language of $\mathcal{A}$. What you need is a notion such as "action A is executable if ...".*

The intended semantics for the actions in $\mathcal{A}$ is: all actions are executable in any state. When $\Psi_D(I, \sigma)$ is undefined, the choice of the original semantics of $\mathcal{A}$ is that the whole domain description is inconsistent. What I meant is instead that A is not executable in σ. In this sense, in $\mathcal{A}$ *it is possible* to express propositions like "I is executable if", but only in a non-intuitive way: in the example of the counter I is not executable in $\{H, L\}$. We need an appropriate semantics for such propositions.

(If there is a proposition "I is executable if ..." there is no need to make Ψ defined on I in states in which I is not executable. As a result, there is nothing that prevent us from using the indefiniteness of Ψ to infer the non-executability of actions. The drawback is that this definition is less intuitive.)

Analyzing the problem of unreachable states, my first idea for solving it was: an interpreted structure (σ, Φ) is a model of D if and only if

1. each action is executable in any state reachable from σ
2. each value proposition is satisfied (as in the old semantics of $\mathcal{A}$)

However, I discarded this idea, and instead I defined the one that is presented in the paper. Note that this semantics, although correct wrt your example, suffers from some drawbacks. For example, if for any state there is an action not executable there, then the domain description is inconsistent. Consider for example the case

I is executable if F
J is executable if $\neg F$

This domain is inconsistent, because in the initial state in which F is true the action J is not executable, while in the initial state in which F is false the action I is not executable. In such cases, it seems possible to infer that, if the initial state is $\{F\}$ then the first action executed is I. For instance, if there is also a proposition

initially F

the first executed action is I. The semantics of $\mathcal{A}$ does not infer any statement about the execution of actions (in $\mathcal{E}$ and similar languages there are propositions like "I at 0" or "I happens at 0"). A statement like "F after I" may be interpreted in two ways:

1. if F *were* executed the result would be a state that implies F
2. F is executable in the initial state, and the resulting state implies F

(The choice of the semantics of the paper is the first one, while the discarded one uses the second one.) Statements like "I at 0" or "I happens at 0" means that I is executed in the time point 0 (and thus the action must be executable in that state).

I discarded the first semantics (preferring the one of the paper) because the impossibility of executing an action in the initial state (or any other state) may influence the set of the possible initial states. The semantics of the paper first determines the set of possible initial states, and only then determines which states are reachable from them. However, in the example of the counter, the initial state $\{H, L\}$ must be rejected *because* the action I is not executable from there. This is why the semantics of the paper fails.

Perhaps the discarded solution is better then the chosen one. The problem is left open. A minimal requirement for a semantics that takes into account the reachability of states is that if D does not have "executable" propositions (or, if Ψ_D is total) then the new semantics must coincide with G&L's semantics. The semantics of the paper (and the one of the previous paragraph) has this property (clearly, this is not enough.)

You also wrote:

> *Also, on page 5 you write:*
>
> > "to prove that D entails $\ulcorner F$ after $A_1; ...; A_m \urcorner$ it suffices to prove that $\ulcorner D \cup \neg F$ after $A_1; ...; A_m \urcorner$ is inconsistent."
>
> *This reduction seems not to go through for your modified semantics of section 6.*

Indeed, this property holds only for the classical semantics of $\mathcal{A}$ (this property is used for proving the complexity of the entailment in the classical semantics of $\mathcal{A}$).

Q6. **Thomas Drakengren** (24.11)

Paolo,

Here are some questions and suggestions about details in your article:

page 16, line -14: What about the case A causes G, A causes $\neg G$? That would be inconsistent. What is the intended meaning in this case?

page 17, line 8: This case is similar to the IJCAI '97 paper by myself and Marcus Bjäreland [c-ijcai-97-1447], where we require one negative precondition and one negative postcondition (which is of course equivalent, replacing true and false). You can probably add some nondeterminism here, retaining tractability, if you do not allow a precondition, the same way as we're doing it (you can then have a Horn postcondition).

page 19, line 3: An inconsistent domain description could never entail the same propositions as a consistent one. What is the intended meaning in this case?

References:

[c-ijcai-97-1447] Thomas Drakengren and Marcus Bjäreland. *Reasoning about Action in Polynomial Time.* Proc. International Joint Conference on Artificial Intelligence, 1997, pp. 1447-1453.

A6. **Paolo Liberatore** (1.12)

Dear Thomas,

Thank you for your suggestions. About your observations:

> *page 16, line -14: What about the case A* causes *G, A* causes *$\neg G$? That would be inconsistent. What do you mean in this case?*

In this case Ψ_D is not total. This can be verified in polynomial time (Lemma 1).

> *page 19, line 3: An inconsistent domain description could never entail the same propositions as a consistent one! What do you mean in this case?*

The original domain description implies (under the semantics of reachable states) the same propositions of the modified one (using Gelfond & Lifshitz's semantics). The point is that I am using two entailment relations for the original domain description and modified one.

Paolo