

Real Animation of TLA⁺ Models

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PROB is a constraint solver, animator and model checker for state-based formal methods. While its main focus is the B-Method, it has supported TLA⁺ for quite a while [2]. The validation tool PROB is complimentary to existing tools: PROB is good at animating or model checking high-level models, TLC [6] is much more efficient for models that do not require constraint solving, while Apalache [3] is good for symbolic model checking. In this presentation we discuss some features and recent improvements of PROB which make it useful for TLA⁺ modelers:

- interactive animation of high-level models now including reals,
- constraint solving with PROB’s default backend or others like B2SAT [4],
- custom graph visualisations of the current state,
- domain specific visualisations based on SVG and HTML.

Below we illustrate these points on three TLA⁺ examples.

Figure 1 shows a TLA⁺ model of a dominating set problem. The constraints of the problem can be elegantly written down in TLA⁺, but unsurprisingly TLC cannot deal with this model. Apalache can deal with a variation of this model in about 47 seconds, but runs into stack overflows for larger instances [4]. PROB can solve the constraints much more effectively. In line 43 of Figure 1 we have activated the B2SAT backend [4], which solves this problem by translation to SAT in 15 ms (similar to the runtime of PROB’s default solver for this graph, but it can scale to much larger instances, see [4]). On line 44 of Figure 1 we instruct PROB on how to graphically render the state, the result of which is shown in the right of the figure.

Figure 3 shows the TLA⁺ model from [1] using the Reals module. PROB now supports floats, used here to provide “approximate” validation.¹ The screenshot also shows a VisB [5] visualisation, giving users and domain experts feedback about the model’s behaviour. One can also export a trace into a stand-alone HTML file, which can be inspected by domain experts without having to install or use PROB. We provide the model, the VisB visualisation file and one HTML export at <https://stups.hhu-hosting.de/models/tla2b/Reals/>.

The third example is a Tic-Tac-Toe model from <https://elliotswart.github.io/pragmaticformalmodeling/> where we added a VisB visualisation. Note that the visualisation is interactive, i.e., one can execute TLA⁺ actions by clicking on the Tic-Tac-Toe board. With suitable annotations it is even possible to activate automatic game play based on Monte-Carlo tree search.

¹ Precise support for reals in PROB is ongoing research.

In summary, we hope that PROB provides useful validation features for TLA⁺, enabling new applications of TLA⁺. A web page about PROB for TLA⁺ is available here: <https://prob.hhu.de/w/index.php?title=TLA>.

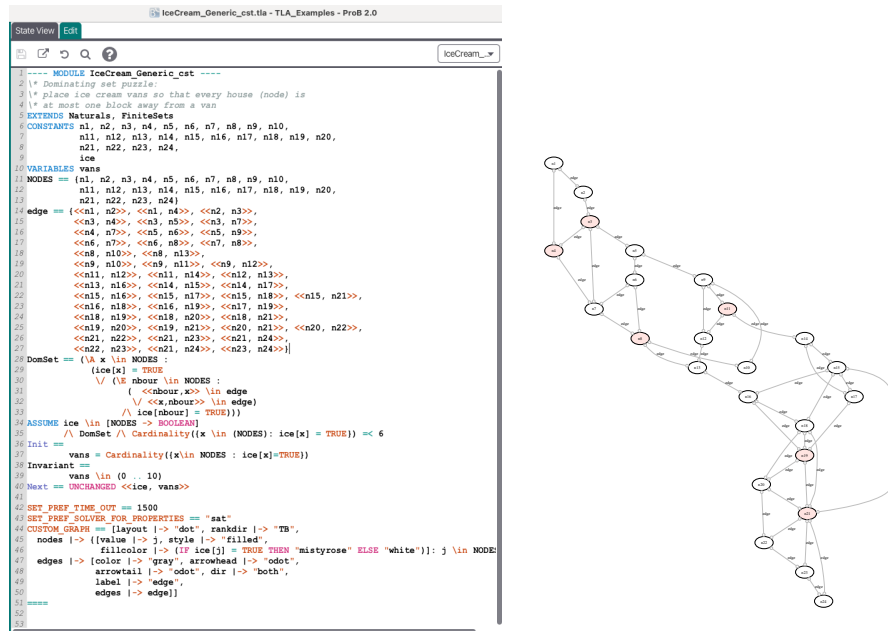


Fig. 1. Dominating Set Example with Custom Graph Visualisation

References

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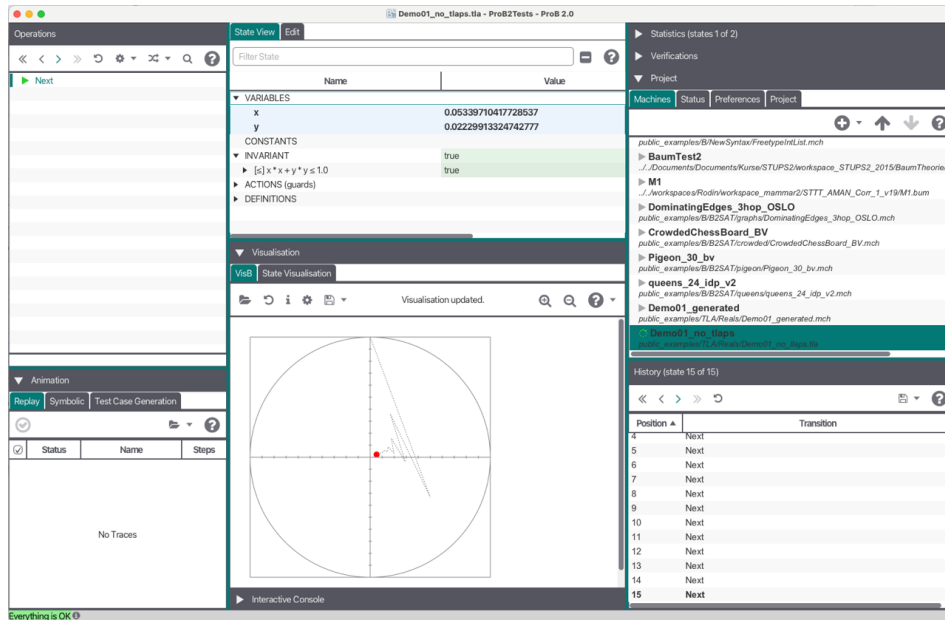


Fig. 2. Animating and Visualising the TLA⁺ model from [1] with Reals in ProB2-UI

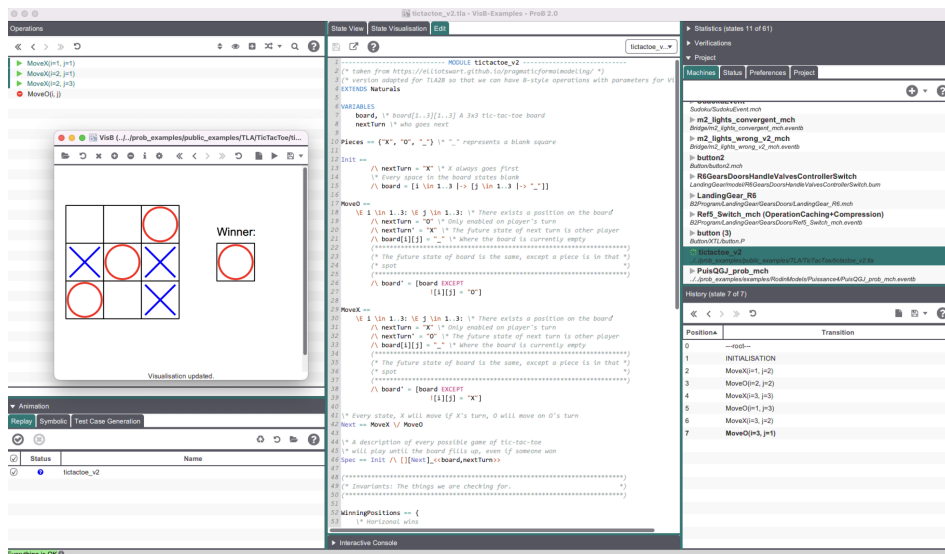


Fig. 3. Animating and Visualising a TLA⁺ model for Tic-Tac-Toe in ProB2-UI