Formal Verification 2023-24: Practical Exercise 1

Model Checking with NuSMV & nuXmv

1 Getting Started

This practical exercise can be undertaken either with NuSMV or nuXmv. The instructions are written referring to the NuSMV tool and documentation. The nuXmv tool should work the same and all NuSMV documentation has been incorporated into the current nuXmv documentation.

For instructions on obtaining and using NuSMV or nuXmv, see the FV OpenCourse page *Getting started with NuSMV & nuXmv*. Also refer to the lecture on NuSMV and the associated examples.

2 LTL Exercise

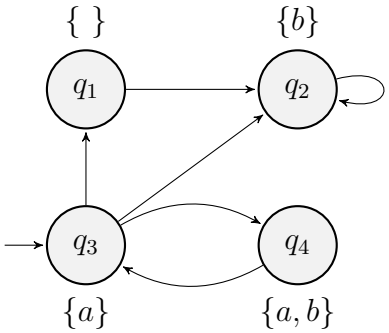

Figure 1: Model for Q1

Create a NuSMV model for the system shown in Fig 1. For each of the LTL formulas ϕ below,

1. $\mathbf{G}\,(\neg a \Rightarrow \mathbf{X}\,b)$
2. $a\,\mathbf{U}\,b$
3. $a\,\mathbf{W}\,b$
4. $\mathbf{X}\,(a \wedge b) \wedge \mathbf{F}\,(\neg a \wedge \neg b)$
5. $\mathbf{F}\,(\mathbf{G}\,b \wedge \mathbf{F}^{-}\,(\neg a \wedge \neg b))$

use NuSMV to determine whether the formula ϕ is valid. For the last two formulas, also persuade NuSMV to exhibit some path which satisfies ϕ.

Hints:

- It's simplest to create a NuSMV model of the state machine that uses 1 state variable with 4 values, one for each of the states of the state machine. Then use `DEFINE` assignments to specify in which states the atomic propositions 'a' and 'b' are true. An alternative approach that is less straightforward to code is to introduce 2 boolean-valued state variables, one for 'a', one for 'b'.
- For (ii), consider what NuSMV does if you direct it to try proving $\neg\phi$.

Check that the answers you get with NuSMV correspond to your own understanding of the model and the formulas. In particular, you should understand why both ϕ and $\neg\phi$ can both be false.

3 CTL Exercise

Use NuSMV to check whether the following CTL formula hold in the model described above.

1. $\mathbf{EG}\, a$
2. $\mathbf{AG}\, \mathbf{AF}\, b$
3. $\mathbf{EF}\, (\neg a \wedge \neg b \wedge \mathbf{AX}\, \mathbf{AG}\, b)$

Again, check that the answers you get with NuSMV correspond to your own understanding of the model and the formulas.

Paul Jackson, 2nd October 2023