Assignment 7
Time Flies

15-414: Bug Catching: Automated Program Verification

Due Friday, December 5, 2025
50 pts

This assignment is due on the above date and it must be submitted electronically on Gradescope. Please carefully read the policies on collaboration and credit on the course web pages at http://www.cs.cmu.edu/~15414/assignments.html.

What To Hand In

You should hand in the following files on Gradescope:

- Submit a PDF containing your answers to the written questions to Assignment 7 (Written). You may use the file `asst7.tex` as a template and submit `asst7.pdf`.

Using LaTeX

We prefer the answer to your written questions to be typeset in LaTeX, but as long as you hand in a readable PDF with your solutions it is not a requirement. We package the assignment source `asst7.tex` with handout to get you started on this.

1 Computation Tree Logic

Task 1 (15 pts). Draw a Kripke structure that satisfies the formula $\mathbf{A}[a\,\mathbf{U}\,\mathbf{AF}\,b] \land \mathbf{EX}\,\neg b$.

Task 2 (15 pts). For each state in your answer to Task 1, label which of the formulas $\mathbf{AF}\,b$, $\mathbf{EX}\,\neg b$, and $\mathbf{A}[a\,\mathbf{U}\,\mathbf{AF}\,b]$ are satisfied. You may refer to them as P, Q, and R, respectively.

2 Temporal distinctions

Task 3 (10 pts). Show that the following pair of CTL and LTL formulas are not equivalent:

$$\mathbf{AF}(a \land \mathbf{AX}a) \qquad \Diamond(a \land \mathbf{X}\,a)$$

To do so, write down a computation structure that satisfies one but not the other. Show that this is the case by providing a counterexample path for the non-statisfied formula, and explaining why the other is modeled by your system.

3 Strange Computations

Task 4 (10 pts). Recall that a computation structure $K = (W, W_0, \curvearrowright, v)$ with initial states $W_0 \subseteq W$ satisfies a CTL formula P if and only if each initial state $s \in W_0$ satisfies P:

$$K \models P \text{ if and only if for all } s_0 \in W_0 . s_0 \models P$$

This definition has a strange property, where it is possible that a given structure K there exists a formula P where $K \not\models P$ and $K \not\models \neg P$. Find a CTL formula and transition system for which this is the case. *Hint:* Strive for simplicity. There are many correct answers to this problem, and some of them are very simple. Start by thinking of very simple formulas, and then try to find a small computation structure over which this is true.