Final

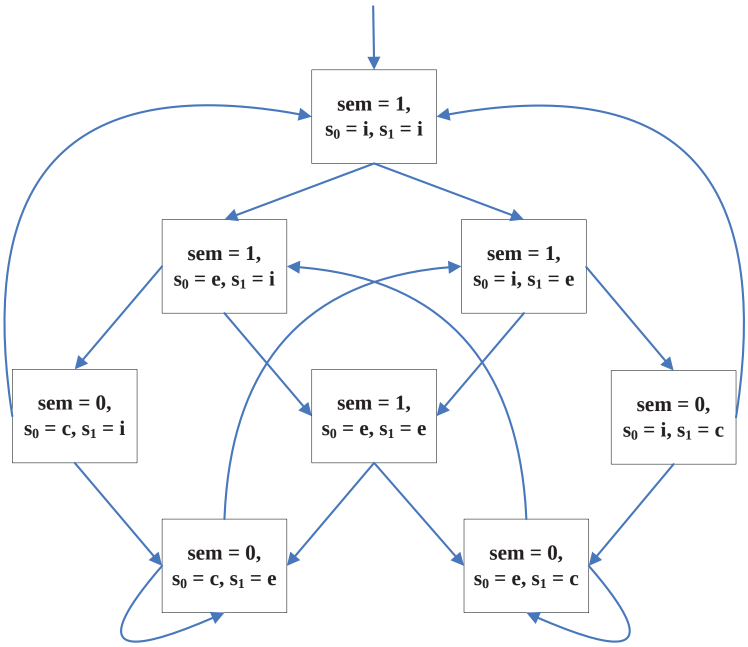
Note

This is an open-book exam. You may consult any books, papers, or notes, but discussion with other students is strictly forbidden.

Problems

There are ten problems/subproblems in total. Please solve eight of them. Two of them will account for 20 points each, while others 10 points each. Please indicate on your exam paper which two problems you wish to receive the 20-points weight.

1. Consider a system with two processes that repeatedly attempt to enter the critical section via the arbitration of a binary semaphore. This system may be modeled as the following Kripke structure.



   (a) Specify the system as NuSMV modules.

   (b) Check if the system satisfies the CTL formula $\mathbf{AG}((s_1 = e) \rightarrow \mathbf{AF}(s_1 = c))$. (Using the procedures in [CGP; Chapter 4.1].) If the formula is not satisfied, what fairness constraint should be added so that the formula will be satisfied?

   (c) Use the symbolic CTL model checking algorithm in [CGP; Chapter 6] to compute the states that satisfy the CTL formula $\mathbf{EF}(\mathbf{AF}(s_0 = c \vee s_1 = e))$.

(d) Use the simple on-the-fly translation algorithm in [CGP; Chapter 9] to construct a generalized Büchi automaton from the LTL formula $\mathbf{G}((s_0 = e) \rightarrow \mathbf{F}(s_0 = c))$.

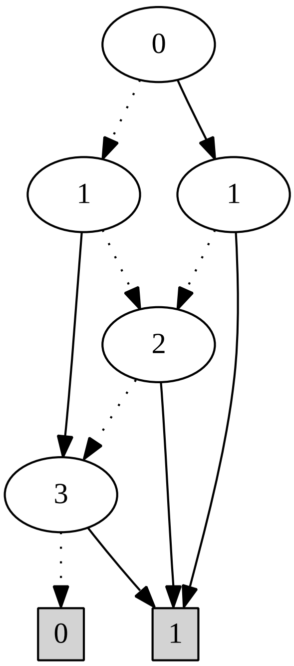
(e) Construct a product of the Kripke structure and the generalized Büchi automaton in 1d.

(f) Use the algorithm in [CGP; Chapter 6.7] to check if the system satisfies the LTL formula in 1d.

(g) Encode the bounded model checking problem of checking the LTL formula $(sem = 1)\,\mathcal{U}\,(s_0 = c)$ against the system within two steps as a Boolean formula.

(h) Consider an abstraction of the system where we only distinguish whether a process is in the critical section or not. Define the abstraction function and draw a state diagram of the abstract system. Does the abstract system satisfy the ACTL formula $\mathbf{AG}(\neg(s_0 = c) \vee \neg(s_1 = c))$? What can be concluded for the original system? Briefly explain the theory that allows you to draw the conclusion.

2. Below is a binary decision diagram (BDD) where a true branch is represented by a solid line and a false branch by a dotted line. Please draw an equivalent BDD in canonical form with the variable ordering 3, 2, 1, 0.



3. Check the satisfiability of $(\bar{a} \vee b) \wedge (\bar{a} \vee \bar{b} \vee c) \wedge (a \vee d) \wedge (\bar{c} \vee \bar{d})$ with the DPLL algorithm.