Final

Note

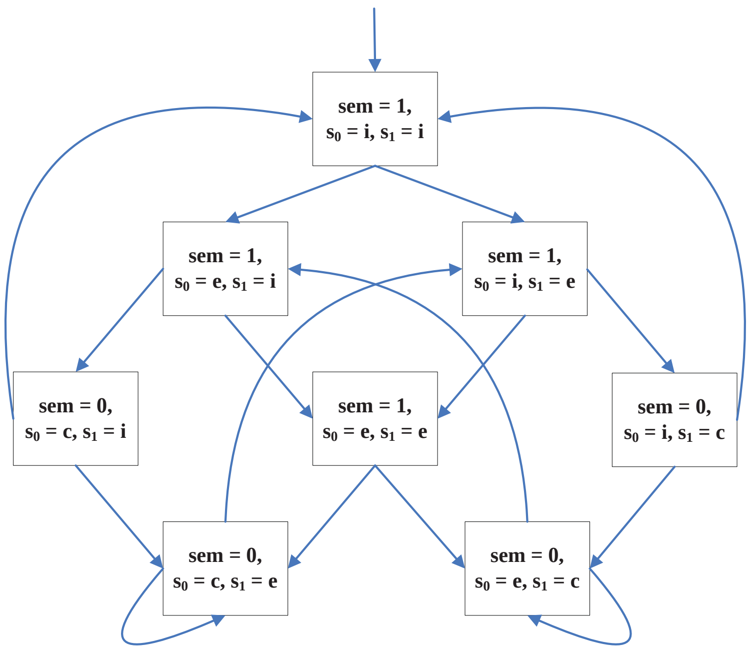
This is an open-book exam. You may consult any books, papers, or notes, but discussion with other students is strictly forbidden.

Problems

Each problem/subproblem accounts for 10 points, unless otherwise marked.

1. Draw a BDD for the boolean function $(a \vee \bar{b}) \wedge (a \vee b \vee c) \wedge (\bar{a} \vee d) \wedge (\bar{c} \vee \bar{d})$ with the variable ordering: a, b, c, d.

2. 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) Check if the system satisfies the CTL formula $\mathbf{AG}((s_0 = e) \rightarrow \mathbf{AF}(s_0 = c))$. (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?

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

(c) (20 points) 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.

3. Consider a Büchi automaton $B = (\Sigma, Q, \Delta, q_0, F)$, where $\Delta \subseteq Q \times \Sigma \times Q$ and $F \subseteq Q$. We define a binary (or transition) relation *post* on Q such that $(q, q') \in \mathit{post}$ iff $(q, a, q') \in \Delta$. Let *pre* be the inverse of *post*. Please find a suitable μ-calculus expression for each of the following sets of states:

   (a) (5 points) the set of states that are reachable from q_0 (by following the *post* relation and consuming the prefix of some input word)

   (b) (10 points) the set of states that are in some nontrivial strongly connected component containing a state in F

   (c) (5 points) the set of states from which the set in 3b can be reached

4. (20 points) Apply the L^* algorithm to learn the regular language $(a + bb)^*$. Show the contents of the observation table every time when it becomes closed and also the corresponding candidate automaton posed in the conjecture query. It is up to you to decide the counterexample returned from a conjecture query.

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