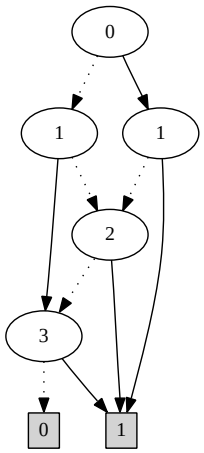
Homework Assignment #4

Note

This assignment is due 2:20PM Wednesday, October 30, 2019. Please write or type your answers on A4 (or similar size) paper. Late submission will be penalized by 20% for each working day overdue. You may discuss the problems with others, but copying answers is strictly forbidden.

Problems

1. (40 points) 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.



   (a) Recover *in a systematic way* the boolean function represented by the BDD; use x_0, x_1, etc. to name the boolean variables.

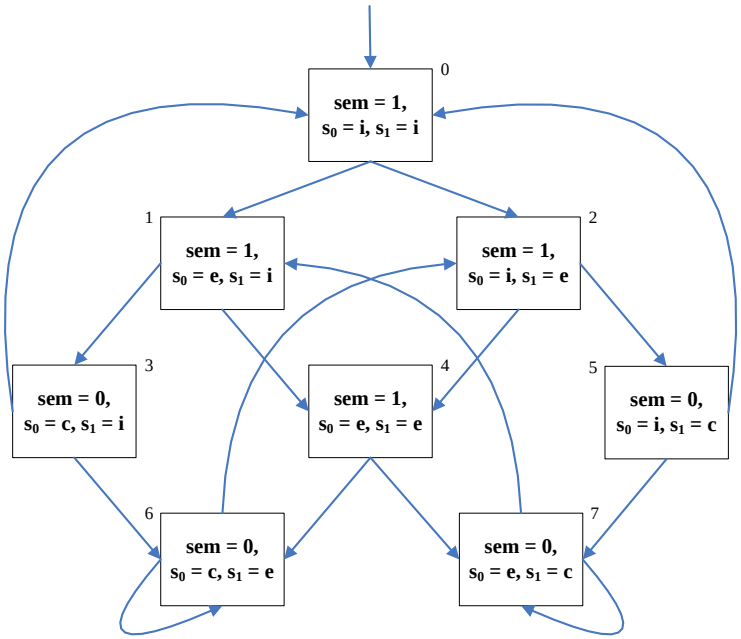
   (b) Draw a BDD (in canonical form) for the same function but with a different variable ordering: 1, 2, 3, 0.

2. (40 points) Consider symbolic model checking of CTL on finite Kripke structures. Prove that, for any CTL formula f, the following statements hold:

   (a) The set of states satisfying $\mathbf{AF}f$ is the least fixpoint of the function $\tau(Z) = f \vee \mathbf{AX}Z$.

   (b) The set of states satisfying $\mathbf{AG}f$ is the greatest fixpoint of the function $\tau(Z) = f \wedge \mathbf{AX}Z$.

3. (20 points) Consider a system with two processes (0 and 1) 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.



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