# EDA 導論 (Introduction to EDA)

*94 學年下學期電機系選修課程*

Homework #3 Simulation and verification (Due: June 6, 2006)

Department:_____ Grade:_____

Id:_____ Name:_____

1. (a) The Boolean difference 'd' of two Boolean functions 'f' and 'g' is defined as "d = 1 iff $((f = 1 \wedge g = 0) \vee (f = 0 \wedge g = 1))$". In other words, "$d = f \oplus g$", where '$\oplus$' is the "exclusive-OR" operator. If we define the operator '–' as the Boolean difference, that is, "$d = f - g$", prove that "$(f - g) \cdot h = (f \cdot h - g \cdot h)$", where '$\cdot$' is the AND operator. (5 pts)

   (b) Prove that "$f - (g - h) = (f - g) - h$". (2 pts)

   (c) Given a Boolean function f, prove that f' = 1 – f, where f' is the inversion of f. (3 pts)

   (d) Let $f_x$ and $f_{x'}$ be the positive and negative cofactors of a Boolean function f, and $f_d$ is the Boolean difference function of $f_x$ and $f_{x'}$. Prove that "$f = f_{x'} - x \cdot f_d$". (5 pts)

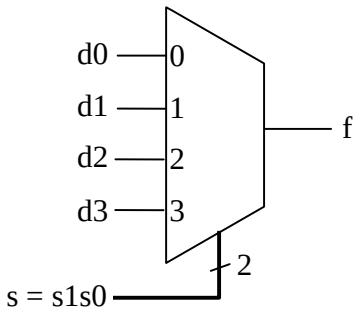
2. Check whether the following Boolean function f(w, x, y, z) is the tautology. If not, show the counter-example:

| w | x | y | z | f |
|---|---|---|---|---|
| 1 | 1 | 0 | - | 1 |
| 1 | – | 0 | 1 | 1 |
| 1 | - | - | - | 1 |
| - | 1 | – | 1 | 1 |
| 0 | 1 | 1 | - | 1 |
| 0 | 0 | - | - | 1 |
| 0 | 0 | 1 | 0 | 1 |

   (a) Use BDD to build the above function. First, build the cubes row by row, and then OR them together. (15 pts)

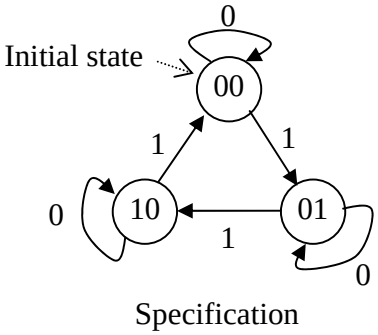
   (b) Convert the above function to CNF. Solve f = 0. (10 pts)

3. Given a multiplexer as shown below:

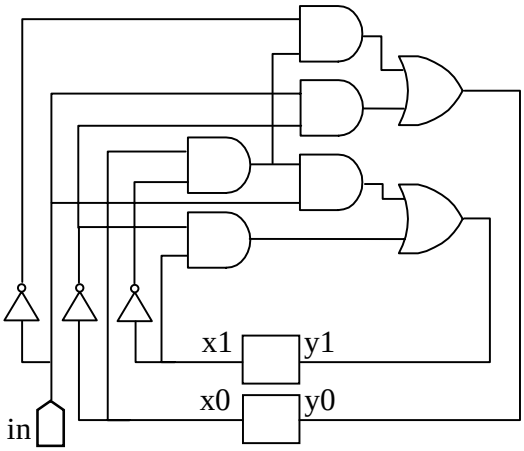



s is a two-bit select signal (s1 s0), and f = di if s = i, for i = 0 ~ 3. Write the CNF for the multiplexer by variables d0, d1, d2, d3, s1, s0 and f. (10 pts)

4. For the finite state machine specification in the lecture note (as copied on the left below), suppose we have the implementation as shown on the right:




Specification




Implementation

(a) Use input "in" as the symbolic variable, perform symbolic simulation to derive the FSM of the implementation. Show the difference between the implementation and specification. (10 pts)

(b) Build the transition relation BDD "TR(y1, y0, x1, x0)" of the implementation (Hint: build the BDD for the combinational part of the circuit first, and then perform existential quantification on the input variable "in"). (10 pts)

(c) Use BDD to perform state reachability analysis on the circuit. Derive the reachable states (represented in BDDs) in time 1, 2, 3,...etc, until fixed point. Show that some illegal state is reached. (10 pts)

(d) Represent the constraints of the combinational part "C(in, x1, x0, y1, y0)" in CNF. Let "F(y1, y0) = y1 · y0" be the condition for the illegal state (11). Use BMC to check whether F can be triggered from the initial state (00). (10 pts)

(e) Compare the three methods above, (i) Symbolic Simulation, (ii) BDD, and (iii) SAT-based BMC. Consider the general cases when the number of input variables, the number of state variables, and the combinational cone can be large. What do you expect the performance of the three methods, when implemented as computer programs, will be? Compare in terms of CPU time and memory. (10 pts)