CIS 540 Spring 2015: Preparing for Midterm Exam

Midterm exam will be held on Wednesday, March 4, 10.30am – 11.50am in Moore 212. The midterm will be out of 100 pts accounting 20% of the overall grade. Midterm is open book: you can consult the textbook and your own personal notes during the exam. The topics for the mid-term are Chapters 2, 3, and 4 of the textbook. You can skip Section 3.3 and the second half of Section 3.4.3 (implementation and operations on ROBDDs).

Homeworks 1, 2, and 3 should give you an idea of problems. **Midterm review session** is scheduled for Monday, March 2, 4.30pm in Room 3C4 of DRLB. Attached is the mid-term exam from 2014.
CIS 540 Spring 2014: Midterm, March 5, 10.30–11.50am

You are allowed to consult your class notes and class handouts.

1. Consider the synchronous reactive component shown in the figure below. List all the possible reactions of the component. List all the await-dependencies among input/output variables. Is the component deterministic? Is the component input-enabled?

```
bool x  
A : u ↦→ y   
  (y := u)  
  
bool u := 0  
A : x, u ↦→ u, z  
  (z := choose(x, u); 
   u := x)  

bool y  
```

2. Consider the Boolean formula

\[(x \lor y) \land (\neg x \lor z) \land (\neg y \lor \neg z).\]

Draw the ROBDD for this formula with respect to the variable ordering \(x < y < z\).

3. Consider the synchronous component shown as an extended state machine in the figure below:  

```
x := x + 1  
int x := 0  
off  
  x := x + 1  
op  
  x := x - 1  
```

Consider the property \(\varphi\) given by \(x \geq 0\). Show that \(\varphi\) is not an inductive invariant of the system. Find a formula \(\psi\) such that \(\psi\) is stronger than \(\varphi\) and is an inductive invariant. Prove your answer.

4. Consider a transition system \(T\) with two integer variables \(x\) and \(y\). The transitions of the system correspond to executing the statement:

\[\text{if} \ (x < y) \ \text{then} \ x := x + y \ \text{else} \ y := y + 1\]

(a) Write the transition formula over the variables \(x, y, x',\) and \(y'\) that captures the transition relation of the system.

(b) Consider a region \(A\) of the above transition system described by the formula \(0 \leq x \leq 5\). Compute the formula describing the post-image of \(A\).

5. Consider an asynchronous process \(P\) with two variables \(x\) and \(y\), both of type \texttt{nat}, with \(x\) initialized to 0 and \(y\) initialized to 1. The behavior of the process is described by two tasks. The task \(A_1\) has the guard condition \(x < y\) and the update code \(x := x + 1\). The task \(A_2\) is
always enabled, and its update code is \( y := x + y \). Answer each of the questions below with a brief justification. When adding fairness assumptions, clearly specify whether you are using strong fairness, or weak fairness, and for which task.

(a) Is it guaranteed that the value of \( x \) eventually exceeds 5? If not, is there a suitable fairness assumption for the two tasks under which this guarantee holds?

(b) Is it guaranteed that the value of \( y \) eventually exceeds 5? If not, is there a suitable fairness assumption for the two tasks under which this guarantee holds?

(c) Is it guaranteed that at some step in the execution the values of \( x \) and \( y \) become equal? If not, is there a suitable fairness assumption for the two tasks under which this guarantee holds?

6. Consider the following solution to the two-process consensus problem in the asynchronous model. The processes use a shared atomic register \( x \) and a shared test-and-set register \( y \). The possible values for both the registers are 0 and 1, and both are initialized to 0. Each process executes the following sequence of steps:

(a) Execute a test-and-set operation on the register \( y \).

(b) If step (a) returns 0, then write its own initial preference to the register \( x \), and decide on this value.

(c) If step (a) returns 1, then read the register \( x \), and decide on the value read.

Consider the three requirements for the consensus problem: validity, agreement, and wait-freedom. Which of these requirements are satisfied by this protocol? Justify your answer.