

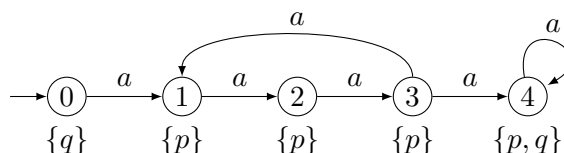
## Homework Assignment #5

### Note

This assignment is due 2:20PM Wednesday, November 13, 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

- (40 points) Consider an extended Kripke structure  $M$  as shown below:



Show the iterative valuations and the final result for the following fixpoints in  $\mu$ -calculus:

- $\mu Q.(q \vee (p \wedge \langle a \rangle Q))$
  - $\mu Q_1.(\nu Q_2.(p \wedge \langle a \rangle Q_2) \vee (q \wedge \langle a \rangle Q_1))$
- (60 points) The following is a NuSMV model for two asynchronous processes that use a semaphore to achieve mutual exclusion.

```

MODULE main
VAR
  semaphore : boolean;
  proc1      : process user(semaphore);
  proc2      : process user(semaphore);
ASSIGN
  init(semaphore) := 0;

MODULE user(semaphore)
VAR
  state : {idle, entering, critical, exiting};
ASSIGN
  init(state) := idle;

```

```

next(state) :=
  case
    state = idle           : {idle, entering};
    state = entering & !semaphore : critical;
    state = critical       : {critical, exiting};
    state = exiting        : idle;
    1                       : state;
  esac;
next(semaphore) :=
  case
    state = entering : 1;
    state = exiting  : 0;
    1                 : semaphore;
  esac;

```

- (a) Write all the necessary boolean formulae that specify the main module as a Kripke structure; you may define shorter substitute names for the variables to save space.
- (b) Please draw BDD diagrams (as small as possible) for the formulae in 2a.