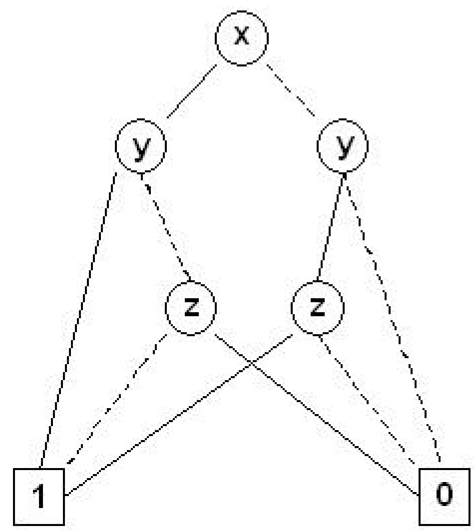
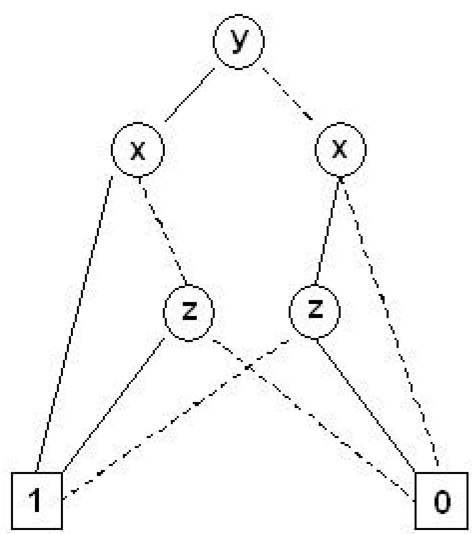
CSEP590 – Modeling Checking and Software Verification
Summer 2003
Solution Set 4

1. Binary decision diagram for f(x,y,z) = (!x+y+!z)•(x+!y+z)•(x+y)
Solutions:

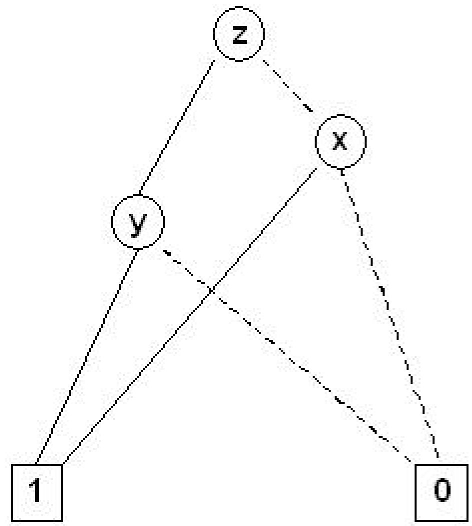
a) [x,y,z]



b) [y,x,z]



c) [y,x,z]



d) With 6 edges, the reduced OBDD with orderings [z,x,y] and [z,y,x] have the minimal number of edges.

2. SMV warm-up with semaphore.
See the SMV paper for what “semaphore.smv” should look like. The added spec is:

```
        AG (proc1.state = entering -> AF proc1.state = critical)
```

The spec is not satisfied and SMV provides a counterexample where proc1 wants to enter the critical section (state = entering), proc2 goes into a loop where it repeatedly enters the critical section and returns to idle, while proc1 only executes while proc2 is in its critical section.

3. Elevator modeling
Solutions:

a) Elevator model:

```
-- CSE 590 HW4
MODULE main
VAR
        -- cabin state variable
        cabin : 0 .. 3;
        -- direction variable
        dir : {up, down};
        -- array of requests
        request : array 0 .. 3 of boolean;
ASSIGN
        next(cabin) :=
                case
                        dir = up & cabin < 3 : cabin + 1; -- up
                        dir = down & cabin > 0 : cabin - 1; -- down
                        1 : cabin; -- stuck
                esac;
        next(dir) :=
```

```
        case
            dir = up & next(cabin) = 3 : down; -- switch to down
            dir = down & next(cabin) = 0 : up; -- switch to up
            1 : dir; -- continue
        esac;
    next(request[0]) :=
        case
            next(cabin) = 0 : 0; -- satisfied
            request[0] : 1;      -- continue
            1 : {0,1};           -- new request?
        esac;
    next(request[1]) :=
        case
            next(cabin) = 1 : 0; -- satisfied
            request[1] : 1;      -- continue
            1 : {0,1};           -- new request?
        esac;
    next(request[2]) :=
        case
            next(cabin) = 2 : 0; -- satisfied
            request[2] : 1;      -- continue
            1 : {0,1};           -- new request?
        esac;
    next(request[3]) :=
        case
            next(cabin) = 3 : 0; -- satisfied
            request[3] : 1;      -- continue
            1 : {0,1};           -- new request?
        esac;

    init(cabin) := 0;
    init(dir) := up;
    init(request[0]) := 0;
    init(request[1]) := 0;
    init(request[2]) := 0;
    init(request[3]) := 0;
SPEC
    -- spec 1: no deadlock
    AG EX 1

    -- spec 2: all requests are eventually satisfied?
    AG(AF!request[0] & AF!request[1] & AF!request[2] & AF!request[3])

    -- spec 3: requests are eventually all satisfied
    AG AF (!request[0] & !request[1] & !request[2] & !request[3])
```

b) Results of running with specs

1) Satisfied
2) Satisfied
3) Not satisfied
   The counterexample will show that there are paths where we can always have an outstanding request, this is easy to see.