CS402/615 Take-home Quiz 1

Max marks: 70 **Time: 1 week**

- *Be brief, complete and stick to what has been asked.*
- *Unless asked for explicitly, you may cite results/proofs covered in class without reproducing them.*
- ***If you need to make any assumptions, state them clearly.***
- ***Do not copy solutions from others. Penalty for offenders: FR grade.***

1. Consider the finite state transducer shown in Figure 1, where the input and output alphabets are both $\Sigma = \{a, b\}$. Let $R \subseteq \Sigma^* \times \Sigma^*$ denote the regular transduction relation implemented by the transducer.

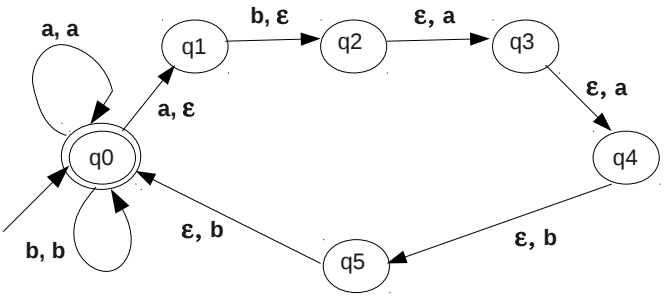

Figure 1: A finite state transducer

   (a) *[10 marks]* Construct a finite state transducer for the transduction relation $R^2 = R \circ R$ using the method described in class (and also explained in the reference material).

   (b) *[10 marks]* Do you think the transduction relation R^* is regular? Justify your answer adequately.

2. Consider function `foo` given below. Note that all variables in `foo` are of pointer (to `myStructType`) type.

```
#define nil NULL

typedef struct myStruct {
  struct myStruct *n;
} myStructType;
```

```
void foo(myStructType *p, myStructType *q)
{
L1:  while ((p != nil) || (q != nil)) do {
L2:   p = q->n;
L3:   q = p->n;
L4:  }
L5:  // end of function
}
```

Suppose none of `p`, `q` or `p->n` are `nil`, but `q->n` and `p->n->n` are `nil` when `foo` is invoked. We wish to analyze the behaviour of `foo` using the automata based technique discussed in class.

Since there are only two program variables (`p` and `q`), we need at most three unique names for heap-shared nodes. Let these be $\{M_0, M_1, M_2\}$.

(a) *[5 marks]* Recall the word-based state encoding scheme discussed in class (and explained in the reference material). Give a word over the alphabet $\{C_N, C_0, C_1, C_2, M_0, M_1, M_2, L1, L2, L3, L4, p, q, .n, \bot, \top \mid \}$ that describes the state of the program when function `foo` is invoked. You may assume the following order (ranking) of names of program variables and heap-shared nodes: $p \prec q \prec M_0 \prec M_1 \prec M_2$

(b) *[5 marks]* Using the same encoding scheme, give a word that describes the state of the program after the statement at `L2` is executed in the first iteration of the loop.

(c) *[20 marks]* Give a finite state transducer implementing the operational semantics of the program statement at location `L1`. Thus, your transducer should be such that if w is a word encoding the state of the program before execution of the statement at `L1`, and if R is the transduction relation of your transducer, then $R(w)$ should be the word encoding the state of the program immediately after execution of `L1`.