Homework # 5 (version 2)

Due Wed. May 14, 2016

There is no structure for this version of homework 5. You may submit ideas on any research topic, directly or tangentially related to the course, for credit. Your submission will be evaluated, entirely subjectively, by Marc. Here is a list of potential topics, but you are encouraged to offer ideas on any topic that piqued your interest throughout the course. Keep your your submissions concise and as coherent as possible.

Biology Part of Course

1. Implement the idea of cycle and event leaping for stochastic simulation. Demonstrate that the simulation algorithm runs faster on certain test cases.

2. Many of the ideas for molecular computation that we discussed were based on *discrete quantities* of molecules (i.e., integer values). Generalize these ideas to *molecular concentrations* (so real values). For instance, describe how we can increment or decrement a concentration by one unit, where the unit is a reference concentration of some type. Note the challenge: absence indicators don't work when it comes to concentrations. Molecular concentrations never decrease to zero because reactions that consume types slow down as the concentrations drop.

3. Bridge between the concepts that we discussed for computing on stochastic bit streams and computing with molecular reactions.

   Begin with the idea from Homework 3. Consider the following representation of real numbers. A real value x between 0 and 1 is represented as $\frac{x_1}{x_1+x_2}$, where x_1 and x_2 are positive integers. Construct a set of chemical reactions that operates on real numbers represented this way, producing a resulting also represented this way.

Computation Part of Course

1. Devise a way to "compact down" conditional permutation programs. So, given a sequence such as this:

```
{x: E, *}
{z: D, *}
{x: E', *}
{z: D'C, C}
{x: *, D}
{y: *, C}
{x: *, D'}
{y: B, C'B}
{x: D, *}
{z: E, *}
{x: D', *}
{z: E'C', C'}
{x: *, C}
{y: *, D}
{x: *, C'}
{y: B', D'B'}
```

   Find a way to compact it down to fewer lines. A first step might be to figure out a way to swap lines. Note that, if adjacent lines reference the same variables, these lines can be combined into a single line by multiplying together the corresponding permutations.

2. Generalize the idea of distributed counting to a distributed finite state machine.

Circuits Part of Course

1. In lieu of stochastic bit streams, find an encoding of numbers that isn't probabilistic and yet still allows two numbers to be multiplied with a single AND gate.

2. Suggest a way synthesize switching circuits according to the *multiple terminal model*. A function F_{ab} is 1 if there is a closed path between terminals a and b, and 0 otherwise. With multiple circuit terminals, $a, b, c, d, \ldots$, different functions can be implement between *pairs* of terminals. If I give you a collection of functions, how can you implement them, efficiently, with such a circuit.

3. Find a single function (as opposed to a collection of functions) that can be implemented with fewer gates if feedback is allowed than if it is not.