Homework Assignment 2
Total Points: 50

Professor Karem A. Sakallah

EECS 598-002: Formal Verification of Hardware & Software Systems

Assigned: January 23, 2024
Due: January 30, 2024

Guidelines

- The College of Engineering Honor Code applies to all work in this course.
- The due date is firm. Follow submission instructions (at the end).

Objectives

This assignment involves the use of the Colorado University Decision Diagram package (CUDD) through the repyCUDD Python wrapper.

1 [Reasoning with BDDs] (20 Points)

Multi-level functions f_1 and f_2 below are proposed as two candidate implementations of the 3-input XOR function $f = a \oplus b \oplus c$. Construct a suitable multi-rooted BDD to determine which of these two functions is a correct implementation of f.

$f_1 = (a+b)(as+bt) + cst$
$s = (ac(a+b))' = (ac)'$
$t = (bc(a+b))' = (bc)'$

$f_2 = u(av+bw) + cvw$
$u = (ab)'$
$v = (acu)'$
$w = (bcu)'$

2 [Symbolic Graph Traversal using BDDs] (30 Points)

The edge relation E of a directed graph G is defined by the following Boolean function:

$$\begin{aligned} E(s_2, s_1, s_0, t_2, t_1, t_0) =& s_2' s_1' s_0' t_2' t_0 + s_2' s_1' s_0 t_2' + s_1 s_0' t_1 t_0 \\ &+ s_2 s_1' t_2' t_1 t_0 + s_2 s_1' s_0 t_2 t_0' + s_2 s_1' s_0' t_2 t_1' t_0 \end{aligned}$$

where $\mathbf{s} = (s_2 s_1 s_0)$ and $\mathbf{t} = (t_2 t_1 t_0)$ are Boolean vectors that encode the source and target vertices of the graph edges.

a. (5 Points) Draw G clearly labeling each of its vertices with an appropriate 3-bit code. You can draw the graph by hand or use the free drawing app https://app.diagrams.net/ for a more professional result. Try to minimize the number of edge crossings.

b. (5 Points) Construct the BDD for E.

c. (20 Points) Construct BDDs for the set of vertices in G that are reachable from the vertex set characterized by the Boolean functions $C_1(\mathbf{s}) = s_2'$ and $C_2(\mathbf{s}) = s_0(s_2 + s_1)$. Express the answers both symbolically and as sets of explicit graph vertices.

Submission Instructions

1. Create a directory named <your uniquname>_hw2
2. Place in the directory the following Python files corresponding to each of the problems or problem parts:
   - Problem 1: h2p1.py
   - Problem 2: h2p2b.py, h2p2c.py
3. Execute your Python files to produce similarly named dot files.
4. Use dot to generate similarly-named pdf files.
5. Use your favorite document editor to write the answers to problem 2.c.
6. Generate a single pdf file named <your uniquename>_hw2.pdf that contains the graph drawing for problem 2.a and the written answers to problem 2.c.
7. Zip the entire directory using "zip -r <your uniquename>_hw2.zip <your uniquname>_hw2" and upload to Canvas.