CS 477: Formal Methods , Spring 2008
Problem Set 1 (due Thursday, February 14th, 4pm)

Turn in your homework at Elaine Wilson's office (3229 Siebel).

1. Modeling using symbolic logic $(5+10+3+10)$

   The cannibals-missionary problem:
   Three cannibals and three missionaries find themselves on a bank of a river that they wish to cross. There's one boat (on their side of the bank) which they can use, but it can carry only two people at a time. Also, cannibals, due to constraints of their traditional beliefs, feel compelled to eat up any missionaries on any bank if they outnumber the number of missionaries on that bank (thankfully the boat is safe because of surveillance cameras).

   (a) Model the dynamics of the cannibal and missionary movements in a system. Your system must be symbolic Boolean description. State clearly what a *state* is, what the state variables are, and model the initial state. Your transitions should model any possible movement of the cannibals and missionaries, except that it will get stuck in configurations where the number of missionaries are outnumbered by the number of cannibals in either bank.

   (b) Model your system in NuSMV and check if there is a solution. Model the specification of reaching the other bank in CTL and model-check it.

   (c) Let us now try 4 cannibals and 4 missionaries. Does NuSMV report it as being solvable?

   (d) Scale the number of missionaries and cannibals (scaling the number of people allowed if need be) and determine the largest model NuSMV can handle (don't let the system run beyond 5min!).

2. Boolean decision diagrams $(5+5)$

   (a) Let $X = \{x_1, x_2, x_3, y_1, y_2, y_3, z_1, z_2, z_3\}$. Draw the BDD diagram the formula that expresses that $\langle x_1, x_2, x_3 \rangle$ and $\langle y_1, y_2, y_3 \rangle$ seen as binary numbers, add up to $\langle z_1, z_2, z_3 \rangle$ seen as a binary number. The ordering $x_3, y_3, z_3, x_2, y_2, z_2, x_1, y_1, z_1$ is recommended! Try to construct a small (if not minimal) BDD.

   (b) Generalize the above construction to any n-bit adder. Your BDD must be of size *linear* in n.