Due: Wed Dec. 2, 2010

Problems:

For some of the problems below you will need an ILP solver. A popular version which is completely free is lp_solve and it is available from http://sourceforge.net. I have placed linux and windows versions of the solve on the web site along with documentation. The default solver runs via a command-line although there is a simple IDE version available for windows. To get started, there is a short intro in the documentation or you can go to the sourceforge web site. (Note the version on the 253 site is 5.5.0.13 which is slightly older than 5.5.2 -- the current version). Since the files are already compiled, you only need to unpack it to use lp_solve. (note, by default, the local directory is not in your path in linux -- to prevent trojans. Thus you need to type: ./lp_solve to start the program unless you make a directory, put the executable and libraries there and add the directory to your path.)

1. Using the ILP package, find an optimal schedule for the following problem:

   operations: {+, -} take 1 cycle on an ALU, * takes 2 cycles on a MPY

   x3 = x1*c1+x2*c2;
   x4 = c3*x3-c4;
   x5 = x1*c4+x3*c5-x4;
   out1 = x5*x3;
   out2 = x3-c6*x1;

   Given 2 MPY and 1 ALU find a Hu lower bound for the minimum latency schedule. Do not modify the operation dependencies given in the problem or eliminate common sub-expressions!

2. Find an exact solution using lp_solve.

3. Describe how to model a 2-stage pipeline multiplier so that it could be used with the ILP program above. (The behavior is that such a multiplier accepts 2 inputs each cycle, but takes 2 cycles to deliver the output. The executions are overlapped so that outputs can happen each cycle, each from inputs read in two cycles earlier on the inputs.)

   How long does the schedule from problem 1 take given 1 ALU and 2 (2-stage pipelined MPY)?

4. Consider the following Synchronous Data-Flow system:

   A: Reads 2 packets from B, 2 from C; Writes 3 packets to D
   B: Reads 1 packet from C; Writes 1 to A
   C: Reads 2 packets from E, 3 Packets from D; Writes 1 packet to A, 1 packet to B
   D: Reads 2 packets from A; Writes 1 packet to C and 1 packet to E
   E: Reads 3 packets from D; Writes 2 Packets to C

   Write the Rate-balance equations for this system. Does the system have a solution? If so, find a minimal register assignment for the links of the system and a repeating schedule.