Introduction to Digital Computers - Spring 1999

Assignment No. 8

Course homepage: http://www.eng.tau.ac.il/~guy/Digital_Computers99/dc_home.html

Firm Deadline: June 23th - before the beginning of the lecture.

Questions:

1. Write DLX instructions for the following program segments:

   (a) Assume that A is an array of 100 elements (size of each element is a word) and that the compiler associates variables g, h, i, j to registers $17 - 20$. Suppose that the array A starts at address $Astart$.

   ```
   LOOP: g = g+A[i];
   i = i+j;
   if (i !=h) goto LOOP;
   ```

   (b) Assume that variables f, g, h, i, j, k correspond to registers $16 - 21$.

   ```
   switch (k) {
      case 0: f = i + j; break;
      case 1: f = g + h; break;
      case 2: f = g - h; break;
      case 3: f = i - j; break;
   }
   ```

2. Design the ALU environment. You may use as a building blocks every circuit that was taught in class (e.g. an adder). The inputs of the ALU environment are:

   (a) S1_bus[31 : 0], S2_bus[31 : 0], IR[2 : 0], IR[28 : 26];

   (b) control signals: Itype (indicating if the instruction's format is I-type), add (indicating that the instruction implies an addition, e.g. in jump instructions), test (active in test&set instructions).

   (c) driver output enable signals: ALUzrDdoe,ALUzcDdoe controlling the output enable drivers that write the signals zr and zc to the D-bus.

   The outputs of the ALU environment are:

   (a) $zc[31 : 0]$ - comparison result, $zr[31 : 0]$ - arithmetic/logical result.

   (b) ovf - indicates if an overflow occurred during addition/subtraction.

   Explain your design, show how the different operations are done by the ALU.

3. Make a list of all the signals between the control and the datapath (C_in, C_out, N_in buses). For each signal, explain its role and specify when it is active (which state of the control or which event in the datapath).

4. Suppose we decide to swap the fields RS2 and RD in R-type instructions. What changes need to be done to the DLX design? Discuss the advantages and disadvantages of such a swapping.

5. Consider the following "multimedia extension" of the instruction set:

`add2u RS1 RS2 RD`

with the meaning:

$$\begin{aligned} \Big[[R_{\langle RD\rangle}[15:0]\Big] &= \Big[R_{\langle RS1\rangle}[15:0]\Big] + \Big[R_{\langle RS2\rangle}[15:0]\Big] \pmod{2^{16}} \\ \Big[R_{\langle RD\rangle}[31:16]\Big] &= \Big[R_{\langle RS1\rangle}[31:16]\Big] + \Big[R_{\langle RS2\rangle}[31:16]\Big] \pmod{2^{16}} \end{aligned}$$

Describe all the required changes needed to implement this additional instruction (changes to datapath environments, control, additional control signals).