CS286: Lecture Note (Lecture #11, September 27, 2023)

The agenda for CS286 lecture #11 (September 27, 2023).

1. Announcements
   - Attendance card
   - Quiz #6 is scheduled on Monday next week (10/2)

2. Exercise #5 on September 18th
   - How much faster are “pipeline processors” compared with “scalar processors”? (whiteboard)

3. Pipeline hazards
   - Data hazards and Control hazards (“Pipeline_Hazards.ppt”)
   - Four types of data hazards (“Four_Data_Hazards.ppt”)
   - Exercise #7 (four data hazards) on September 18th

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**QUESTION #7**

Assume that all the inputs for each instruction must be available by the beginning of the ID phase and the output from each instruction becomes available at the end of the WB phase, find which of the following four datapath architectures can data hazards for each of RAR, RAW, WAR, and WAW?

(a) Scalar processors
(b) Super-scalar processors
(c) Pipeline processors
(d) Super-pipeline processors

<table>
<thead>
<tr>
<th>1st instruction</th>
<th>READ</th>
<th>WRITE</th>
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<tbody>
<tr>
<td><strong>2nd instruction</strong></td>
<td>READ</td>
<td>RAR</td>
</tr>
<tr>
<td>WRITE</td>
<td>WAR</td>
<td>WAW</td>
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Exercise #6 (control hazards) on September 18th

QUESTION #6

Suppose the branch frequencies (as percentage to all the instructions) are as follows:

- Conditional branches: 11%
- Jumps and calls: 4%
- Conditional branches: 55% are taken

We are examining a ten-phase pipeline processor, in which different instructions require different number of processor cycles to complete (as shown below). Assume that each conditional branch requires eight cycles to complete (the decision of a conditional instruction is made available at the end of the eight cycle). Similarly, each unconditional branch requires six cycles to complete (the decision of an unconditional instruction is made available at the end of the sixth cycle). All other instructions require exactly ten cycles to complete.

Questions: Assuming that only the first pipe stage can always be done independent of whether the branches goes and ignoring other pipeline stalls, (a) how much faster would the machine be without any branch hazards? (b) If the pipeline becomes deeper, what would you expect for the speed up? For (a), show all your work.

4. Quiz #6 Question Review (10 minutes)