Homework Chapter 6 Part 2
Computer Organization Spring 2002

Due date: 2:30 PM, Monday, 3/18/02, TA responsible: Y. Abbas

Problem 1 (40 points)

Recall that forwarding can be done from a load to a store that follows immediately and stores the same data that was loaded. This is MEM to MEM stage forwarding.

Consider the pipeline design that is given in the text that performs the forwarding checks in the EX stage for EX to EX and MEM to EX forwarding, e.g., Figure 6.40.

Describe how you would modify that pipeline to add MEM to MEM forwarding for a lw followed by a dependent sw.

1. Describe (in words not logic equations) the conditions that must be met for forwarding to occur.
2. Identify the source of the data in the pipeline that is forwarded and the destination to which it is forwarded.
3. Describe any additional combinational logic or control lines that must be added to the pipeline and be specific about what stage the logic is in and from where it gets its inputs.
4. Describe changes to existing control signal settings (if any) that are required.
5. Describe any additional information that must be added to the pipeline registers (be specific about which registers and what information).
6. Write the logical conditions in a form similar to those in the text on pages 480 and 481.

Problem 2 (40 points)

The forwarding logic that is described in the text and the notes for EX to EX and MEM to EX forwarding is such that the logic is placed in the EX stage of the instruction that consumes the forwarded data.

It is also possible to put the logic in the ID stage. This logic would produce the control signals needed to cause forwarding when the consuming instruction reached the EX stage.

Consider the pipeline design that is given in the text that performs the forwarding checks in the EX stage for EX to EX and MEM to EX forwarding, e.g., Figure 6.40.

Describe how you would modify that pipeline to make decisions for forwarding to the EX stage of a consuming instruction during the ID stage of the consuming instruction. Note that the forwarding still occurs during the EX stage of the consuming instruction. The signals needed to make it happen are produced when the consuming instruction is in its ID stage.

1. Describe (in words not logic equations) the conditions that must be met for forwarding to occur.
2. Identify the sources of the data in the pipeline that is forwarded and the destinations to which it is forwarded.
3. Describe any additional combinational logic or control lines that must be added to the pipeline and be specific about what the logic does and from where it gets its inputs.
4. Describe changes to existing control signal settings (if any) that are required.
5. Describe any additional information that must be added to the pipeline registers (be specific about which registers and what information).
6. Write the logical conditions in a form similar to those in the text on pages 480 and 481.
**Hint:**
The pipeline diagram shows the relationship between the consuming instruction and the three preceding instructions in the code that may have as their destination one of the source registers of the consumer, i.e., they are producers.

<table>
<thead>
<tr>
<th></th>
<th>IF</th>
<th>ID</th>
<th>EX</th>
<th>ME</th>
<th>WB</th>
</tr>
</thead>
<tbody>
<tr>
<td>producer 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>producer 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>producer 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>consumer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Consider this table and decide which of the instructions must be considered when generating the logic for ID stage forwarding decisions and which, if any, do not. Also note the stages in which the producers are when the consumer is in the ID stage and the EX stage. This should help decide where data is located for the decision making and for the actual forwarding.

**Problem 3 (20 points)**

Consider the following code:
```
and $15, $13, $11
addu $4, $2, $7
ori $2, $5, 160
lw $2, 0($2)
lb $5, 0($2)
subu $3, $5, $4
addiu $9, $10, 1
```

1. Identify any dependences in the code. Which, if any, dependences do not cause stalls due to forwarding? Which, if any, dependences cause stalls even with forwarding?

2. Fill in a pipeline diagram like the one given in the hint in problem 2.