

Hazard Lab

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1. Calculated CPI with stalls = 1.6392

Ideal CPI = 1.0

CPI With Stalls Calculation

$\text{CPI} = \text{total number of cycles} / \text{total number of instructions}$

$= (\text{total instructions} + \text{num of 1 cycle stalls} + 2 * \text{num of 2 cycle stalls}) / \text{total instructions}$

$= 1.6392$

$= 63.92\% \text{ slowdown}$

2. Calculated CPI with stalls = 1.4125

CPI With Stalls Calculation

$\text{CPI} = (\text{total instructions} + \text{num of 1 cycle stalls} + 2 * \text{num of 2 cycle stalls}) / \text{total instructions}$

$= 1.4125$

$= 41.25\% \text{ slowdown}$

The two cycle stall was a load to use hazard because it's WX forwarding. The one cycle stall is a normal raw hazard which uses MX forwarding.

3. Calculated CPI with stalls = 1.2037

CPI With Stalls Calculation

$\text{CPI} = (\text{total instructions} + \text{num of 1 cycle stalls} + 2 * \text{num of 2 cycle stalls}) / \text{total instructions}$

$= 1.2037$

$= 20.37\% \text{ slowdown}$

The one cycle stall can be caused by a WAW dependency with 1 interweaved independent instruction or a structural hazard. The two cycle stall is a back to back WAW dependency or 2 or more consecutive memory operations followed by an ALU operation.

Benchmark for Question 1 Explanation

We used the O1 compilation flag. We have two loops, the first loop creates a 2 cycle stall for MAX_2CYCLE iterations. The second loop creates a 1 cycle stall for MAX_1CYCLE iterations.

To calculate 2 cycle stall it would be 2 consecutive dependent instructions. First instruction writes to a register, while the second reads from the same register. Refer to line 53 which points out that variable a is being written to and then read from by the subsequent instruction on line 54. This will cause a RAW hazard that forces the pipeline to stall for 2 cycles. Refer to the comments from line 42 to 48 which has the assembly code clearly showing register 2 having the RAW hazard.

To calculate 1 cycle stall it would be 2 dependent instructions separated by 1 independent instruction. Refer to line 72 which points out that variable h is written to, and then on line 73 an independent instruction is added for padding. The next instruction on line 74 reads from h, and causes a RAW hazard that forces the pipeline to stall for 1 cycle. Refer to the comments from line 62 to 68 which has the assembly code clearly showing register 2 having the RAW hazard.