Wyatt Tack

CPE-333

**Quiz Week 4: Pipelining Problems**

1. How many clock cycles to execute the following 5 instructions With Forwarding

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Clock: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| add x1w x2r x0r | IF | DEC | ALU | DM  fw | WB |  |  |  |  |  |  |  |  |  |  |
| sub x1w x2r x1r |  | IF | DEC | ALU | DM  fw | WB |  |  |  |  |  |  |  |  |  |
| lw x3w 0(x1r) |  |  | IF | DEC | ALU | DM | WB  fw |  |  |  |  |  |  |  |  |
| sw x4r 0(x3r) |  |  |  | IF | DEC | DEC  stall | ALU | DM | WB |  |  |  |  |  |  |
| add x1w x2r x2r |  |  |  |  | IF | IF | DEC | ALU | DM | WB |  |  |  |  |  |

1. The 5 instructions will take 10 clock cycles

2 How many clock cycles to execute the following instructions no forwarding

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Clock: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| beq x1r x2r label | IF | DEC | ALU | DM |  |  |  |  |
| add x1w x2r x3r |  | IF | DEC | ALU | Flush | Flush |  |  |
| sub x1w x2r x4r |  |  | IF | DEC | Flush | Flush |  |  |
| add x5w x6r x7r |  |  |  |  |  |  |  |  |
| label: exit |  |  |  | IF | DEC | ALU | DM | WB |

1. The 5 instructions will take 8 clock cycles

3.a How many clock cycles to execute the following 6 instructions With Forwarding

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Clock: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| addi x1w x0r 3 | IF | DEC | ALU | DM  fw | WB  fw |  |  |  |  |  |  |  |  |  |  |
| addi x2w x1r 2 |  | IF | DEC | ALU | DM | WB |  |  |  |  |  |  |  |  |  |
| lw x3w 0(x1r) |  |  | IF | DEC | ALU | DM | WB  fw |  |  |  |  |  |  |  |  |
| add x2w x2r x3r |  |  |  | IF | DEC | DEC  stall | ALU | DM | WB |  |  |  |  |  |  |
| addi x3w x1r 1 |  |  |  |  | IF | IF | DEC | ALU | DM | WB |  |  |  |  |  |
| sw x0r 0(x7r) |  |  |  |  |  |  | IF | DEC | ALU | DM | WB |  |  |  |  |

1. The 6 instructions will take 11 clock cycles

3.b How many clock cycles to execute the loop without Forwarding, loop executes 100 times

ASSUMING BRANCH PREDICTOR IS PC+4, i.e. wrong 100 times

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Clock: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |  |  |
| label: lw x0w 0(x1r) | IF | DEC | ALU | DM | WB |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| add x3w x2r x0r |  | IF | DEC  stall | DEC  stall | DEC | ALU | DM | WB |  |  |  |  |  |  |  |  |  |  |  |
| sw x3r 0(x1r) |  |  | IF | IF | IF | DEC | DEC | DEC | ALU | DM | WB |  |  |  |  |  |  |  |  |
| addi x1w x1r 4 |  |  |  |  |  | IF | IF | IF | DEC | ALU | DM | WB |  |  |  |  |  |  |  |
| addi x4w x4r -1 |  |  |  |  |  |  |  |  | IF | DEC | ALU | DM | WB |  |  |  |  |  |  |
| bnez x4r label |  |  |  |  |  |  |  |  |  | IF | DEC | DEC | DEC | ALU | DM | WB |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | IF | IF | IF | DEC | ALU | flush | flush |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | IF | DEC | flush | flush |  |  |
| label:… |  |  |  |  |  |  |  |  |  |  |  |  |  |  | IF | DEC | ALU | DM | WB |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Each loop executes every 14ccs. Last loop takes extra 2 to finish WB. = 14\*100+2

1. Code will execute in 1402 clock cycles.