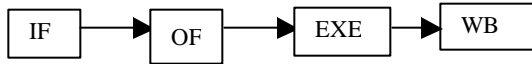


Notes for Feb 23

Pipeline



TRUE DATA DEPENDANCY (Read After Write)

$I_1 - \text{ADD } R_3, R_2, R_1 \quad R_3 \leftarrow R_2 + R_1$   
 $I_2 - \text{SUB } R_4, R_3, 1 \quad R_4 \leftarrow R_3 - 1$

|         |       |       |       |       |       |                                   |
|---------|-------|-------|-------|-------|-------|-----------------------------------|
|         | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ |                                   |
| $I_1$ - | IF    | OF    | EXE   | WB    | ---   |                                   |
| $I_2$ - | --    | IF    | OF    | EXE   | WB    | $\leftarrow R_3$ GETS WRONG VALUE |

STALLING (Data Hazard)

|         |       |       |       |       |       |       |       |
|---------|-------|-------|-------|-------|-------|-------|-------|
|         | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ | $t_6$ |
| $I_1$ - | IF    | OF    | EXE   | WB    | ---   | ----- | ----  |
| $I_2$ - | --    | IF    | Stall | Stall | OF    | EXE   | WB    |

ANTIDEPENDANCY (Write After Read)

$I_1 - \text{ADD } R_3, R_2, R_1 \quad R_3 \leftarrow R_2 + R_1$   
 $I_2 - \text{SUB } R_2, R_4, 1 \quad R_2 \leftarrow R_4 - 1$

|         |       |       |       |       |       |
|---------|-------|-------|-------|-------|-------|
|         | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ |
| $I_1$ - | IF    | OF    | EXE   | WB    | ---   |
| $I_2$ - | --    | IF    | OF    | EXE   | WB    |

- if there is a True Data Dependency before  $I_1$  -

|         |       |       |       |       |       |       |       |       |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|
|         | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ | $t_6$ | $t_7$ |
| $I_1$ - | IF    | Stall | Stall | Stall | Stall | OF    | EXE   | WB    |
| $I_2$ - | --    | IF    | OF    | EXE   | WB    | ---   | ----- | ----  |

$\leftarrow$  Problem with  $I_2$

(Write After Write)

$I_1 - \text{ADD } R_3, R_2, R_1 \quad R_3 \leftarrow R_2 + R_1$   
 $I_2 - \text{SUB } R_2, R_4, 1 \quad R_2 \leftarrow R_4 - 1$   
 $I_3 - \text{ADD } R_3, R_2, R_5 \quad R_3 \leftarrow R_2 + R_5$

|         |       |       |       |       |       |       |       |       |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|
|         | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ | $t_6$ | $t_7$ |
| $I_1$ - | IF    | OF    | EXE   | WB    | ---   | ----- | ----  | ----  |
| $I_2$ - | --    | IF    | OF    | EXE   | WB    | ----  | ----  | ----  |
| $I_3$ - | --    | --    | IF    | Stall | Stall | OF    | EXE   | WB    |