

Quiz #4

Consider the following code fragment:

```
LOOP: LD    F1, 0(R2)
      SUB.D  F5, F1, F3
      S.D    F5, 0(R2)
      SUBI   R2, R2, #8
      BNEZ   R2, Loop
```

| Instruction producing result | Instruction consuming result | Latency in clock cycle |
|------------------------------|------------------------------|------------------------|
| FP ALU op | Another FP ALU op | 3 |
| FP ALU op | Store Double | 2 |
| Load Double | FP ALU op | 1 |
| Load Double | Store Double | 0 |
| Integer ALU op | Load Double | 2 |

- (1) Find out all the “stall” if no rescheduling or pipeline unrolling is used.
- (2) Unrolling the loop 4 times and reschedule the instruction if needed to avoid “stalls”.

(1) Loop: LD F1, 0(R2)
 stall
 SUB.D F5, F1, F3
 stall
 stall
 S.D F5, 0(R2)
 SUBI R2, R2, #8
 stall
 BNEZ R2, Loop

— 共用到 4 个 stall

(2) step 1: replication

```

Loop: LD  F1, 0(R2)
      stall
      SUB.D F5, F1, F3
      stall
      stall
      S.D  F5, 0(R2)
      SUBI R2, R2, #8
      stall stall
      LD  F1, 0(R2)
      stall
      SUB.D F5, F1, F3
      stall
      stall
      S.D  F5, 0(R2)
      SUBI R2, R2, #8
      stall stall
      LD  F1, 0(R2)
      stall
      SUB.D F5, F1, F3
      stall
      stall
      S.D  F5, 0(R2)
      SUBI R2, R2, #8
      stall stall
      LD  F1, 0(R2)
      stall
      SUB.D F5, F1, F3
      stall
      stall
      S.D  F5, 0(R2)
      SUBI R2, R2, #8
      stall
      BNEZ R2, Loop
    
```

← ALU和lw间要
加入2个stall

exe Time
= 36 cycles

Step 2: merge

SUBI R1, R2, #8 可以合并到最后

```

Loop: LD  F1, 0(R2)
      stall
      SUB.D F5, F1, F3
      stall
      stall
      S.D  F5, 0(R2)
      LD  F1, -8(R2)
      stall
      SUB.D F5, F1, F3
      stall
      stall
      S.D  F5, -8(R2)
      LD  F1, -16(R2)
      stall
      SUB.D F5, F1, F3
      stall
      stall
      S.D  F5, -16(R2)
      LD  F1, -24(R2)
      stall
      SUB.D F5, F1, F3
      stall
      stall
      S.D  F5, -24(R2)
      SUBI R2, R2, #32
      stall
      BNEZ R2, Loop
    
```

exe Time
= 27 cycles

Step 3: rename

```
Loop: LD  F1, 0(R2)
      stall
      SUB.D F5, F1, F3
      stall
      stall
      S.D  F5, 0(R2)
      LD  F6, -8(R2)
      stall
      SUB.D F7, F6, F3
      stall
      stall
      S.D  F7, -8(R2)
      LD  F8, -16(R2)
      stall
      SUB.D F9, F8, F3
      stall
      stall
      S.D  F9, -16(R2)
      LD  F10, -24(R2)
      stall
      SUB.D F11, F10, F3
      stall
      stall
      S.D  F11, -24(R2)
      SUBI R2, R2, #32
      stall
      BNEZ R2, Loop
```

Step 4: schedule

```
Loop: LD  F1, 0(R2)
      LD  F6, -8(R2)
      LD  F8, -16(R2)
      LD  F10, -24(R2)
      SUB.D F5, F1, F3
      SUB.D F7, F6, F3
      SUB.D F9, F8, F3
      SUB.D F11, F10, F3
      S.D  F5, 0(R2)
      S.D  F7, -8(R2)
      SUBI R2, R2, #32
      S.D  F9, -16(R2)
      S.D  F11, -24(R2)
      BNEZ R2, Loop
```

exe Time

= 14 cycles

exe Time

= 27 cycles