

2467819

|                | I <sub>1</sub> | I <sub>2</sub> | I <sub>3</sub> | I <sub>4</sub> | I <sub>5</sub> | I <sub>6</sub> | I <sub>7</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| I <sub>1</sub> | -              |                |                |                |                |                |                |
| I <sub>2</sub> | x              | -              |                |                |                |                |                |
| I <sub>3</sub> | RAW            | -              |                |                |                |                |                |
| I <sub>4</sub> | x              | -              |                |                |                |                |                |
| I <sub>5</sub> | RAW            | RAW            | -              |                |                |                |                |
| I <sub>6</sub> |                |                |                | RAW            | -              |                |                |

4. ① Overall =  $\frac{T_{old}}{T_{new}}$

处理40条指令  $T_{old} = CPI_{old} \times N_{instruction} \times T_A$

$T_{new} = CPI_{new} \times N_{instruction} \times T_B$

Overall =  $\frac{[(5+5-1) \times T_A + T_B] \times 8}{[(8+12-1) \times T_B + 3T_A] \times 5}$

= 1.21

(2)  $CPI = \sum_i^n CPI_i \times \left( \frac{x_i}{N_{instruction}} \right)$

对不含分支指令的指令

$CPI_1 = \frac{[(5+5-1) \times T_A + T_B]}{5T_A} = 2.8$

含分支指令

$CPI_2 = \left[ \frac{0.5 \cdot (N+K-1)}{N} \right] \times (2+5) = 7$

$CPI = 80\%$

平均每5个指令经历一周期停顿

(1)

$$CPI_A = 1 + 0.2 = 1.2$$

平均每8条指令经历三周期停顿

$$CPI_B = 1 + 0.375 = 1.375$$

$$\text{Overall} = \frac{CPI_A \times N \times T_A}{CPI_B \times N \times T_B} = \frac{1.2 \times 1}{1.375 \times 0.6} = 1.45$$

(2) 对 A. 每对错误预测分支分支

~~$$CPI_A = \frac{(N-k+1) + 2N}{N}$$~~

$$= 3$$

$$\begin{aligned} CPI_A &= 3 \times 0.2 \times 0.05 + 1 \times 0.2 \times 0.95 + 1.2 \times 0.8 \\ &= 1.18 \end{aligned}$$

对 B. 对错误预测分支分支

$$CPI_B = 6$$

$$CPI_B = 6 \times 0.2 \times 0.05 + 1 \times 0.2 \times 0.95 + 1.375 \times 0.8$$

$$= 1.55$$

6. (1) { addi a1, a1, i

{ sub a1, 0(a2) RAW

{ addi a2, a2, 4 RAW

{ sub a4, a3, a2

{ sub a4, a3, a2  
bnez a4, Loop RAW

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

lw a<sub>1</sub>, 0(a<sub>2</sub>) IF ID EX MEM WB

addi a<sub>1</sub>, a<sub>1</sub> IF ID EX MEM WB MEM WB  
S S EX

sd a<sub>1</sub>, 0(a<sub>2</sub>) IF ID S S S S EX

addi a<sub>2</sub>, a<sub>2</sub>, 4 IF ID EX MEM WB

sub a<sub>4</sub>, a<sub>3</sub>, a<sub>2</sub> IF ID S S EX MEM WB

bnez a<sub>4</sub>, Loop IF ID S S S S EX MEM WB

S S S S S IF  
需要9个

(1) add √ addi √ ld X sd V bne V jals X jaix X

(2).

1 2 3 4 5 6 7 8 9

lw a<sub>4</sub>, 0(a<sub>2</sub>) IF ID EX MEM WB

addw a<sub>1</sub>, a<sub>4</sub>, a<sub>1</sub> IF ID, ID<sub>2</sub> EX MEM WB  
S EX

addiw a<sub>2</sub>, a<sub>3</sub>, -1 IF ID EX MEM WB

addiw a<sub>3</sub>, a<sub>3</sub>, 4 IF ID EX MEM WB

bnez a<sub>2</sub>, Loop IF ID S EX MEM WB

10个周期

1 2 3 4 5 6 7 8 9  
IF ID EX MEM WB

IF ID S EX MEM WB

IF ID EX MEM WB

IF ID EX MEM WB

IF ID EX MEM WB

9个

(2) 需要两个时钟周期

$$x_2(6), CP_I = \frac{9}{6} = \frac{3}{2}$$

$$x_2(8), CP_I = \frac{17}{8} = \frac{17}{8}$$

|                |    |    |     |     |     |     |     |     |     |     |     |     |     |     |    |    |    |    |
|----------------|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|
| 1              | 2  | 3  | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16 | 17 | 18 | 19 |
| ld a1, a(a2)   | l1 | l2 | ld1 | ld2 | ex1 | ld1 | ld2 | ex2 | m1  | m2  | wb1 | wb2 |     |     |    |    |    |    |
| addi a1, a1, 1 |    |    | ld1 | ld2 |     | ld1 | ld2 |     | ex1 | ex2 | m1  | m2  |     |     |    |    |    |    |
| sd a1, o(a2)   |    |    | ld1 | ld2 |     | ld1 | ld2 |     | ex1 | ex2 | m1  | m2  | wb1 | wb2 |    |    |    |    |
| addi a2, a2, 4 |    |    |     |     |     |     |     |     | ld1 | ld2 | es  | s   | ex1 | m1  |    |    |    |    |
| sub a2, a3, a2 |    |    |     |     |     |     |     |     | ld1 | ld2 | es  | s   | ex1 | m1  |    |    |    |    |
| ld a2, a(a2)   |    |    |     |     |     |     |     |     | ld1 | ld2 | es  | s   | ex1 | m1  |    |    |    |    |
| addi a2, a2, 4 |    |    |     |     |     |     |     |     | ld1 | ld2 | es  | s   | ex1 | m1  |    |    |    |    |
| sub a2, a3, a2 |    |    |     |     |     |     |     |     | ld1 | ld2 | es  | s   | ex1 | m1  |    |    |    |    |
| ld a2, a(a2)   |    |    |     |     |     |     |     |     | ld1 | ld2 | es  | s   | ex1 | m1  |    |    |    |    |