

2467819

2.	I ₁	I ₂	I ₃	I ₄	I ₅	I ₆	I ₇
I ₁	-						
I ₂	x	-					
I ₃		RAW	-				
I ₄			x	-			
I ₅			RAW	RAW	-		
I ₆					RAW	-	

4. (1) $S_{overall} = \frac{T_{old}}{T_{new}}$

外溢40条指令

$$T_{old} = CPI_{old} \times N_{instruction} \times T_A$$

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

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

$$= 1.21$$

(2) $CPI = \sum_{i=1}^n CPI_i \times \left(\frac{x_i}{N_{instruction}} \right)$

对不含分支指令的指令

$$CPI_1 = \frac{[(5+5-1) \times T_A + T_A]}{5T_A} = 2$$

含分支指令

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

$$CPI = 8\%$$

(1) 平均每5个指令经历一周期停顿

$$CPI_A = 1 + 0.2 = 1.2$$

平均每8条指令经历三周期停顿

$$CPI_B = 1 + 0.375 = 1.375$$

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

(2) 对A. 每对错误预测的分支指令

$$CPI_A = \frac{(N-k+1) + 2N}{N} = 3$$

$$CPI_A = 3 \times 0.2 \times 0.05 + 1 \times 0.2 \times 0.95 + 1.2 \times 0.8 = 1.18$$

对B. 对错误的分支指令

$$CPI_B = 6$$

$$CPI_B = 6 \times 0.2 \times 0.05 + 1 \times 0.2 \times 0.95 + 1.375 \times 0.8 = 1.55$$

6, 11, $\left\{ \begin{array}{l} \text{addi } a1, a1, 1 \\ \text{sch } a1, 0(a2) \end{array} \right.$ RAW

$\left\{ \begin{array}{l} \text{addi } a2, a2, 4 \\ \text{sub } a4, a3, a2 \end{array} \right.$ RAW

$\left\{ \begin{array}{l} \text{sub } a4, a3, a2 \\ \text{bnez } a4, \text{Loop} \end{array} \right.$ RAW

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

ld a1, 0(a2) IF ID EX MEM WB

addi a1, a1, 1 IF ID EX MEM WB
S S EX

sd a1, 0(a2) IF ID S S S S EX

addi a2, a2, 4 IF ID EX MEM WB

sub a4, a3, a2 IF ID S S EX MEM WB

bnez a4, Loop IF ID S S S S EX MEM WB

S S S S S IF

(1) add addi ✓ ld X sd ✓ bne ✓ jal X jalr X

(2)

1 2 3 4 5 6 7 8 9

lw a4, 0(a2) IF ID EX MEM WB

addw a1, a4, a1 IF ID ID EX MEM WB
S EX

addiw a2, a2, -1 IF ID EX MEM WB

addiw a3, a3, 4 IF ID EX MEM WB

bnez a2, 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) 需要几个时钟周期

又由(6) $CP_1 = \frac{P}{P} = \frac{1}{1} \cdot \frac{3}{2}$

$$\times f(8), \quad \text{CPI} = \frac{17}{6} = 2\frac{5}{6}$$

Op	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
ld a1, r(a2)	IF1	IF2	ID1	ID2	EX1	EX2	M1	M2	WB1	WB2									
addi a1, a1, 1	IF1	IF1	IF2	ID1	ID2	S	S	S	EX	EX2	M1	M2	WB1	WB2					
sd a1, 0(a2)			IF1	IF2	ID1	ID2	S	S	S	S	EX	EX2	M1	M2	WB1	WB2			
addi a2, a2, 4			IF1	IF2	ID1	ID2	ID2	EX1	EX2	M1	M2	WB1	WB2						
sub a4, a3, a2				IF1	IF2	IF2	ID1	ID2	S	EX1	EX2	M1	M2	WB1	WB2				
move a0, a0				IF1	IF2	IF1	ID2	ID1	ID2	EX	EX2	EX	EX2	M1	M2	WB1	WB2		
loop						IF1	IF2	S	S	S	S	S	IF1	IF2					