

	I1	I2	I3	I4	I5	I6
2.	I1	/				
I2	无	/				
I3	无	RAW	/			
I4	无	<del>RAW</del>	<del>RAW</del>	/		
I5	<del>RAW</del>	RAW	RAW	RAW	/	
I6	无	无	无	无	无	/

$$4.(1) \quad \begin{aligned} T_{total} &= 2ns + n \times 1ns = 2 + 2 \\ \text{Instr} &= 0.6ns + \frac{1}{8} \times 3ns = 0.6ns + 0.375ns \\ A \text{周期数} &= 5x \\ B \text{周期数} &= \frac{n+4}{5} \end{aligned}$$

$$S = \frac{\frac{5}{8} \times 1ns + \frac{1}{5} \times 1ns}{\frac{5}{8} \times 0.6ns + \frac{n}{5} \times 3 \times 0.6ns} = \frac{0.4n + 0.8}{0.75n + 0.55}, n \text{为指令数量}$$

$$(2) CPI = \frac{\text{周期数}}{\text{指令数}}$$

$$\begin{aligned} CPI_A &= \frac{(0.8n + 0.2 \times 0.95n) + 5 + (0.2 \times 0.05n + 2 \times 5 - 1)}{n} \\ &= \frac{(0.8n + 0.2 \times 0.95n) + 12 - 1}{n} \\ &= \frac{(1 - 0.2 \times 0.05)(n + 5 - 1) + 0.2 \times 0.05[n + 12 - 1 + 5]}{n} \\ &= \frac{n + 9.02}{n} \end{aligned}$$

$$\begin{aligned} CPI_B &= \frac{(1 - 0.2 \times 0.05)(n + 12 - 1) + 0.2 \times 0.05[n + 12 - 1 + 5]}{n} \\ &= \frac{n + 11.05}{n} \end{aligned}$$

6.(1) ~~"ld a1, 0(a2)" 与 "addi a1, a1, 1"~~ 存在 ~~RAW~~ 冲突

~~"addi a2, a2, 4" 与 "sub a4, a3, a2"~~ 存在 ~~RAW~~ 冲突.

~~"sub a4, a3, a2" 与 "bnez a4, Loop"~~ 存在 RAW 冲突.

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

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

~~sd a1, 0(a2)~~

IF S S ID EX MEM WB

~~addi a2, a2, 4~~

S S IF ID EX MEM WB

~~sub a4, a3, a2~~

S S IF ID S S EX MEM WB

~~bnez a4, Loop~~

S S IF ID S S EX MEM WB

一次循环需要 ~~25~~ 个周期, 总要 ~~25 \* 16 = 400~~ 个周期.

~~160~~

7. (1) ~~a1 = 0 → a1 = 1 → a2 = 4 → a4 = 95 → ... → a1 = 0.~~

~~s s if s s id s s ex mem wb  
s s s if s s id ...  
s s s s if ...  
if~~

~~+1 次循环:~~

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

~~if id s s ex mem wb~~

~~addi a1, a1, 1~~

~~if s s id ex mem wb~~

~~sd a1, 0(a2)~~

~~if s s id ex mem wb~~

~~addi a2, a2, 4~~

~~if s s id ex mem wb~~

~~sub a4, a3, a2~~

~~if s s id ex mem wb~~

~~bnez a4, Loop~~

~~if s s id ex mem wb~~

~~ld a1, 0(a2)~~

~~if id ex mem wb~~

~~+1 次循环: 14 + 9 = 23 个周期~~

~~... 需要 25 \* 23 = 575 个周期~~

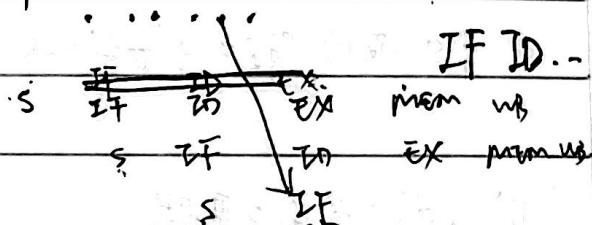
7.(1) 需要 25 次循环

ld a1, 0(a2) IF ID EX MEM WB  
addi a1, a1, 1 IF ID S EX MEM WB  
sd a1, 0(a2) IF S ID EX MEM WB  
addi a2, a2, 4 IF S ID EX MEM WB  
sub a4, a3, a2 IF S ID EX MEM WB  
bneq a4, Loop. IF S ID EX MEM WB

ld a1, 0(a2)  
一次循环需要 ~~11~~ 个周期, 总需要 ~~25~~ 个周期

(2) 则一次循环需要 ~~9~~ 个周期, ← EX 给出预测结果.

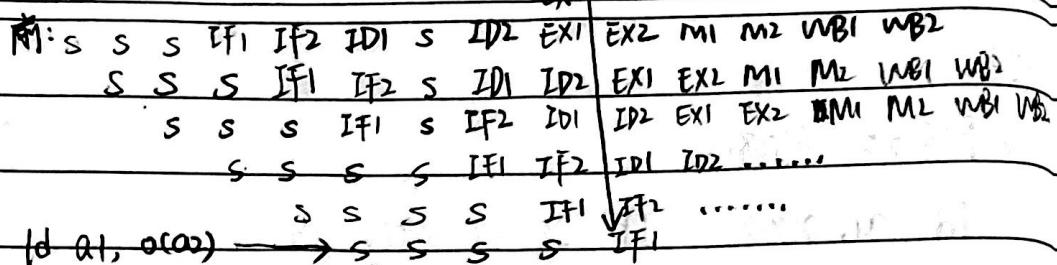
总需要 ~~25 × 9 = 225~~  
~~25 × 8 + 11 = 205~~



8.(1) ld a1, 0(a2) IF1 IF2 ID1 ID2 EX1 EX2 M1 M2 WBI WB2  
addi a1, a1, 1 IF1 IF2 ID1 ID2 S S S EX1 EX2 M1 M2 WBI WB2  
sd a1, 0(a2) IF1 IF2 ID1 S S S ID2 EX1 EX2 M1 M2 S WBI WB2  
addi a2, a2, 4 IF1 IF2 ID1 S S S ID2 EX1 EX2 M1 M2 WBI WB2  
sub a4, a3, a2 IF1 IF2 ID1 S S S ID2 S EX1 EX2 M1 M2 WBI WB2  
bneq a4, Loop. IF1 IF2 ID1 S S S ID2 S S EX1 EX2 M1 M2 WBI WB2

ld a1, 0(a2) IF1 IF2 ID1 ID2 EX1 EX2 M1 M2 WBI WB2  
addi a1, a1, 1 IF1 IF2 ID1 ID2 S S S EX1 EX2 M1 M2 WBI WB2  
sd a1, 0(a2) IF1 IF2 ID1 S S S ID2 EX1 EX2 M1 M2 S WBI WB2  
addi a2, a2, 4 IF1 IF2 S S S ID1 ID2 EX1 EX2 M1 S M2 WBI WB2  
sub a4, a3, a2 IF1 S S S IF2 ID1 ID2 EX1 EX2 S M1 M2 WBI WB2  
bneq a4, Loop. S S S IF1 IF2 ID1 ID2 S EX1 EX2 M1 M2 WBI WB2  
S S S IF1 IF2 ID1 S ID2 EX1 EX2 M1 M2 WBI WB2

预测结果



∴ 一次循环需要 15 个周期

总需要  $25 \times 15 = 375$  个周期。

(2) 第 6 题 CPI =  $\frac{1490}{1850} = 2.67$

第 7 题 CPI =  $\frac{275}{150} = 1.83$

第 7 题 (2) CPI =  $\frac{225}{150} = 1.5$

第 8 题 (1) CPI =  $\frac{375}{150} = 2.5$

19. (1) add: 需要 2 周期

addi: 不需要

ld: 不需要

sd: 不需要

bne: 需要

j: 不需要

jalr: 不需要

(2) 单次循环:

lw a4, 0(a3) IF ID ID EX MEM WB

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

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

addiw a3, a3, 4 S S S IF ID S EX MEM WB

bnez a2, Loop S S S IF ID S EX MEM WB

单次循环要 13 个周期。

S S S 2F S ID ..  
S S S S S IF

IF

IF  
→ IF

### (3) 单次循环:

lw a4, 0(a3) IF ID ID EX MEM WB

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

addw a2, a2, -1 S IF S ID EX MEM WB

addw a3, a3, 4 S S IF ID EX MEM WB

bnez a2, Loop S S IF ID EX MEM WB

S S IF ...  
S S IF  
IF  
IF  
→ IF

单次循环共 11 个周期。