

solution 2

1.解 a.

寄存器	源指令	目标指令	数据相关类型
R1	①	②	RAW
R1	①	②	WAW
R1	①	③	RAW
R1	②	③	RAW
R2	①	④	WAR
R2	③	④	WAR
R2	④	⑤	RAW
R4	⑤	⑥	RAW

b.时序如下:

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LD	R1, 0(R2)	F	D	X	M	W													
DADDI	R1, R1, #1		F	s	s	D	X	M	W										
SD	0(R2), R1					F	s	s	D	X	M	W							
DADDI	R2, R2, #4								F	D	X	M	W						
DSUB	R4, R3, R2									F	s	s	D	X	M	W			
BNEZ	R4, Loop												F	s	s	D	X	M	W
LD	R1, 0(R2)																	F	D

所需周期: $98 \times 16 + 18 = 1586$

c.时序如下:

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LD	R1, 0(R2)	F	D	X	M	W													
DADDI	R1, R1, #1		F	D	s	X	M	W											
SD	R1, 0(R2)			F	s	D	X	M	W										
DADDI	R2, R2, #4					F	D	X	M	W									
DSUB	R4, R3, R2						F	D	X	M	W								
BNEZ	R4, Loop							F	s	D	X	M	W						
(incorrect instruction)										F	s	s	s	s					
LD	R1, 0(R2)										F	D	X	M	W				

所需周期: $9 \times 98 + 12 = 894$

(默认判断 R4 的值在 EX 阶段时, 则所需周期为 $9 \times 98 + 11 = 893$)

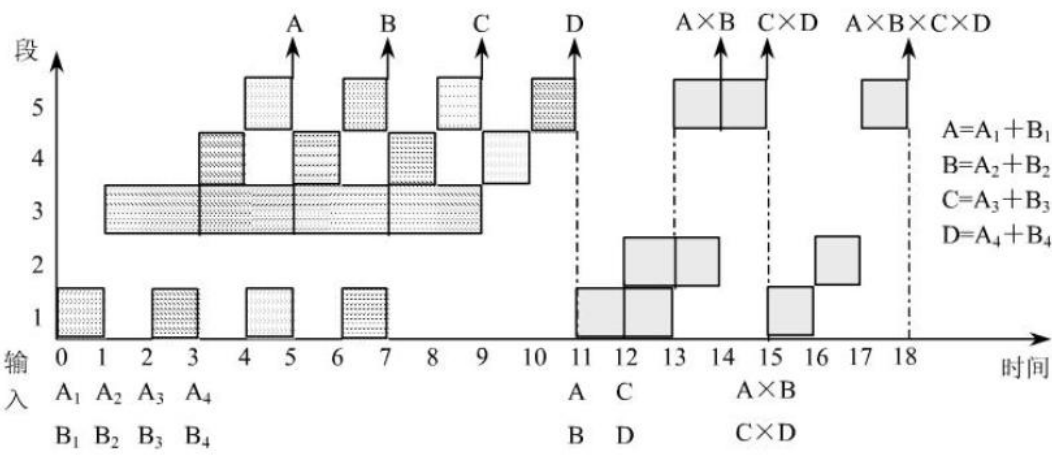
d.时序如下:

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LD	R1, 0(R2)	F	D	X	M	W													
DADDI	R1, R1, #1		F	D	s	X	M	W											
SD	R1, 0(R2)			F	s	D	X	M	W										
DADDI	R2, R2, #4					F	D	X	M	W									
DSUB	R4, R3, R2						F	D	X	M	W								
BNEZ	R4, Loop							F	s	D	X	M	W						
LD	R1, 0(R2)									F	D	X	M	W					

所需周期：8×98+12 = 796

(默认判断 R4 的值在 EX 阶段时，则所需周期为7×98+11=697)

2.解：时空图如下：



$$\begin{aligned} \text{吞吐率: } TP &= \frac{7}{18\Delta t} \\ \text{加速比: } S &= \frac{29\Delta t}{18\Delta t} = 1.61 \\ \text{效率: } E &= \frac{4 \times 5 + 3 \times 3}{5 \times 18} = 0.322 \end{aligned}$$

3.解: a.仅考虑数据冒险时:

$$5 \text{ 级流水线 } CPI = \frac{6}{5}; 12 \text{ 级流水线 } CPI = \frac{11}{8}$$

$$\text{加速比: } \frac{I \times \frac{6}{5} \times 1}{I \times \frac{11}{8} \times 0.6} \approx 1.45$$

b.考虑分支错误的停顿时:

$$CPI = \text{分支预测指令 } CPI + \text{非分支预测指令 } CPI$$

$$= 0.2 * CPI * 0.95 + 0.2 * (CPI + CPI \text{ 额外}) * 0.05 + 0.8 * CPI$$

$$= CPI + 0.2 * CPI \text{ 额外} * 0.05$$

$$\text{第一台机器: } CPI = \frac{6}{5} + 0.2 \times 0.05 \times 2 = 1.22$$

$$\text{第二台机器: } CPI = \frac{11}{8} + 0.2 \times 0.05 \times 5 = 1.425$$