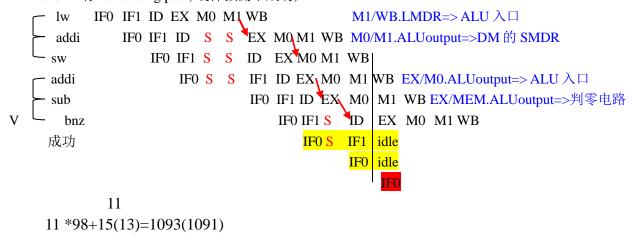
Answer for homework assignment 3

A.1

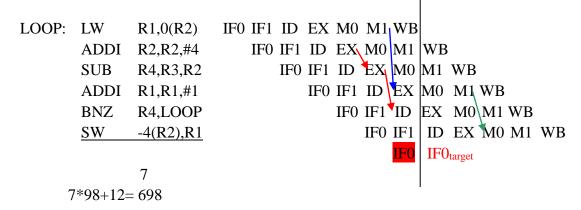
假设:转移目标地址计算和条件判断在 ID 级进行

(1)已知:<mark>无</mark>任何 forwarding path,但在一个时钟周期内对寄存器堆可以进行一次写和一次读(前半周期写,后半周期读)。转移用 flushing 方法。 IF0 IF1 ID EX M0 M1 WB Lw IFO IF1 S S S ID EX MO M1 WB addi IFO S S S IF1 S S ID EX M0 M1 WB S IF1 ID EX M0 M1 WB addi IFO IF1 S S S ID EX M0 M1WB sub S S IF1 S S S ID EX M0 M1 WB IFO S bn z LW IFO_{i+1} S S S IF1 IFO_{target} ... 20 IF0 IF1 ID EX M0 M1 WB Lw IF0 IF1 ID S S S EX M0 M1 WB addi EX M0 M1 WB IFO S S S ID EX M0 M1 WB IFO S S EX M0 M1WB sub ID S S ID EX M0 M1 WB bn z LW IFO_{i+1} S S S IF1 S S 20 20*98 + 24(20) = 1984(1980)

(2) 有 forwarding path, 硬件预测不成功,..



(3) 有一个延时槽,有 forwarding path,<mark>利用延时转移技术,可调整指令顺序或部分修改指令操作数</mark>,但不允许减少循环内的指令数, 使得尽可能减少 Stall。



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A.2
(1) 无 forwarding path, 转移目标地址计算和条件判断在 ID 级进行,flushing 方法
                IF ID EX M WB
LD
      F0, 0(R2)
                    IF ID EX M
LD
      F4, 0(R3)
                                 WB
      F0, F0, F4
                         S
MUL
                                 ID M1 M2 M3 M4 M5 M6 M7 M
                                                               WB
      F2, F0, F2
                                    S S S
                                             S
                                                 S
                                                    S S S
ADD
                                                               ID A1 A2 A3 A4 M WB
      R2, R2, #8
                                                               IF ID EX M WB
ADDI
ADDI
      R3, R3, #8
                                                                  IF ID EX M WB
      R5, R4, R2
                                                                     IF S
                                                                            ID EX M
SUB
      R5, LOOP
                                                                            IF S S
                                                                                      ΙĎ
BNEZ
                                                                                         EX M WB
                                                                                      IF
22*98 + 25 = 2181
(2) 有 forwarding path, 转移目标地址计算和条件判断在 ID 级进行,预测不成功
      F0, 0(R2)
                IF ID EX M WB
LD
LD
      F4, 0(R3)
                    IF ID EX M WB MEM/WB.LMDR=>MUL 入口
                                 M1 M2 M3 M4 M5 M6 M7 M WB MUL/MEM.MUL 数据寄存器=>ADD 入口
MUL
      F0, F0, F4
                                                        A1 A2 A3 A4 M WB 写 F2
ADD
      F2, F0, F2
      R2, R2, #8
                                      \mathbf{S} \mathbf{S}
                                              S
                                                S S
                                                        ID EX M WB
ADDI
                                                        IF ID EX M WB 写 R5
      R3, R3, #8
ADDI
                                                                        WB EX/MEM.ALUoutput=>判零电路
SUB
      R5, R4, R2
                                                           IF ID EX M
                                                                        EX M WB
BNEZ
      R5, LOOP
                                                               IF S
                                                                     †D
                                                                     IF
                                                                        idle
                                                                         IF
17*98 + 19 = 1685
```

```
(3)
   LD
         F0, 0(R2)
                   IF ID EX M
Loop:LD
         F4, 0(R3)
                      IF ID EX M WB DM.LMDR=>MUL入口
                            ID EX M WB MEM/WB.ALUoutput=>ALU 入口
         R2, R2, #8
   ADDI
                                ID M1 M2 M3 M4 M5 M6 M7 M WB MUL/MEM.MUL 数据寄存器=>ADD 入口
   MUL
         F0, F0, F4
                                   ID EX M WB
   SUB
         R5, R4, R2
   ADDI
         R3, R3, #8
                                   IF ID EX M WB
                                       IF ID S
                                                S S S
   ADD
         F2, F0, F2
                                                          A1 A2 A3 A4 M WB
         R5, LOOP
                                          IF S S S S
                                                          ID EX M WB
   BNEZ
         F0, 0(R2)(延时槽指令)
                                                             ID EX M WB
   LD
                                                             IF
1+12*98+15 = 1192
Loop: LD
         F0, 0(R2)
                   IF ID EX M
                         ID EX M WB DM.LMDR=>MUL 入口(H4)
   LD
         F4, 0(R3)
                             ID EX M WB MEM/WB.ALUoutput => ALU 入口
         R2, R2, #8
   ADDI
                                      、M2 M3 M4 M5 M6 M♥ M WB MUL/MEM.MUL 数据寄存器=>ADD 入口
                                IĎ M1 \
   MUL
         F0, F0, F4
                                      EX M WB EXE/MEM.ALU output => 判零电路
   SUB
         R5, R4, R2
   ADDI R3, R3, #8
                                       ID
                                          EX M WB
                                          ID EX M WB
   BNEZ R5, LOOP
                                                   S
   ADD F2, F0, F2
                                            ID S
                                                      S
                                                             A1 A2 A3 A4 M WB
                                                             ID EX M WB
```

12*98+19 = 1195

A.3

Given: unconditional resolved at the end of 2nd stage, conditional resolved at the end of 3rd stage.

Unconditional: L1 L2 L3 L4

L1 L1(target) 1 stall

conditional:

1. Flushing: L1 L2 L3 L4

L1 s L1 (target or pc+4) 2 stalls

2. predict-untaken:

untaken L1 L2 L3 L4

L1 L2 L3 L4 0 stall

Taken L1 L2 L3 L4

<u>L1 s</u> L1 (pc+4) 2 stall

3. Predict-taken:

taken L1 L2 L3 L4

L1 L1(t) L2 L3 1 stall

Taken L1 L2 L3 L4

L1 L1(t) L1 (pc+4) 2 stall

设 CPIideal = 1

CPIflushing: = CPIideal + 1% * 1 + 15% * 2 = 1.31

speedup = 1.31

CPIpredict-untaken = CPIideal + 1% * 1 + 15% * (60% * 2 + 40% * 0) = 1.19

speedup = 1.19

CPIpredict-taken = CPIideal + 1% * 1 + 15% * (60% * 1 + 40% * 2) = 1.22

speedup = 1.22