

Homework 4

Problem 1

Suppose the CPU is pipelined with Data Forwarding, there are five instructions:

```
irmovl $0, %eax
popl %eax
popl %ebx
addl %eax,%ebx
pushl %eax
```

Draw the pipelined diagram of these instructions, and point out forwarding(s) in the diagram.

- 1) Initially, all registers have value \$0.
- 2) has to explicitly specify the *src* and *dest* of each forwarding value (e_valE, W_valE, m_valM, etc.)
(MEM[%esp]=1, MEM[%esp+4]=2)

Problem 2

```
#demo-retB.y
0x000:    irmovl Stack,%esp  # Intialize stack pointer
0x006:    call p             # Procedure call
0x00b:    irmovl $5,%esi     # Return point
0x011:    halt
0x020:    .pos 0x20
0x020: p: irmovl $-1,%edi    # procedure
0x026:    ret
0x027:    irmovl $1,%eax     # Should not be executed
0x02d:    irmovl $2,%ecx     # Should not be executed
0x033:    irmovl $3,%edx     # Should not be executed
0x039:    irmovl $4,%ebx     # Should not be executed
0x100:    .pos 0x100
0x100: Stack:                # Stack: Stack pointer
```

In the above example, when **ret** at 0x026 is in its D, E, M stages, there would be **stall** at F stage and **bubble** at D stage. Explain why this happens and the difference between stall and bubble?

Problem 3

For each of the instruction **that would cause exception**, specify its cause (halt, bad address or invalid instruction) and the stage where exception can be detected, otherwise leave blank.

Instruction	Cause	Stage
halt		
.byte FF		
jmp \$-1		
rmmovl %eax,0x10000(%eax) where %eax=\$100		
xor %eax, %eax jne t t: .byte 0xFF		

Problem 4

Suppose we have the following statistics for a certain program:

- 1) Fraction of instructions that are loads: 10%
- 2) Fraction of load instructions requiring stall: 20%
- 3) Number of bubbles injected each time: 1
- 4) Fraction of instructions that are cond. Jumps: 35%
- 5) Fraction of cond. jumps mispredicted: 40%
- 6) Number of bubbles injected each time: 2
- 7) Fraction of instructions that are returns: 1%
- 8) Number of bubbles injected each time: 3

Calculate CPI.