302558184  
302650072  
203090051  
029998937

**Appendix B**

Answer the following questions.

B.1) What are the limitations due to the pipeline latency of the following combinations:

* lw after add where the add Rd is the lw Rs
* lw after add where the add Rd is the lw Rt
* add after lw where the lw Rt is the add Rt
* beq after lw where the lw Rt is the beq Rs

Use a similar figure to Fig.2 and Fig. 3 to demonstrate your answers.

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

NOP

NOP

add **$3**,$5,$8

WB

EX

ID

IF

NOP

WB

EX

ID

LW $9, 0($3)

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

lw $3, 0($9)

add **$3**,$5,$8

WB

EX

ID

IF

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

NOP

NOP

lw **$3**,16($10)

WB

EX

ID

IF

NOP

WB

EX

ID

add $8, $5, $3

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

NOP

NOP

lw **$3**,16($10)

WB

EX

ID

IF

NOP

WB

EX

ID

Beq $3, $5, label

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

B.2) What are the limitations of all cases of B.1 after you add he Data Forwarding?

a) all limitations are gone

b) all limitations are gone

c) all limitations are gone

d) The NOPS stays - there is still need for branch\_forwarding.

B.3) How many times do we perform the instruction following a jal instruction? Explain in detail. What are the implications? If this is a problem, what do you suggest in order to solve it?

We perform the next instruction twice. One is a clock right after the JAL is fetched, because in that clock the next instruction is fetched, and the second is when we return.

We can put NOP after the JAL.

B.4) How soon after jal instruction can we issue a jr $31 instruction in order to return to the right location in the code? Give the answer before data forwarding is added and then after the data forwarding is added

Before data forwarding:

4 instructions, because we have to wait for the WB phase of JAL.

After data forwarding:

3 instructions because of the transparent GPR.