BYOC\_HW6 Simulation 2:

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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. Explain your answer!

B.1.a - lw after add where the add Rd is the lw Rs

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

Nop

Nop

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

WB

EX

ID

IF

lw $4,16($3)

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

B.1.b - lw after add where the add Rd is the lw Rt

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

lw $3,16($4)

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

WB

EX

ID

IF

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

B.1.c - add after lw where the lw Rt is the add Rt

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

NOP

NOP

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

WB

EX

ID

IF

Add $8,$5,$3

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

B.1.d - beq after lw where the lw Rt is the beq Rs

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

nop

nop

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

WB

EX

ID

IF

beq $3, $5, L1

ת

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

B.2.a - lw after add where the add Rd is the lw Rs

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

Lw $4,16($3)

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

WB

EX

ID

IF

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

הסבר – add מקבל תוצאה בשלב הex ומבצע forward לשלב הid של lw .

B.2.b - lw after add where the add Rd is the lw Rt

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

Lw $3,16($4)

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

WB

EX

ID

IF

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

הסבר – לא נדרש שום דבר בדיוק כמו בסעיף B1.b

B.2.c - add after lw where the lw Rt is the add Rt

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

NOP

Add $8,$5,$3

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

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

הסבר: lw מקבל תוצאה בשלב הMEM ויבצע forwarding לשלב הid של add

B.2.d - beq after lw where the lw Rt is the beq Rs

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

NOP

Beq $3,$5,L1

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

WB

EX

ID

IF

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

הסבר: lw מקבל תוצאה בשלב הmem וbeq צריך אותה בשלב הID לכן יבוצע forwarding לאחר NOP.

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?

ההוראה מתבצעת פעמיים, כדי לפתור את הבעיה נזכור את הכתובת חזרה לאחר פקודת JAL ברגיסטר יעודי אשר ישמור את הכתובת PC+4

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. . Explain your answer!

No data forwarding:

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

jr $31

jal routine1

WB

EX

ID

IF

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

MEM

EX

With data forwarding:

WB

EX

ID

IF

WB

EX

ID

IF

WB

EX

ID

IF

jal routine1

WB

EX

ID

IF

jr $31

WB

EX

ID

IF

CK

MEM

MEM

MEM

MEM

MEM

EX