On my honor I have neither given nor received any unauthorized and/or inappropriate assistance for all sessions of this exam. The work done on this exam is totally my own. I understand that by the school code, violation of these principles will lead to exam grade and is subject to harsh discipline issues.

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Q1) 3-way
4 word block
cache size = 48 words

22 33 10 17 8 1 35
M M M M H M H

27 20 50
M H M

0	~~32 33 34 35~~ 48 49 50 51	16 17 18 19	0 1 2 3
1	20 21 22 23		
2	8 9 10 11	24 25 26 27	
3			

$\left(\frac{22}{4}\right)$ mod 4

5

$\left(\frac{23}{4}\right)$

$\left(\frac{35}{4}\right)$

0 1 2 3
4 5 6 7
8 9 10 11
12 13 14 15
16 17 18 19
20 21 22 23
24 25 26 27
28 29 30 31
32 33 34 35
36 37 38 39

22 mod 3

33 mod 3

a)

48 49 50 51	16 17 18 19	0 1 2 3
20 21 22 23		
8 9 10 11	24 25 26 27	

b) $10 \times 50 + 7 \times 500$
$= 4000$ ns

500
3500

işlem kısmı

$\left(\frac{22}{4}\right) = 5$ mod $4 = 1$

$\left(\frac{33}{4}\right) = 1$ mod $4 = 0$

$\left(\frac{10}{4}\right) = 2$ mod $4 = 2$

$\left(\frac{17}{4}\right) = 4$ mod 4

$\left(\frac{8}{4}\right) = 2$ mod 4 $= 2$

$\left(\frac{35}{4}\right) = 8$ mod 4 $= 0$

$\left(\frac{27}{4}\right) = 6$ mod $4 = 2$

$\left(\frac{27}{4}\right)$

$(\frac{?}{5}) = 2$

8 mod 3 = 2

0 1 2

$\left(\frac{22}{4}\right) = 5$ mod $4 = 1$

22 mod 3 = 1

10 mod 3 = 1

0 1 2 3

$\left(\frac{20}{4}\right) = 5$ mod $4 = 1$

$\left(\frac{33}{4}\right) = 8$

$\frac{17}{4} = 4$

17 mod 3

0 1 2

$\frac{20}{4}$

$\left(\frac{12}{4}\right) = 4$

20 mod 3 = 2

Q 2) 2 way

size = 2048 KB (cache size)

block size = 4096 bytes

offset = 12 bit

$\frac{2^{21}}{2^{12}} = 2^9 / 2^1 = 2^8$

7 → 128
8 → 256
9 → 512
10 → 1024
11 → 2048

8 bit index

Tag = 12 bit

Tag	index	way	H/M
x007C120B	007	C1	0	M
x036A120B	036	A1	0	M
x007C111A	007	C1	1	H
x044A1F12	044	A1	0	M

Example run

$s0 = x$

Q 3)

s1	t0	s0
0	0	12
0	1	3
1		0 x

complicated run

s1	t0	s0
0	x	x
x	x/4	x/4
x+x/4	x/16	x/16
$x+\frac{x}{4}+\frac{x}{16}$		

result
$= x + \frac{x}{4} + \frac{x}{16}$

$x = s0$

logic shift is 0 ahead
take is 1

001
1
―
1

0 is shift
1 is take

Assume that
$s0 = 12$
$= 01100$

0110
1
―
0

00001

00011

1

31/4 1

15

25/2 12

2 6

2 3

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CSE3038 – Spring 2021 - CHEAT SHEET for FINAL

ALU control	Function
0000	AND
0001	OR
0010	add
0110	subtract
0111	set-on-less-than
1100	NOR

Instruction opcode	ALUOp	Instruction operation	Funct field	Desired ALU action	ALU control input
LW	00	load word	XXXXXX	add	0010
SW	00	store word	XXXXXX	add	0010
Branch equal	01	branch equal	XXXXXX	subtract	0110
R-type	10	add	100000	add	0010
R-type	10	subtract	100010	subtract	0110
R-type	10	AND	100100	AND	0000
R-type	10	OR	100101	OR	0001
R-type	10	set on less than	101010	set on less than	0111

2-bit ALUOp derived from opcode

Figure 4.12 (260)

ALUOp		Funct field					
ALUOp1	ALUOp0	F5	F4	F3	F2	F1	F0	Operation
0	0	X	X	X	X	X	X	0010
X	1	X	X	X	X	X	X	0110
1	X	X	X	0	0	0	0	0010
1	X	X	X	0	0	1	0	0110
1	X	X	X	0	1	0	0	0000
1	X	X	X	0	1	0	1	0001
1	X	X	X	1	0	1	0	0111

Figure 4.13 (261)

The Main Control Unit

Control signals derived from instruction

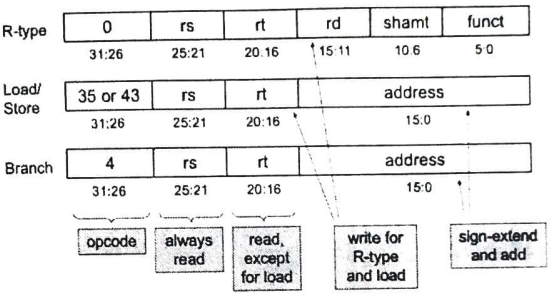

Figure 4.18 (Jump control line should be added)

Instruction	RegDst	ALUSrc	Memto-Reg	Reg. Write	Mem-Read	Mem-Write	Branch	ALUOp1	ALUOp0
R-format	1	0	0	1	0	0	0	1	0
lw	0	1	1	1	1	0	0	0	0
sw	X	1	X	0	0	1	0	0	0
beq	X	0	X	0	0	0	1	0	1

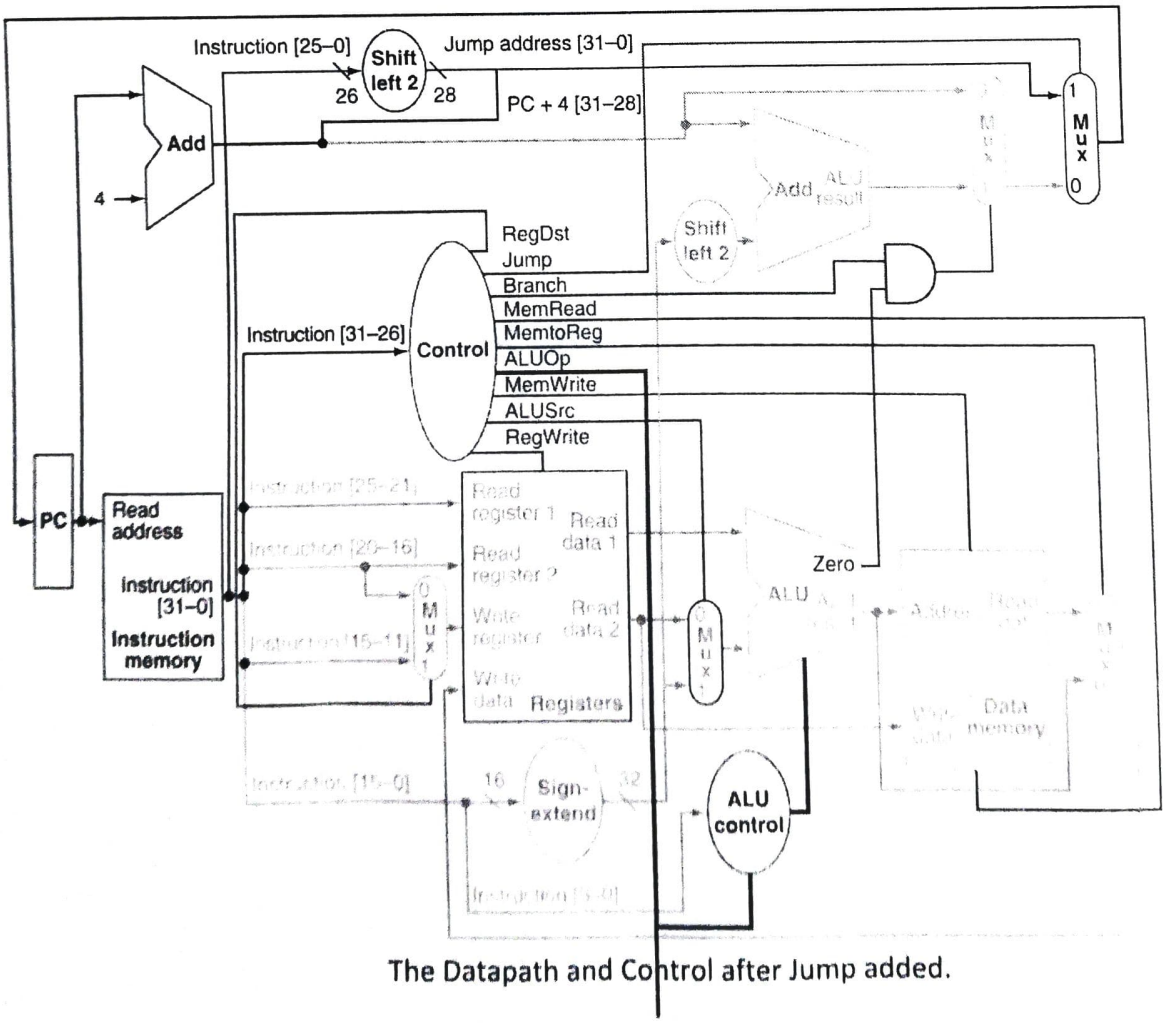

Figure 4.24

The Datapath and Control after Jump added.

Pipeline →

$CPI = \text{Base } CPI + (\#\text{instruction} \times \#\text{stall})$

IF ID Ex Mem WB

add s0, s1, s2 IF ID Ex Mem WB (→ forwarding)
add s3, s4, s0 IF ID Ex Mem WB

lw s0, 20(t1) IF ID Ex Mem WB
add s2, s1, s0 IF (S) ID Ex Mem WB

Clock cycles = IC × CPI

CPU time = IC × CPI × CCT

= IC × CPI / clock rate

Cache:

CPU Time: (CPU exec time + Memory stall cycles) × CCT

Memory stall clock cycles = $\frac{\text{instructions}}{\text{program}}$ × Miss rate × Miss penalty

Avg. Mem. Access time = (Hit time × Hit ratio) + (Miss time × Miss ratio)

(Miss time = Hit time + Miss penalty)

Direct mapped:

Block Addr = $\lfloor \text{word Addr} / \text{words per block} \rfloor$ mod N → number of blocks in cache (satır sayısı)

Set associative:

Block Addr = $\lfloor \text{word Addr} / \text{words per block} \rfloor$ mod N → Number of sets in cache

" $\lfloor \frac{\text{word adr}}{\text{words per block}} \rfloor$ mod satır = satırı verir. "

" word addr mod block sayısı = kalanı verir "

lw (s5), 200(s4)
add s6, (s5), s8
add s7, s5, s9
sub s3, s7, s10

IF	ID	Ex	Mem	WB				
	IF	ID	(S)	Ex	Mem	WB		
		IF	(S)	ID	Ex	Mem	WB	
				IF	ID	Ex	Mem	WB

Forwarding + write read feature ✓

IF	ID	Ex	Mem	WB						
	IF	(S)	(S)	ID	Ex	Mem	WB			
				IF	ID	Ex	Mem	WB		
					IF	(S)	(S)	ID	Ex	Mem	WB

no forwarding ✗
write read ✓

ikisinde yoksa WB altına yazmayacak

cache size = 4096 KB
block size = 64 words
4-way

1 word = 4 byte

$64 \times 4 = 256 \text{ bytes} = 2^8$ bytes
offset = 8 bit

$4096 KB = 2^{22}$ byte → $\frac{2^{22}}{2^8} = 2^{14}$ ⇒ $\frac{2^{14}}{4\text{-way}} = 2^{12}$ ⇒ 12 bit index

($1KB = 2^{10}$ byte)

(2^{14}: 1 word olduğu için satır sayısı)

12	12	8

Total size:
Each row: data bits + tag + valid
$= 64 \times 4 \times 8 + 12 + 1 = 2061$

Total size =
$2061 \times (2^{12} \times 4\text{-way}) = \ldots$