Module: R4: Computer Architecture

Section: Pipelining & Hazards Task: Pipelining & Hazards

Task

Pipelining & Hazards

➤ Question 1:

a. Average CPI:

For Version A:

$$CPI_{avg} = (%age_A \times CPI_A) + (%age_B \times CPI_B) + (%age_C \times CPI_C) + (%age_D \times CPI_D)$$

$$CPI_{avg} = (2 \times 0.4) + (3 \times 0.25) + (3 \times 0.25) + (7 \times 0.1) = 3$$

For Version B:

$$\begin{aligned} \text{CPI}_{\text{avg}} &= (\text{\%age}_{\text{A}} \text{ x CPI}_{\text{A}}) + (\text{\%age}_{\text{B}} \text{ x CPI}_{\text{B}}) + (\text{\%age}_{\text{C}} \text{ x CPI}_{\text{C}}) + \\ (\text{\%age}_{\text{D}} \text{ x CPI}_{\text{D}}) + (\text{\%age}_{\text{E}} \text{ x CPI}_{\text{E}}) + (\text{\%age}_{\text{F}} \text{ x CPI}_{\text{F}}) + (\text{\%age}_{\text{G}} \text{ x CPI}_{\text{G}}) \end{aligned}$$

$$CPI_{avg} = (2 \times 0.15) + (2 \times 0.15) + (4 \times 0.1) + (6 \times 0.1) + (1 \times 0.1) + (2 \times 0.2) + (2 \times 0.2) = 2.5$$

b. MIPS:

For Version A:

MIPS =
$$\frac{frequency}{CPI \times 10^6}$$

MIPS = $\frac{600 \times 10^6}{3 \times 10^6}$ = 200 MIPS

For Version B:

MIPS =
$$\frac{frequency}{CPI \times 10^6}$$

MIPS = $\frac{700 \times 10^6}{2.5 \times 10^6}$ = 280 MIPS

c. Design Choice:

Processor B with 700 MHz and 280 MIPS is better than processor A with 600 MHz and 200 MIPS.

Here's why:

- Clock Speed: Processor B has a higher clock speed (700 MHz) compared to Processor A (600 MHz). This means that process B can execute more cycles per second, which generally leads to better performance.
- MIPS: Processor B also has a higher MIPS (Million Instructions Per Second) value (280 MIPS) compared to Processor A (200 MIPS).
 This means that the Processor B can theoretically execute more instructions per second, which can lead to better performance.

➤ Question 2:

a. Non-Pipelined Machine:

It takes a total of 48 cycles as shown by the table below:

															N	lo	n	-ķ	ji	pe	eli	in	е	d	N	la	C	hi	n	е																		
	Cycles	1	2	3	4	5	6	7	8	9	1 0	1 1	1 2	1 3	1 4	1 5	1 6	1 7	1 8	1 9	2 0	2 1	2 2	2 3	2 4	2 5	2 6	2 7	2 8	2 9	3 3	3 3	3 ;	3 3	3	3 6	3 7	3 8	3 9	4 0	4 1	4 2	4 3	4 4	4 5	4 6	4 7	4 8
0	MUL R3 , R1 , R2	F	D			E 3				w																																						
1	ADD R5 , R4 , R3										F	D	E 1			E 4	ıw																															
2	ADD R6 , R4 , R1																	F	D				E 4	w																								
3	MUL R7 , R8 , R9																								F	D			E 3	- 1	- 1	- 11	N															
4	ADD R4 , R3 , R7																																	F	1 1	1	1	E 4	IW									
5	MUL R10 , R5 , R6																																							F	D		1	1		E 5		IW.

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b. A pipelined machine with five adders and five multipliers without data forwarding:

It takes a total of 28 cycles as shown by the table below:

	A pipelin	ed	m	ac	hir	пе	wi	th	fiv	е	ad	de	rs	ar	d	fiv	e r	nu	ltip	olie	ers	W	ith	ou	t c	lat	a		
										f	orv	va	rdi	ng															
	Cycles	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
0	MUL R3 , R1 , R2	F	D	E1	E2	E3	E4	E5	E6	W																			
1	ADD R5 , R4 , R3		F	D	- 1	-	-	-	-	-	D	E1	E2	E3	E4	W													
2	ADD R6, R4, R1			F	- 1	-	-	-	-	- 1	- 1	D	E1	E2	E3	E4	W												
3	MUL R7 , R8 , R9											F	D	E1	E2	E3	E4	E5	E6	W									
4	ADD R4, R3, R7												F	D	-	-	-	-	-	- 1	D	E1	E2	E3	E4	W			
5	MUL R10 , R5 , R6																				F	D	E1	E2	E3	E4	E5	E6	W

c. A pipelined machine with five adders and five multipliers with data forwarding:

It takes a total of 26 cycles as shown by the table below:

A	A pipelined ma	acł	nin	e١	vitl	h f	ive	a	dde	ers	a	nd	fiv	e ı	mu	lltip	olie	ers	wi	th	da	ta	fo	Wa	ard	linç	g
	Cycles	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
0	MUL R3 , R1 , R2	F	D	E1	E2	E3	E4	E5	E6	W																	
1	ADD R5 , R4 , R3		F	D	- 1	- 1	-	- 1	- 1	E1	E2	E3	E4	W													
2	ADD R6 , R4 , R1			F	- 1	- 1	-	ı	- 1	1	D	E1	E2	E3	E4	W											
3	MUL R7 , R8 , R9										F	D	E1	E2	E3	E4	E5	E6	W								
4	ADD R4 , R3 , R7											F	D	-	- 1	ı	ı	ı	E1	E2	E3	E4	W				
5	MUL R10 , R5 , R6												F	-	-	-	-	-	_	D	E1	E2	E3	E4	E5	E6	W

d. A pipelined machine with one adder and one multipliers without data forwarding:

It takes a total of 32 cycles as shown by the table below:

Α	pipelined r	na	ıcl	nir	ne	W	ith	0	ne	a	do	de	r a	ıno	d c	one	e r	ทเ	ılti	pli	ier	. W	/ith	10	ut	da	ata	a fo	or۱	Na	ırd	lin	g
	Cycles	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
0	MUL R3 , R1 , R2	F	D	E1	E2	E3	E4	E5	E6	W																							
1	ADD R5 , R4 , R3		F	D	- 1	- 1	1	- 1	-	- 1	D	E1	E2	E3	E4	W																	
2	ADD R6 , R4 , R1			F	- 1	-	-	-	-	-	-	D	-	-	-	E1	E2	E3	E4	W													

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3	MUL R7 , R8 , R9						F	-	-	- 1	-	D	E1	E2	E3	E4	E5	E6	W									
4	ADD R4 , R3 , R7											F	D	-	-	-	1	1	1	D	E1	E2	E3	E4	W			
5 1	MUL R10 , R5 , R6												F	-	-	-	1	1	-	1	D	E1	E2	E3	E4	E5	E6	W

e. A pipelined machine with one adder and one multipliers with data forwarding:

It takes a total of 29 cycles as shown by the table below:

	A pipelined	n b	าล	chi	ne	e W	ith	0	ne	a	dd	er	an	d	on	e r	nu	ltip	olie	er v	wit	h (da	ta	for	Wa	arc	lin	g	
	Cycles	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
0	MUL R3 , R1 , R2	F	D	E1	E2	E3	E4	E5	E6	W																				
1	ADD R5 , R4 , R3		F	D	-	-	-	-	-	E1	E2	E3	E4	w																
2	ADD R6 , R4 , R1			F	-	-	-	-	-	-	D	-	-	E1	E2	E3	E4	W												
3	MUL R7 , R8 , R9										F	- 1	-	-	D	E1	E2	E3	E4	E5	E6	W								
4	ADD R4 , R3 , R7														F	D	-	1	1	1	1	E1	E2	E3	E4	w				
5	MUL R10 , R5 , R6															F	-	-	-	-	-	-	D	E1	E2	E3	E4	E5	E6	w

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