Assignment Project Exam Help

Add WeChat powcoder

L16_1 PipelineAssignment Project Exam Help
Performance Data-Hazards

EECS 370 – Introduction to Computer Organization – Fall 2020 Add We Chat powcoder

Assignment Project Exam Help Learning Objectives Add WeChat powcoder

 To identify and apply performance metrics related to data hazards for the LC2K pipeline datapath.

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Assignment Project Exam Help Building with Pipelines Add WeChat powcoder



- CPI for pipelining:
 - 1 (ideal case no stalls)
 - > 1 (reality, dependent Brown Help
- What if we want to inhorove porformance?
 - Want CPI as low as possible lower than 1 Add WeChat powcoder
- Use Parallelism
 - Instruction Level Parallelism (ILP) Within task
 - Thread Level Parallelism (TLP) Having many tasks
 - Data Level Parallelism (DLP) Many tasks with same instructions

Assignment Project Exam Help LC2K Pipeline Summary

Fetch	Decode	Execute	Memory	WB
PC read		Need register values	Branches resolved	Register values produced

Data hazards

- Hazard exists if producer-consumer of a register within a 2-instruction window
 Assignment Project Exam Help
 - Note for project, the window is 3 instructions
- Detect and stall insertensigh AND 18 to producer and consumer
- Detect and forward
 - Handles all cases except LW-USE, need 1 noop here

Control hazards

- Detect and stall needs 3 noops inserted after each branch
- Predict and squash
 - Zero noops if predict correctly
 - 3 if predict incorrectly

Assignment Project Exam Help Review: Basic Performance Equation Add WeChat powcoder



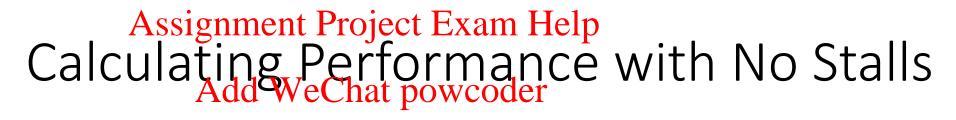
- Execution time (Time/Program) =
 - # of instr (I/P) x CPI (C/I) x cycle time (T/C)

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Multi-cycle decreases dyclestime but decreases CPI

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- Pipelining decreases CPI
 - Approaches 1.0 if no stalls (hazards that are fixed by stalling)





How many cycles does this code take to execute?

add 1 2 3 nor 1 4 5 add 4 6 7 Assignment Project Exam Help

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What value is written to the ALU result field of the Mem/WB pipeline register at the end of cycle 5.

Assignment Project Exam Help Calculating Performance with No Stalls Add WeChat powcoder



How many cycles does this code take to execute?

No stalls - Final WB @ cycle 7

add	1	2	3
nor	1	4	5
add	4	6	7

	Time:	1	2	3	4	5	6	7	8
P	ssignment l	roje	GbEX	am I	MEP	WB			
	norhat 4.5/pc	OWCO	der.c	d Om	EX	ME	WB		
	add 3 5 6			IF	D	EX	ME	WB	

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What value is written to the ALU result field of the Mem/WB pipeline register at the end of cycle 5.

nor result

Assignment Project Exam Help Performance: Data Hazards - Detect and Stall Add WeChat powcoder

How many data hazards are there in this code?

add 1 2 3 nor 3 4 5 add 3 5 6

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How https://stplocycled@rweome
detect and stall to handle the
hazards! WeChat powcoder

Time:	1	2	3	4	5	6	7	8	9	10	11
add 1 2 3	IF	ID	EX	ME	WB						
nor 3 4 5											
add 3 5 6											

Assignment Project Exam Help Performance: Data Hazards - Detect and Stall Add WeChat powcoder

add 1 2 3 nor 3 4 5

How many data hazards are there in this code?

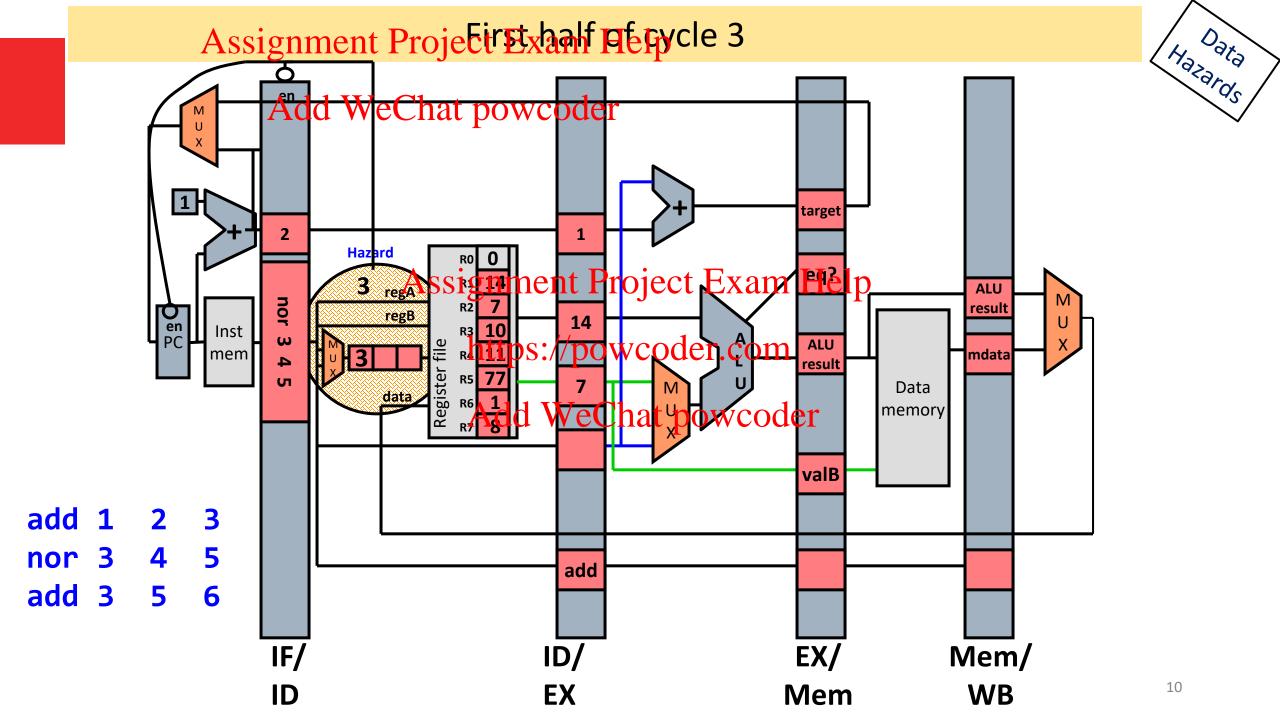
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How https:stploweled frwe use detect and stall to handle the hazards! WeChat powcoder

Stall: 4 cycles

Total: 11 cycles

Time:	1	2	3	4	5	6	7	8	9	10	11
add 1 2 3	IF	ID	EX	ME	WB						
nor 3 4 5		IF	ID*	ID*	ID	EX	ME	WB			
add 3 5 6			IF*	IF*	IF	ID*	ID*	ID	EX	ME	WB



Assignment Project Exam Help Performance: Data Hazards - Detect and Forward Add WeChat powcoder

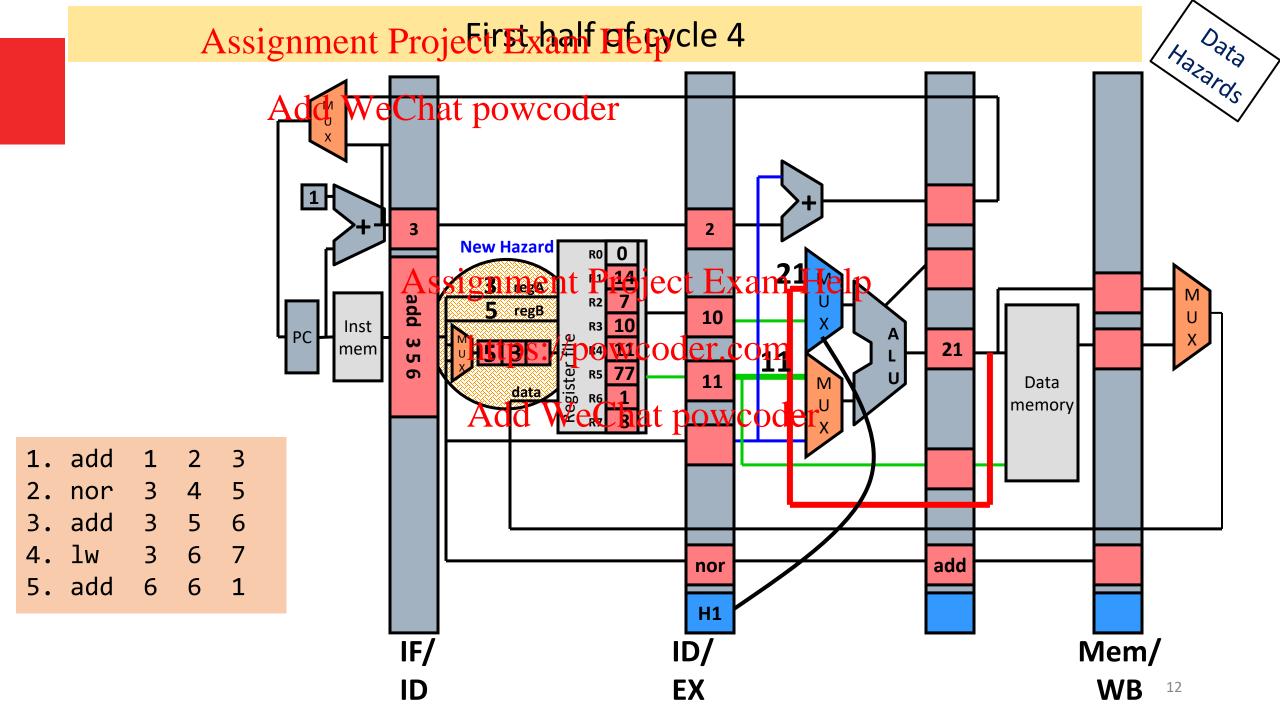
Performance

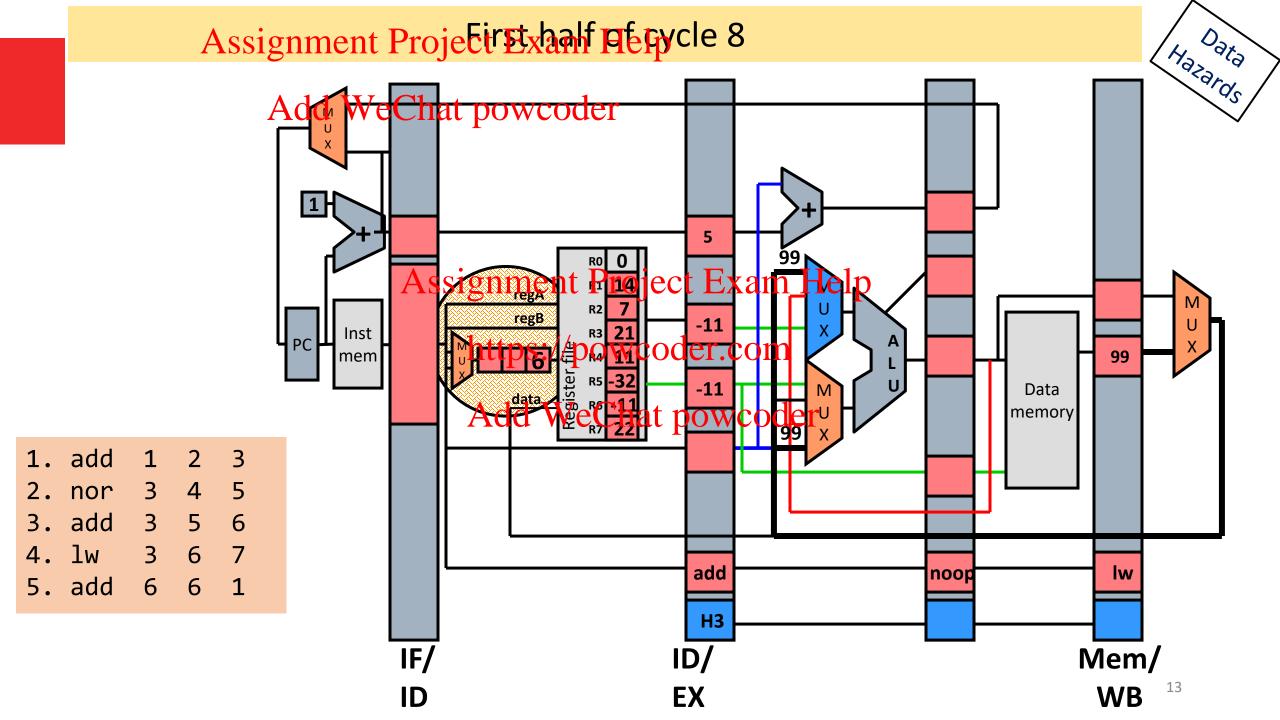
Where do the values for the second add instruction come from?

add	1	2	3
nor	3	4	5
add	3	5	6
lw	3	6	7
add	6	6	1

	Time:	1	2	3	4	5	6	7	8	9	10	11
Assi	eddhent ³ Pr	·biec	PE	x ^E Am	Me	1WB						
	nor 3 4 5	3				-r						
]	natos:5/190v	VCO	der.	com								
	lw 367	,										
	Add WeC	hat	pow	cod	er							

How many stall cycles on the LC2K pipelined datapath with data forwarding from lecture?





Assignment Project Exam Help Performance: Data Hazards - Detect and Forward Add WeChat powcoder

Performance

Where do the values for the second add instruction come from?

From Mem/WB and EX/Mem

add	1	2	3
nor	3	4	5
add	3	5	6
1w	3	6	7
add	6	6	1

	Time:	1	2	3	4	5	6	7	8	9	10	11
Ass	add 123 100ment I	or Toi		EX 21	ME	WB						
	nor 3 4 5		IF	ID	EX	ME	WB					
	attes://po	owc	odei	r! © Oj!:		EX	ME	WB				
	lw 367				IF	ID	EX	ME	WB			
	addded6We	Cha	t po	WCC	der	IF	ID*	ID	EX	ME	WB	

Data forward

How many stall cycles on the LC2K pipelined datapath with data forwarding from lecture?

1 stall for lw → add

Assignment Project Exam Help Logistics Add WeChat powcoder

- There are 3 videos for lecture 16
 - L16_1 Pipeline-Performance_Data-Hazards
 - L16_2 Pipeline-Parsoirgmancent Controlett Transforment Help
 - L16_3 Pipeline-Performance https://powcoder.com
- There is one worksheet Afdd Lect Collect for the form of the collection of the col
 - 1. L16 worksheet

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L16_2 PipelineAssignment Project Exam Help
Performance Control-Hazards

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Assignment Project Exam Help Learning Objectives Add WeChat powcoder

• To identify and apply performance metrics related to control hazards for the LC2K pipeline datapath.

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Performent: Project Form Hazlards — Speculate and Squash Add WeChat powcoder



 How many cycles are saved if you perform speculate and squash for the following code (assume that branches are predicted to be not

```
taken)?

add 1

beq 1

nor 6

add 3

4

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https://powcoder.com

nor 6

4

5

Assignment Project Exam Help

beq 1

5

5

4

5

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```

Assume the branch is taken: How many cycles to execute this code?

Assume the branch is not taken: How many cycles execute this code?

Performance: Project Form Land and Squash Add WeChat powcoder

add 3 4 5 https://powcoder.com

nor 6 4 1



Branch prediction not taken

add 1 2 3 beq 1 5 1 nor 6 4 1 add 3 4 5

Time:	1	2	3	4	5	6	7	8	9	10	11
add 1 2 3	IF	ID	EX	ME	WB						
beq 14 5 5 1 21	nme	nt P	roie	ct F	Exar	n He	eln				

Branch taken

Add WeChatppowcodetaken

Time:	1	2	3	4	5	6	7	8	9	10	11
add 1 2 3	IF	ID	EX	ME	WB						
beq 1 5 1											
nor 6 4 1											
add 3 4 5											

Performance: Project Form Hazlards — Speculate and Squash Add WeChat powcoder



Branch prediction

not taken

add 1 2 3 beq 1 5 1 nor 6 4 1 add 3 4 5

Branch taken

Time:	1	2	3	4	5	6	7	8	9	10	11
add 1 2 3	IF	ID	EX	ME	WB						
beq 14551g1	nme	nt P	rbie	ex E	M ar	WBI	elp				
nor 6 4 1					EX		1				
add 3 4 5 h1	tps:	//po	WCC)V(. Det	N F	ID	EX	ME	WB	

Add WeChatapawcadetaken

Time:	1	2	3	4	5	6	7	8	9	10	11
add 1 2 3	IF	ID	EX	ME	WB						
beq 1 5 1		IF	ID	EX	ME	WB					
nor 6 4 1			IF	ID	EX	ME	WB				
add 3 4 5				IF	ID	EX	ME	WB			

Assignment Project Exam Help Performance: Control Hazards — Detect and Stall Add WeChat powcoder

Performance Performance

Branch taken

Same code, detect and stall

add	1	2	3
beq	1	5	1
nor	6	4	1
add	3	4	5

Time:	1	2	3	4	5	6	7	8	9	10	11
add 1 2 3	IF	ID	EX	ME	WB						
beq 14 5 5 1 21	nme	nt P	rbie	€¥ E	L M an	NBI (elp				
nor 6 4 1			IF*	IF*	IF*		1				
add 3 4 5 h1	tps:	//po	WCC	oder	.cor	n f	ID	EX	ME	WB	

Add WeChatepawcodetaken

Time:	1	2	3	4	5	6	7	8	9	10	11
add 1 2 3	IF	ID	EX	ME	WB						
beq 1 5 1		IF	ID	EX	ME	WB					
nor 6 4 1			IF*	IF*	IF*	IF	ID	EX	ME	WB	
add 3 4 5							IF	ID	EX	ME	WB

Performent: Project Form Hazlards — Speculate and Squash Add WeChat powcoder



 How many cycles are saved if you perform speculate and squash for the following code (assume that branches are predicted to be not

```
taken)?

add 1

beq 1

nor 6

add 3

4

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beq 1

https://powcoder.com

nor 6

4

5

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beq 1

5

https://powcoder.com

add 3

4

5

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```

Assume the branch is taken: How many cycles to execute this code?

```
3 instructions + 3 stalls + 4 to empty pipe = 10 cycles
```

Assume the branch is not taken: How many cycles execute this code?
 4 instructions + 4 to empty pipe = 8 cycles

Assignment Project Exam Help Performance: Control Hazards I Add WeChat powcoder



Assume halt is resolved in WB stage

```
Assume the first branch is taken 50% of the add 1 2 3 time and the loop iterates 100 times and beq 1 5 1 forwarding for all data hazards.

1. How many cycles does the code take add 3 4 5 assuming detect and stall fortigential by the box oder. For the loop iterates 100 times and beq 1 5 1 forwarding for all data hazards.

1. How many cycles does the code take add 3 4 5 hazards?

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```

Assignment Project Exam Help Control Hazards - Stall Add WeChat powcoder

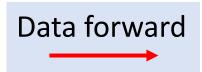


```
beq
                                    10
                   add
                      Assignment Project Exam Help
      time
                           https://powcoder.com
              decode execute Androw exchate powcoder
beq
        fetch
add
               fetch*
                     fetch*
                             fetch*
                                     fetch
                                     OR
                      Branch target
                                     fetch
                      address
```

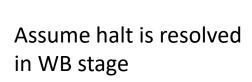
Assignment Project Exam Help Time Graph — Detect and Forward Add WeChat powcoder



Time:	1	2	3	4	5	6	7	8	9	10	11	12	13
add 1 2 3	IF	ID	EX	ME	WB S191	nme	ent I	Proj	ect	Exa	m I	Help)
nor 3 4 5		IF	ID	EX	Mh	tps	://pc)WC	ode	r.cc	m		
add 6 3 7			IF	ID	EXA	dd	We	Cha	t po	WC(ode	r	
lw 3 6 10				IF	ID	EX	ME	WB					
sw 6 2 12					IF	ID*	ID	EX	ME	WB			



Assignment Project Exam Help Performance: Control Hazards I





```
Assume the first branch is taken 50% of the add 1 2 3 time and the loop iterates 100 times and beq 1 5 1 forwarding for all data hazards.

1. How many cycles does the code take assuming detect and stall fortion wooder beam 5 hazards?

Add WeChat powcoder
```

```
# Instructions = 100*(0.5*5 + 0.5*4) + 1 = 451

Time = 451 + load stalls + branch stalls + empty pipe

Time = 451 + 100*0.5*1 +

Time = 451 + 100*0.5*1 + (100*3 + 100*3) + 4

Time = 1105
```

Assignment Project Exam Help Performance: Control Hazards II Add WeChat powcoder

Assume halt is resolved in WB stage

Assume the first branch is taken 50% of the add 1 2 3 time and the loop iterates 100 times and beq 1 5 1 forwarding for all data hazards.

2. How many cycles does the code take add 3 4 5 assuming speculate and squash where coder beam 5 7 all branches are predicted not taken?

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Pipeline

Assignment Project Exam Help Performance: Control Hazards II Add WeChat powcoder

Assume halt is resolved in WB stage

```
Assume the first branch is taken 50% of the add 1 2 3 time and the loop iterates 100 times and beq 1 5 1 forwarding for all data hazards.

2. How many cycles does the code take add 3 4 5 assuming speculate and squash where coder. 5 7 all branches are predicted not taken?

Add WeChat powcoder.
```

```
# Instructions = 100*(0.5*5 + 0.5*4) + 1 = 451
Time = 451 + load stalls + branch stalls + empty pipe
Time = 451 + 100*0.5*1 + (100*0.5*3 + 99*3) + 4
Time = 952
```

Assignment Project Exam Help Performance: Control Hazards III Add WeChat powcoder

Assume halt is resolved in WB stage

Assume the first branch is taken 50% of the add 1 2 3 time and the loop iterates 100 times and beq 1 5 1 forwarding for all data hazards.

3. How many cycles does the code take Assignment Project Exam Help add 3 4 5 assuming speculate and squash where coder begin 5 7 -5 backward branches are predicted taken halt and forward branches not taken WETEN) at powcoder Assume that the predictor has a BTB with entries for both branches to start.

Assignment Project Exam Help Performance: Control Hazards III Add WeChat powcoder

Assume halt is resolved in WB stage

Assume the first branch is taken 50% of the add 1 2 3 time and the loop iterates 100 times and beq 1 5 1 forwarding for all data hazards.

3. How many cycles does the code take add 3 4 5 assuming speculate and squash where coder beam 5 7 -5 backward branches are predicted taken halt and forward branches not taken WETEMAT powcoder. Assume that the predictor has a BTB with entries for both branches to start.

```
# Instructions = 100*(0.5*5 + 0.5*4) + 1 = 451
Time = 451 + load stalls + branch stalls + empty pipe
Time = 451 + 100*0.5*1 + (100*0.5*3 + 1*3) + 4
Time = 658
```

Assignment Project Exam Help Performance: Control Hazards IV Add WeChat powcoder

Assume the first branch has the pattern **TTTN** that repeats, and the loop is iterated 100 times and forwarding for all data hazards.

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4. How many cycles does the code take if a 2-bit counter

BTB is used to predict each branch phow many cycles does the code take? Assume initial state of branch predictor counter is "10" (Avdit) WeChat powcoder

Assume halt is resolved in WB stage

add	1	2	3
beq	1	5	1
1w	6	4	1
add	3	4	5
beq	5	7	-5
halt	t		

Assignment Project Exam Help Performance: Control Hazards IV Add WeChat powcoder

Assume the first branch has the pattern **TTTN** that repeats, and the loop is iterated 100 times and forwarding for all data hazards.

Assignment Project Exam Help

4. How many cycles does the code take if a 2-bit counter

BTB is used to predict each branch predictor counter is "10" (WIT) WeChat powcoder beq 1 5 1

Assume halt is resolved in WB stage

```
add 1 2 3
beq 1 5 1
lw 6 4 1
add 3 4 5
beq 5 7 -5
halt
```

```
# Instructions = 100*(0.25*5 + 0.75*4) + 1 = 426
Time = 426 + load stalls + branch stalls + empty pipe
Time = 426 + 100*0.25*1 + 100*0.25*3 + 1*3 + 4
Time = 533
```

beq 5 7 -5 is correct 99 times, then incorrect last iteration

Assignment Project Exam Help Logistics Add WeChat powcoder

- There are 3 videos for lecture 16
 - L16 1 Pipeline-Performance_Data-Hazards
 - L16_2 Pipeline-Performance Control-Hazards Help
 - L16 3 Pipeline-Performance

https://powcoder.com

- There is one worksheet for lecture 16
 Add WeChat powcoder
 - 1. L16 worksheet
- There are optional, supplementary videos with detailed walk-through for the examples
 - These are optional, if you want to see the (repetitious) walk-through for examples in the lecture.

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L16_3 Pipeline-Performance

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Assignment Project Exam Help Learning Objectives Add WeChat powcoder

• To identify and apply performance metrics related to all hazards for the LC2K pipeline datapath.

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Assignment Project Exam Help Classic Performance Problem Add WeChat powcoder



Program with following instruction breakdown:

lw 10%
sw 15%signment Project Exam Help
beq 25% https://powcoder.com

- Speculate "always not-taken" and squash.
 80% of branches not-takenAdd WeChat powcoder
- Full forwarding to execute stage. 20% of loads stall for 1 cycle
- What is the CPI of the program?
- What is the total execution time if cycle frequency is 100MHz?

Assignment Project Exam Help Classic Performance Problem



 Program with following instruction breakdown:

CPI = 1 + 0.10 (loads) * 0.20 (load use stall)*1+ 0.25 (branch) * 0.20 (miss rate)*3

10% lw

CPI = 1 + 0.02 + 0.15 = 1.17

15% signment Project Exam Help 25% Time = 1.17* 10ns = 11.7ns beq

R-type

SW

https://powcoder.com

- Speculate "always not-taken" and squash. 80% of branches not-takenAdd WeChat powcoder
- Full forwarding to execute stage. 20% of loads stall for 1 cycle
- What is the CPI of the program?
- What is the total execution time if cycle frequency is 100MHz?

Assignment Project Exam Help Classic Performance Problem 2.0 Add WeChat powcoder



- Assume branches are resolved at Execute?
 - What is the CPI?
 - What happens to exski gimment Project Exam Help
 - What is the total execution time? https://powcoder.com

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Assignment Project Exam Help Classic Performance Problem 2.0 Add WeChat powcoder



- Assume branches are resolved at Execute?
 - What is the CPI?
 - What happens to exskigimment Project Exam Help
 - What is the total execution time? https://powcoder.com

```
CPI = 1 + 0.10 (loads) *0.20 (load use stall)*1
+ 0.25 (branch) * 0.20 (miss rate)*2

CPI = 1 + 0.02 + 0.1 = 1.12
```

Assignment Project Exam Help Performance: Deeper Pipelines Add WeChat powcoder



- Assume the setup of the previous problem.
- What if we have a 10-stage pipeline?
 - Instructions are fetchessignment Project Exam Help
 - Register file is read at stage 3.
 Execution begins at stage 5.

 - Branches are resolved at staged7.WeChat powcoder
 - Memory access is complete in stage 9.
- What's the CPI of the program?
- If the clock rate was doubled by doubling the pipeline depth, is performance also doubled?

Assignment Project Exam Help Performance: Deeper Pipelines Add WeChat powcoder



- Assume the setup of the previous problem.
- What if we have a 10-stage pipeline?
 - Instructions are fetchessignment Project Exam Help
 - Register file is read at stage 3.

 https://powcoden.com/branch) * 0.20 (N stalls) * ??? + 0.10 (loads) * 0.20 (load use stall) * ???

 - Branches are resolved at staged? We Chat powcoder
 - Memory access is complete in stage 9.
- What's the CPI of the program?
- If the clock rate was doubled by doubling the pipeline depth, is performance also doubled?

Assignment Project Exam Help Performance: Deeper Pipelines Add WeChat powcoder



- Assume the setup of the previous problem.
- What if we have a 10-stage pipeline?
 - Instructions are fetched state of Project Pkath Help
 - Register file is read at stage 3.

- + 0.10 (loads) * 0.20 (load use stall) * 4
- Execution begins at stage https://powcoder.com25 (branch) * 0.20 (N stalls) * 6
- Branches are resolved at stage 7.
- Memory access is complete in stage 5.hat powcoder $\frac{\text{CPI} = 1 + 0.08 + 0.30}{\text{CPI} = 1 + 0.08 + 0.30} = 1.38$
- What's the CPI of the program?
- If the clock frequency was doubled by doubling the pipeline depth, is performance also doubled?

Assignment Project Exam Help Up Next... Caches Add WeChat powcoder

- This is the last lecture on pipeline datapath.
- Next lecture: caches
 - Usually memory hierarchy between the processor and main memory

https://powcoder.com

• Starting Thursday Prof. Satish Narayanasamy will be recording lectures and holding office hours dd WeChat powcoder

It was great to teach you!

Assignment Project Exam Help Logistics Add WeChat powcoder

- There are 3 videos for lecture 16
 - L16_1 Pipeline-Performance_Data-Hazards
 - L16_2 Pipeline-Parsoirgmancent Controlett Transforment Help
 - L16_3 Pipeline-Performance https://powcoder.com
- There is one worksheet Afdd Lect Collect for the form of the collection of the col
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