

# CSE 490/590 Computer Architecture

## Pipelining III

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### Last Time...

- MIPS pipelining
  - 5 stages
- Pipelining hazards
  - Structural hazards
  - Data hazards
  - Control hazards
- Structural hazards
  - Resource conflict
  - MIPS doesn't have it
- Data hazards
  - Stall
  - Bypass

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### Resolving Data Hazards (2)

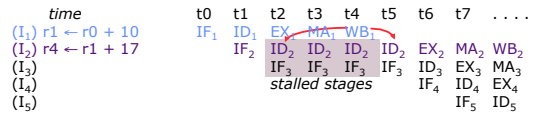
Strategy 2:

Route data as soon as possible after it is calculated to the earlier pipeline stage → *bypass*

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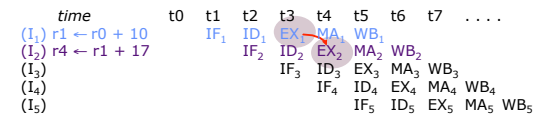
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### Bypassing



Each *stall* or *kill* introduces a bubble in the pipeline ⇒  $CPI > 1$

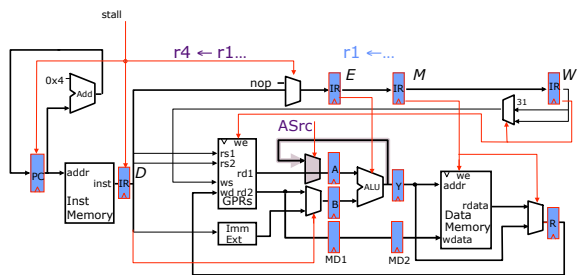
A new datapath, i.e., a *bypass*, can get the data from the output of the ALU to its input



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### Adding a Bypass



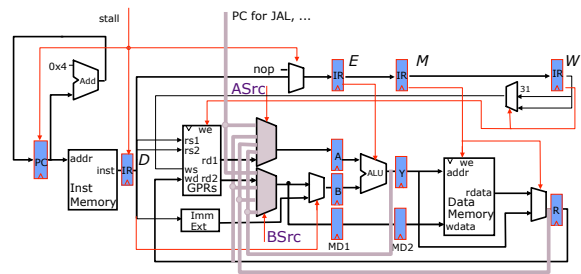
When does *this* bypass help?

...	(I <sub>1</sub> )	r1 ← r0 + 10	r1 ← M[r0 + 10]	JAL 500
(I <sub>2</sub> )	r4 ← r1 + 17	yes	r4 ← r1 + 17	no

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### Fully Bypassed Datapath



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## Resolving Data Hazards (3)

Strategy 3:

Speculate on the dependence. Two cases:

Gessed correctly → do nothing

Gessed incorrectly → kill and restart

.... We'll later see examples of this approach in more complex processors.

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## Control Hazards

• What do we need to calculate next PC?

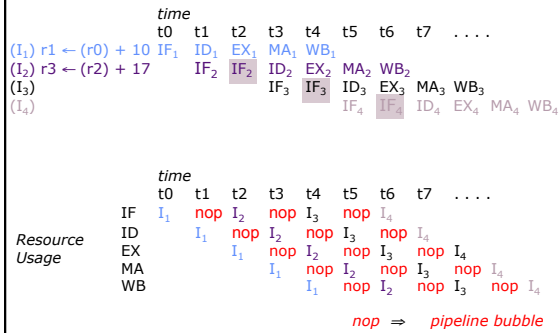
- For Jumps
  - » Opcode, offset and PC
- For Jump Register
  - » Opcode and Register value
- For Conditional Branches
  - » Opcode, PC, Register (for condition), and offset
- For all other instructions
  - » Opcode and PC
  - have to know it's not one of above

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## PC Calculation Bubbles

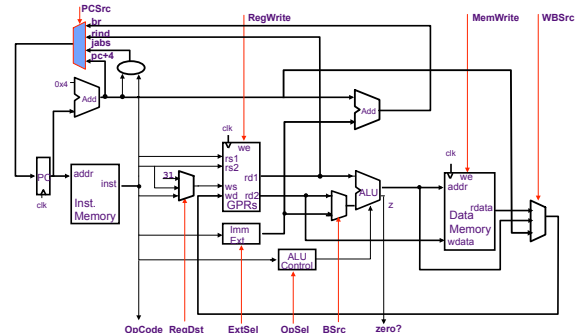
(assuming no branch delay slots for now)



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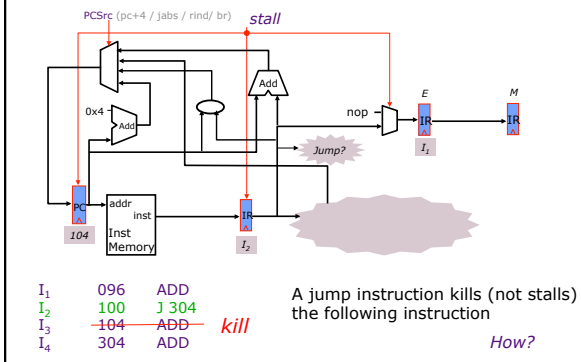
## Harvard-Style Datapath for MIPS



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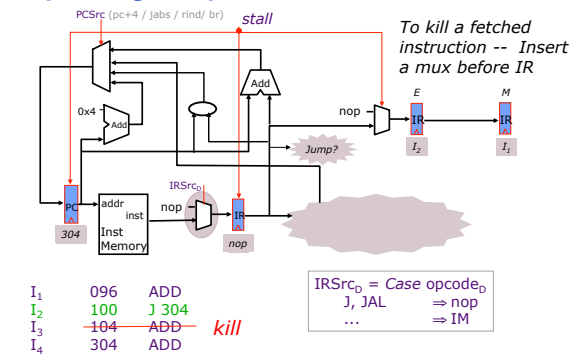
## Speculate next address is PC+4



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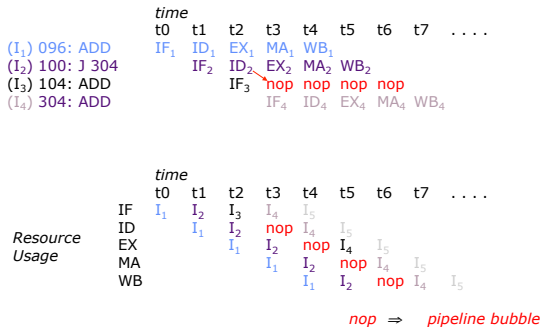
## Pipelining Jumps



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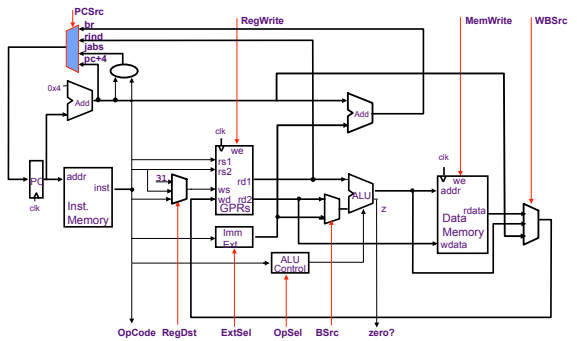
### Jump Pipeline Diagrams



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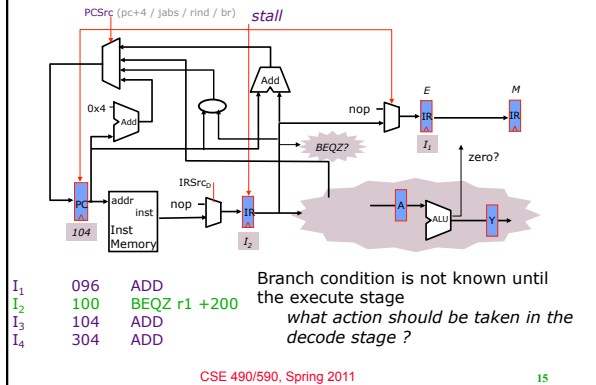
### Harvard-Style Datapath for MIPS



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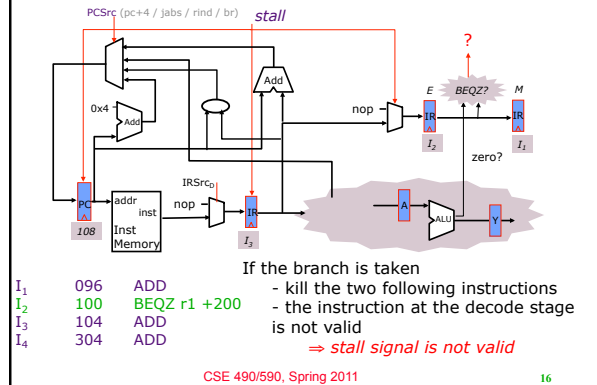
### Pipelining Conditional Branches



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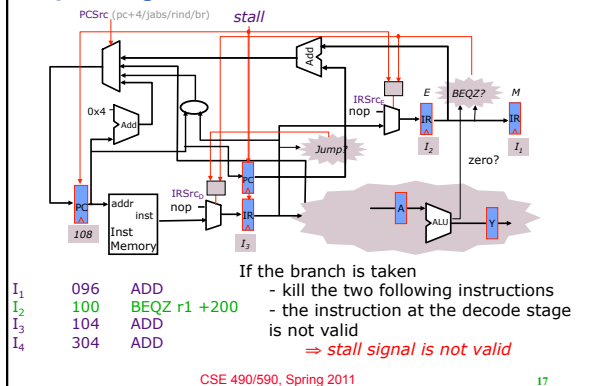
### Pipelining Conditional Branches



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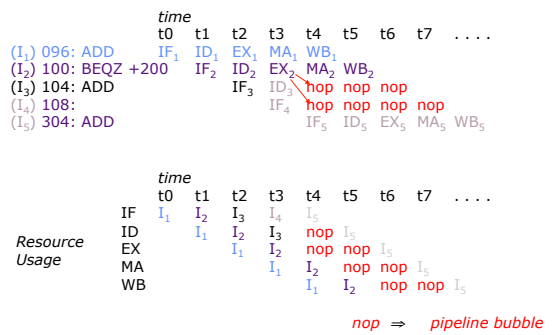
### Pipelining Conditional Branches



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### Branch Pipeline Diagrams (resolved in execute stage)



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## CSE 490/590 Administrivia

- Recitations notes will be up online too.
- Very important to attend
  - Recitations next week & the week after
- Quiz 1
  - Fri, 2/4
  - Closed book, in-class
  - Includes whatever we cover until today
- Next class (Wed): review

## Acknowledgements

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