

RISC-V Processor Design

Building Tiny Veda

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Lecture 8

Agenda

- Multiplier
- Pipeline Stalls
- Divider

Multiplier

- Combinatorial units that takes two operands and produces a result
- If the operands are XLEN, the result is 2XLEN
 - This is why we have lower and upper halves of the result in RV Instructions

Multiplier

- Reality of multipliers is extremely complex
 - Booth Encoding + Wallace Tree/Dadda Tree (for more advanced courses, link in the description)
- We will implement a simple one that respects a the real latency of a multiplier
 - Three cycles latency, fully pipelined

Pipeline Stalls

- Even when this simple multiplier, we need to stall the pipeline
- Suppose this sequence of instructions:

```
mul x1, x2, x3  
add x4, x5, x6
```

- The first instruction will take 3 cycles to complete
- The second instruction will start only after the first one has finished
- We need to stall the pipeline of the second instruction until the first one has finished, otherwise we execute on commit out of order
- Nothing bad with executing out of order, but commit should be ALWAYS in order

Pipeline Stalls

- Consider this other sequence of instructions:

```
mul x1, x2, x3  
mul x7, x5, x6
```

- Here, we don't want to stall since the unit is fully pipelined and we can send the two instructions in

Pipeline Stalls

- Consider this other sequence of instructions:

```
mul x1, x2, x3  
mul x4, x1, x6
```

- Here, there's a true dependency between the two instructions
- We need to stall the second instruction until the first one has finished
- Otherwise, we will have a data hazard

Pipeline Stalls for Multiplier

- We need to stall in two cases:
 - i. When the first instruction is a multiply and the second one is not
 - ii. When the first instruction is a multiply and the second one is a multiply and theres a RAW dependency

Divider

- Divider is one of the slowest units you can find in a processor
- Iterative Non-restoring algorithm, 1 quotient bit per cycle --> state machine
- Non-deterministic latency, worst case takes 32 cycles
- I've added a short circuit for the following cases:
 - Divide by zero
 - Divide by one
 - Small Numbers look up table
- All the short circuit close in 1 cycle

Divider Stalls

- There's no way around here, we always need to stall the pipeline until the divider has finished

Divider Architectures

- There's a lot of ways to implement a divider
 - SRT Divider (base-2, base-4, base-8)
 - Newton-Raphson Divider
 - Goldschmidt Divider
- Want to know more? Check out the courses in the link in the description

New Pipeline Architecture



