Project: “LEG” Out-Of-Order CPU Competition

Contributors:

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Disclaimer:

As this competition is a semesterly competition, to promote creativity and unique designs while preventing plagiarism, final codes should not be released online publicly, but can be provided in private if needed.

Description:

- **Designed from scratch a functional RISC-V processor capable of out-of-order execution using register renaming. Utilized SystemVerilog to implement rename-dispatch units, functional units for ALU, a combined pipelined dadda multiplier and Synopsys divider, as well as GShare branch prediction, branch target buffer, as well as a pipelined cache with prefetching. To minimize misprediction penalties we implemented early branch recovery as well as a load-store queue.**

- **1st place** of 36 teams at UIUC, graded on 11 benchmarks like chip area, power usage, runtime, and IPC

- See specific results for team LEG: https://github.com/illinois-cs-coursework/sp24_ece411_.release/blob/_grade/leaderboard_mp_ooo_comp.md

Out-Of-Order Competition Benchmark Tests

Performance Score = Power * (Delay^3) * Area^(1/2)

- RSA Encryption
    - Uses Square-multiply algorithm of exponentiation to perform RSA encryption on small messages
    - Uses modular arithmetic, so heavily benefits from a divider
    - Has strong branch correlation
- DNA Sequence Alignment
    - Computes sequence alignment on two DNA sequences.
    - Has branch correlation
    - Has mostly linear access pattern
- Compression
    - Computes Huffman Encoding
    - Linear data streaming
- Recursive Sudoku Solver
    - Rercursive code
    - Many helper functions
    - Easter egg: This is from ECE 220!
- Physics sim
    - Performs Matrix-Multiplication for mesh transformations, and uses GJK algorithm for collision detection
    - Heavy on arithmetic instructions
    - Many helper functions
    - Computes averages, so benefits from a divider
- FFT
    - Computes approximation of FFT on a signal
    - Recursive
- Graph traversal
    - Random access on a linked data structure
    - Performs computation on each node with strong ILP
    - Easter egg: Performs BitBeast operations from your first Midterm!
- Sorting
    - Performs recursive out of place mergesort
    - Using many loads and stores
    - Recursive