Performance Analysis

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testingAddAndNand

Multi-cycle:

IC: 6991

Cycles: 15987

$t_{clk}: \frac{1}{5} t_{clk}$

$$Avg. CPI = \frac{total\ number\ of\ cycles}{total\ number\ of\ instructions} = \frac{15987}{6991} \approx 2.287\ cyc/instr$$

$$exec = IC \times CPI \times t_{clk}$$
$$= 6991 \times 2.287 \times \frac{1}{5} t_{clk}$$
$$= 3197.683 \times t_{clk}$$

Single-cycle:

IC:6991

Cycles: 6991

$t_{clk}: t_{clk}$

$$Avg. CPI = \frac{total\ number\ of\ cycles}{total\ number\ of\ instructions} = \frac{6991}{6991} = 1\ cyc/instr$$

$$exec = IC \times CPI \times t_{clk}$$
$$= 6991 \times 1 \times t_{clk}$$
$$= 6991 \times t_{clk}$$

$$speedup = \frac{perf(multi)}{perf(single)} = \frac{exec(single)}{exec(multi)} = \frac{6991 \times t_{clk}}{3197.683 \times t_{clk}} \approx \mathbf{2.186x}$$

The multi-cycle design is 2.186x faster than the single-cycle machine when executing a large number of adds and nands.

testingLwAndSw

Multi-cycle:

IC: 13976

Cycles: 62888

$t_{clk}: \frac{1}{5} t_{clk}$

$$Avg. CPI = \frac{total\ number\ of\ cycles}{total\ number\ of\ instructions} = \frac{62888}{13976} \approx 4.500\ cyc/instr$$

$$exec = IC \times CPI \times t_{clk}$$
$$= 13976 \times 4.500 \times \frac{1}{5} t_{clk}$$
$$= 12578.4 \times t_{clk}$$

Single-cycle:

IC:13976

Cycles: 13976

$t_{clk}: t_{clk}$

$exec = IC \times CPI \times t_{clk}$

$= 13976 \times 1 \times t_{clk}$

$= 13976 \times t_{clk}$

$$speedup = \frac{perf(multi)}{perf(single)} = \frac{exec(single)}{exec(multi)} = \frac{13976 \times t_{clk}}{12578.4 \times t_{clk}} \approx \mathbf{1.11x}$$

The multi-cycle design is 1.11x faster than the single-cycle design when executing a large number of lw and sw instructions. The speedup is less than the speedup for the other tests because the number of cycles (5) per lw and sw reduces the advantage of the clock being faster on the multi-cycle design.

testingBeq

Multi-cycle:

IC: 7997

Cycles: 22996

$t_{clk}: \frac{1}{5} t_{clk}$

$$Avg.CPI = \frac{total\ number\ of\ cycles}{total\ number\ of\ instructions} = \frac{22996}{7997} \approx 2.876\ cyc/instr$$

$exec = IC \times CPI \times t_{clk}$

$= 7997 \times 2.876 \times \frac{1}{5} t_{clk}$

$= 4599.8744 \times t_{clk}$

Single-cycle:

IC:7997

Cycles: 7997

$t_{clk}: t_{clk}$

$exec = IC \times CPI \times t_{clk}$

$= 7997 \times 1 \times t_{clk}$

$= 7997 \times t_{clk}$

$$speedup = \frac{perf(multi)}{perf(single)} = \frac{exec(single)}{exec(multi)} = \frac{7997 \times t_{clk}}{4599.8744 \times t_{clk}} \approx \mathbf{1.739x}$$

The multi-cycle design is 1.739x faster than the single-cycle design when executing a large number of beq instructions.

testingJalr

Multi-cycle:

IC: 7001

Cycles: 14020

$t_{clk}: \frac{1}{5} t_{clk}$

$$Avg.CPI = \frac{total\ number\ of\ cycles}{total\ number\ of\ instructions} = \frac{14020}{7001} \approx 2.003\ cyc/instr$$

$exec = IC \times CPI \times t_{clk}$

$= 7001 \times 2.003 \times \frac{1}{5} t_{clk}$

$= 2804.6006 \times t_{clk}$

Single-cycle:

IC:7001

Cycles: 7001

$t_{clk}: t_{clk}$

$exec = IC \times CPI \times t_{clk}$

$= 7001 \times 1 \times t_{clk}$

$= 7001 \times t_{clk}$

$$speedup = \frac{perf(multi)}{perf(single)} = \frac{exec(single)}{exec(multi)} = \frac{7001 \times t_{clk}}{2804.6006 \times t_{clk}} \approx \mathbf{2.496x}$$

The multi-cycle design is 2.496x faster than the single-cycle design when executing a large number of jalr instructions.