0907432 Computer Design (Fall 2020)

Homework 1

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P1. A multicore processor has a clock rate of 3.0 GHz and voltage of 1.0 V. Assume that, on average, it consumes 75 W of static power and 30 W of dynamic power when all its six cores are active. It executes a program consisting of 10^{10} instructions on a single core with the following instruction mix.

Instruction Type	CPI	Frequency
Arithmetic	1.0	50%
Load/store	2.0	40%
Branch instructions	1.5	10%

a) Find the total execution time for this program on one core.

CPU Time = IC × Σ (CPI × freq) ÷ clock rate
= 10^{10} × (1.0 × 0.5 + 2.0 × 0.4 + 1.5 × 0.1) ÷ 3 × 10^{9}
= 10 × (0.5 + 0.8 + 0.15) ÷ 3
= 10 × 1.45 ÷ 3 = 4.833 seconds

b) When this program is parallelized and run on the six cores, the number of arithmetic and load/store instructions per core is divided by 4, but the number of branch instructions remains the same. What is the execution time of the parallel program?

Exec. Time = IC × Σ (CPI × freq) ÷ clock rate
= 10^{10} × (1.0 × 0.5÷4 + 2.0 × 0.4÷4 + 1.5 × 0.1) ÷ 3 × 10^{9}
= 10 × (0.125 + 0.2 + 0.15) ÷ 3
= 10 × 0.475 ÷ 3 = 1.583 seconds

c) What is the speedup of the parallel program?

Speedup = 4.833 ÷ 1.583 = 3.05

d) Assumes that the power consumed is proportional to the number of active cores. What are the energies consumed by the serial program on the single core and the parallel program on the six cores?

Energy of the serial program = Exec. Time × Power
= 4.833 × (75 + 30) ÷ 6
= 85 Joules
Energy of the parallel program = Exec. Time × Power
= 1.583 × (75 + 30)
= 166 Joules

e) What is the average capacitive load of this processor when the six cores are active?

Dynamic Power = ½ × Capacitive load × Voltage^2 × Frequency
30 = ½ × Capacitive load × 1.0^2 × 3×10^{9}
Capacitive load = 2 × 30 ÷ 3×10^{9} = 20 nF (nano Farads)

f) What is the average current drawn by this processor when the six cores are active?

Power = Current × Voltage
Current = (75+30) ÷ 1.0 = 105 Amperes