EECS 151/251A Problem Set 1

Due Monday, Jan 29th, 2024

Problem 1: Moore's Law [30 pts]

Consider state-of-the-art processor chips from the 1970's, 1980's, 1990's, 2000's, and after 2010. Choose a processor from each period. (You may choose which every processor you like, but make sure they are spaced out by around 10 years. Use of Wikipedia or WikiChip is acceptable.)

1. For each look up the approximate number of transistor per chip. Plot the number of transistors per chip over time, with a log scale on the y-axis [15 pts].
2. On another set of axis, plot the clock frequency of each over time (on a log plot) [15 pts].

Problem 2: Pareto Optimality [30 pts]

Frequency (f)	Chip Capacitance (C)	Cost
2 GHz	1 nF	\$10
2 GHz	3 nF	\$25
4 GHz	10 nF	\$25
4 GHz	5 nF	\$25
4 GHz	6 nF	\$50
1 GHz	15 nF	\$50
5 GHz	3 nF	\$100
5 GHz	2 nF	\$135

After performing a design exploration, John has found the follow options for processors for his robotics project. He wants to maximize clock frequency while minimizing cost. His robot is only able to efficiently cool 30W. Assume that each processor has $V_{dd} = 1.5V$. Pick which points are on the frequency-cost Pareto Optimal frontier and meet his power constraints. (You can use the following equation for chip power: $P = \frac{1}{2} \cdot C \cdot V_{dd}^2 \cdot f$)

Problem 3 - Dennard Scaling [30 pts]

Let us assume that we live in a world with perfect Dennard Scaling. I currently have access to a chip built with transistors with a width of 5nm. The chip has operational frequency of 2.5 GHz, V_{dd} of 1.5V, and a performance of 20TFLOPs/sec (FLOPs is Floating Point Operations). The total chip consumes 20W and has 10 billion transistors.

1. If I switch to the exact same chip but upgrade to a 4nm width transistor, what will the following values be in order to continue Dennard Scaling [15 pts]:

(a) Voltage

(b) Frequency

(c) Power per transistor

(d) Total Power of the Chip

(e) Performance (FLOPs/sec) (assume that the FLOPs per cycle scales proportionally to the the number of transistors)

2. How small should the transistor be in order for me to run my 50 TFLOP workload in less than one second? [15 pts]

Problem 4 - Technology Survey [10 pts]

Take a look at your laptop/desktop computer. What processor is it using? Which technology node was it designed in (14 nm, 12 nm, 7 nm, etc.)? How many cores does it have? Does it have dedicated hardware accelerator blocks?