EEL 6764 Principles of Computer Architecture
Homework #1

1 Problems

1. Decide whether each of the following questions is true or false. Add brief explanation (1-2 sentences) to get all credits. (10pt each)

   (a) Hardware enhancements that improve performance always increase energy-efficiency.
   False Adding more HW such as cache improves performance, but increases energy consumption.

   (b) The reliability of the system is limited by the weakest component even if some components are made 10X more reliable.
   True

   (c) You can afford to not pay attention to Amdahl?s law because it is not applicable anymore.
   False

   (d) The operating clock frequency of a processor is a good metric to measure its performance.
   False We need to consider IC and CPI in addition to frequency.

   (e) The future of Moore's law (in terms of performance scaling) is mostly dependent on parallelization of programming rather than blindly adding multiple cores in chip.
   True No performance improvement if SW cannot be executed in parallel on a multi-core processor. Also, domain-specific architecture is another promising direction for performance.

2. Complete the following problems at the end of chapter 1 of the textbook.

   1.8 (a) Nothing on dynamic energy, or you could save some static energy due to leak current.
   (b) $Energy = 0.5 \times load \times V^2$. Changing the frequency does not affect energy?only power. So the new energy is $0.5 \times load \times (0.5 \times V)^2$, reducing it to about 1/4 the old energy.

   1.9 (a) 60%
   (b) The original power is 90% of the max power. New power is $0.4*0.9+0.6\times0.2 = 0.48$, which means $0.9 - 0.48 = 42\%$ savings.
   (c) $Power \approx load \times V^2 \times Frequency$. By reducing V by 20% and frequency by 40%, the new power is $load \times (0.8 \times V)^2 \times (0.6 \times Frequency) = (0.64 \times 0.6) \times Power = 0.384 \times Power$. This translates to 61.6% power savings.
   (d) $Power_{new} = (0.4 + 0.3 \times 0.2) \times Power_{orig} = 0.46 \times Power_{orig}$. This means 54% savings.

   1.12 (b) By Amdahl's law,

$$2 = \frac{1}{(1-x) + \frac{x}{20}} \quad \Rightarrow \quad x = \frac{10}{19} = 0.526$$

   (c) $x = \frac{10}{19}$ is the portion that now executes 20 times faster.

$$\frac{x/20}{1 - x + x/20} \approx 5.3\%$$

(d) With two units, the new execution time is

$$0.5 + 0.5(\frac{0.1}{20} + \frac{0.9}{2 \times 20}) \approx 0.514 \quad \Rightarrow \quad \text{speeup} = 1/0.514 \approx 1.95$$

With four units, the new execution time is

$$0.5 + 0.5(\frac{0.1}{20} + \frac{0.9}{4 \times 20}) \approx 0.51 \quad \Rightarrow \quad \text{speeup} = 1/0.51 \approx 1.96$$

1.14 (a) $\frac{1}{0.8+0.2/2} = 1.11$

(b) $\frac{1}{0.7+0.2/2+0.1\times1.5} = 1.05$

(b) Percentage of time spent on FP: $\frac{0.2/2}{0.7+0.2/2+0.1\times1.5} = 10.5\%$, percentage of time time spent on data cache is $\frac{0.1\times1.5}{0.7+0.2/2+0.1\times1.5} = 15.8\%$

1.16 (a) $\frac{1}{0.2+0.8/N}$

(b) $\frac{1}{0.2+0.8/8+0.005\times8} = 2.94$