Homework – Chapter 10

Upload to GradeScope – instead of filling in my template, you will be given a chance to select regions of your submission that contain your answer.

For this series of two questions, you are advised to setup an excel spreadsheet that has all of these values in cells, so that you can change cell values and recalculate each of the numbers (read question 2 before solving question 1 and you'll see what I mean):

1. Compute the effective CPI for the computer system with paging. The base CPI for a program is 0.6, including 20% loads and stores, and before paging is enabled. The computer uses a fast disk drive that has an average latency of 1.25ms, transfers data at 200GB/sec, and is connected to a fast SATA-3 6bps bus. The operating system adds 10,000 *instructions* to each paging request. The CPU runs at 2.8GHz. The page size is 4KB. The main memory 'hits' at 99.9995% accuracy.

$$T_{read} = \frac{1s}{204800KB} * \frac{4KB}{\square} * \frac{1000ms}{1s} = \frac{4000ms}{204800} = 0.02ms$$

$$T_{seek} = 1.25ms$$

$$T_{ctrl} = \frac{1s}{6 \times 10^9 b} * \frac{10b}{B} * \frac{4096B}{\square} * \frac{1000ms}{1s} = \frac{40960ms}{6 \times 10^9} = 0.06ms$$

$$T_{total} = 1.25 + 0.06 + 0.0195 = 1.33ms$$

$$\frac{2.8 \times 10^9 Hz}{1s} * \frac{1s}{1000ms} * \frac{1.33ms}{\square} = 3,724,000\ cycles$$

3,724,000 + 10,000 = 3,734,000 cycles

(1.2 * (1 - 0.999995) * 3,734,000) + 0.6 = 23.004 effective CPI

2. You are tasked to improve performance. Compute the speed-up for making the following changes:
   a. CPU upgrade to 3.5GHZ
   b. Doubling memory, reducing the miss-rate by 1/3rd
   c. Choosing a better algorithm that improves locality and reduces unnecessary memory access, so now the program uses 10% loads and stores, and miss rate is reduced by 1/4th.

a.

$$\frac{3.5 \times 10^9 Hz}{1s} * \frac{1s}{1000ms} * \frac{1.33ms}{\square} = 4665000\ cycles$$

4,665,000 + 10,000 = 4,675,000 cycles

(1.2 * (1 - 0.999995) * 4,675,000) + 0.6 = 28.65 CPI

b.

(1.2 * (1 - 0.99999833) * 3,734,000) + 0.6 = 8.083 CPI

c.

(1.1 * (1 - 0.99999875) * 3,734,000) + 0.6 = 5.734 CPI

3. Do a little research, what algorithms do Windows and Linux use for their page replacement strategy.

   Windows uses the LRU-approximation clock algorithm, with a combo of local and global page-replacement policies.

   Linux uses the LRU-approximation clock algorithm as well and also keeps two lists. The active_list and inactive_list.

4. Consider the following page reference string with three frames.
   2.2.1.2.5.3.4.6.7.7.0.5.6.2.3.0.1.7 ??

   Assuming demand paging, with three frames, how many page faults would occur for:
   a) LRU
   b) FIFO
   c) Optimal replacement