CE/CZ 4123 Tutorial 3 – Memory Hierarchy

Question 1

We consider three-layer memory hierarchy, L(i), L(i+1), L(i+2). Their access costs are c1, c2, c3, respectively, with c1<c2<c3. Assume that the data access always checks the existence of data in the order of L(i), L(i+1), and L(i+2). The miss rates of L(i) and L(i+1) are m1 and m2, respectively.

(1) Show that we can estimate the data access cost by c1+m1c2+m1m2c3.

(2) Suppose m1=m2=0.1, show that the over cost is at most 1.11c3.

Question 2

Consider reading data from memory hierarchy consisting of L1-cache, L2-cache, and main memory. Their read access times and hit ratios are given below:

L1-cache:
read access time: 2 nanoseconds; hit ratio: 0.8
L2-cache:
read access time: 8 nanoseconds: hit ratio: 0.9
Main memory:
read access time: 90 nanoseconds.

Please estimate the average data read cost (considering L1, L2 caches and main memory only).

Question 3

Consider the 2nd magic function we mentioned in the lecture, i.e., the magic function that can tell us which pages contain the qualified data. In practice, such magic function is implemented by a certain data structure and hence it incurs some cost when call the function.

Suppose the cost of calling the function is equal to accessing log(N) pages, where N is the number of pages used to store the data. Please give a condition about when is beneficial to use the function.

Question 4

Consider the array-scanning scenario introduced in the lecture. In the lecture, we consider a single query for x>4. In big data systems, many queries are issued together.

Suppose our system needs to handle the following two queries:

1) Select x>4
2) Select x<2

Please explain an efficient way of finishing these two queries together and analyze the number of page accesses needed.