CS310: Advanced Data Structures and Algorithms

Fall 2021 Assignment 2

Due: Sunday, October 2, 2022 on Gradescope

Goal

Practice lists, stacks, Sets and Maps. Some runtime revision.

Questions

1. (a) Suppose a `List<String> list1` has elements "A", "B", "C", and "D". What is returned by:

   1. `list1.iterator().next();`

      "A"

   2. `list1.listIterator().next();`

      "A"

   3. `list1.listIterator(2).next();`

      "C"

   4. `list1.listIterator(4).previous();`

      "D"

   (b) Say what is deleted (or what happens) if next/previous is followed by removed in all of the above operations. Explain (**answer each part separately. That is — assume the list is back intact after you answer part 1, and you start with a fresh copy of a 4-item list for part 2**).

   (c) If we had the following sequence of commands:
   `list1.listIterator(2).next();`
   `list1.listIterator(2).remove();`
   `list1.listIterator(4).previous();`
   What would be returned? What would the list look like following these operations?

2. (a) Say you have a `HashMap<Integer, Integer>` of size 1000 and one search operation takes approximately 1ms. How long will one search take (approximately, on average) on a `HashMap<Integer, Integer>` of size 2000?

   (b) Same question, only `TreeMap<Integer, Integer>`.

   (c) Same, but a `LinkedList<Integer>`.

3. Write Java functions (static methods) that provide the following computed mappings. Do not use Maps, just very simple functions **using character arithmetics**, 1-2 lines should suffice:

   (a) 'a' → 0, 'b' → 1, . . . , 'z' → 25, and also, 'A' → 0, . . . , 'Z' → 25 (in one map). Note that Java supports arithmetic with char variables: ch - 'a' is 0 if char ch is 'a', 1 if it is 'b', and so on.

   (b) "aa" → 0, "ab" → 1, "ac" → 2, . . . , "az" → 25, "ba" → 26, "bb" → 27, . . . , "zz" → (26*26*-1)

(c) The inverse of b: input a number and return a pair of letters (in other words — reverse the directions of the arrows in b).

4. What methods of Map can be implemented in O(1) time with a good hash function and a properly-sized hash table? What methods of Set? Could we implement List with a hash table? Explain.

5. Given below are descriptions of some computer programs. Each of them reads a text file from standard input. For each of them specify:

   - Which APIs would you use. Choose from APIs discussed in class: List / Map / Set
   - Which implementations of the APIs would you use, e.g. Linked List / HashTable / Tree ...
   - Describe how you would use the API to implement the program. Give pseudocode or describe step by step how your program would work. No need to write an actual program.
   - Give the time complexity of your program in terms of the number of words or lines read (whichever is appropriate).

   Try to make your programs as simple and efficient as possible. What the programs should do:

   (a) Print lines of the file in reverse order.

   (b) Print all different words in the file, each word printed exactly once (order not important).

   (c) Print all different words in the file, with each word print how many times it occurs in the file (order not important).