Assignment 4 - Coding Questions

Date: 29th October 2020
Deadline: 12th November 2020, 11:59 PM IST

Instructions:
• Please submit the zip file containing code in cpp and response in pdf format. Also, mention the name and roll number of all group members, and only one submission is required per group.
• For those who have opted for individual submission, you need to mention your name, roll number and group number.
First two questions are of 4 marks each. Rest are for practice.

1. (a). Create an RB Tree with following operations:
   (1) Insertion
   (2) Deletion
   (3) Searching
   (b). Compute the average of numbers in a given range using RB Trees.

2. You are given an array A of N integers and Q queries. Queries are of two types:
   1) l r v -> decrement the values of A between index l and r (both inclusive) by v.
   2) v -> print the index of the leftmost element whose value is less than v. If no such element exists then print -1.

   Input :
   First line contains two integers -> value of N and Q;
   Second line contains N space separated integers -> A[0] A[1] ------ A[N - 1]
   Each of the next Q lines contain queries.
   Query is of type
   1) t l r v
   2) t v
   Here t is the type of query (1 or 2).

   Output
   Print answer for every query of type 2.

   Limits :
   1 <= N, Q <= 100,000
   -1000,000,000 <= A[i] <= 1,000,000,000
   -1000,000,000 <= v <= 1,000,000,000
   0 <= l <= r < N
   1 <= t <= 2

Sample 1
Input :
5 5
2 5 3 7 5
1 2 4 4
2 1
1 0 2 -10
2 -44
2 7

Output :
2
-1
3

Explanation :
2 5 3 7 5 <- initial array
2 5 3-4 7-4 5-4 == 2 5 -1 3 1 <- After query 1
2 <- Answer for query 2 (A[2] = -1 < 1)
2-(-10) 5-(-10) -1-(-10) 3 1 == 12 15 9 3 1 <- After query 3
-1 <- Answer for query 4 (no element of A is less than -44)
3 <- Answer for query 5 (A[3] = 3 < 7)

Following are Practice Questions

3. Consider an empty Red Black tree, given a set of numbers to be inserted. Write a function to return the number of rotations required. [Assume the root is black]
   For example ,
   Input: set, {1,2,3}
   Output: 1
   Explanation:
   - Insert 1
     1
   - Insert 2
     1
     \
     2
   - Insert 3
     1
     \
     2
     \
     3
     - One rotation required to balance

       2
       / \
       1 **3**
     - Recolor root to black
       2
       / \
       1 **3**

   Input: {1,2,3,4,5,6,7}
   Output: 4
   Explanation: When we insert 2,5,7 [inserting 7 requires 2 rotations].

4. The ***join*** operation takes two dynamic sets S_1 and S_2 and an element x such that for any $x_1 \in S_1$ and $x_2 \in S_2$, we have $key[x_1] \le key[x] \le key[x_2]$. It returns a set $S = S_1 \cup \{x\} \cup S_2$. In this problem, we investigate how to implement the join operation on red-black trees.
   implement the operation RB-JOIN(T_1,x,T_2), which destroys T_1 and T_2 and returns a red-black tree $T = T_1 \cup \{x\} \cup T_2$. Let n be the total number of nodes in T_1 and T_2.

5. Harris has build a tree with following properties
    - Each node is either black or red
    - Root is black initially
    - The color of both the children are the same and opposite to that of the parent , i.e, both childs of a red colored node are black and both childs of a black colored node are red.
    - Every node has two children

    Help him perform the following functions

    (a) Write a function to change the color of all the red colored nodes to black and all black colored nodes to red.
    (b) Write a function that takes parameters x,y and color (where color can be red or black), and suppose the color is black, then the function outputs the number of black coloured nodes on the path from node x to node y (Both included).
    [Assume the root of the tree is labelled 1 and for a node labelled i, left child label is 2*i and right child label is 2*i+1].