CP3161 DATA STRUCTURES AND ALGORITHMS LABORATORY

Lab 6– Programs Date :05.8.26

REB BLACK TREE

Question 1: EA database receives keys in either ascending, descending, or random order.

Develop a program to:

1. Insert 20 keys in ascending order.
2. Insert 20 keys in descending order.
3. Insert 20 randomly generated keys.
4. Construct a Red-Black Tree for each case.
5. Calculate:
    - tree height,
    - number of rotations,
    - number of recolorings.
6. Compare the three cases and determine which insertion pattern causes the most balancing operations.

Spot Qn :

An operating system maintains its active processes using a Red-Black Tree, where the Process ID (PID) is used as the key. The system must support dynamic process creation, termination, searching, and reporting.

Initially, the following processes are created:

```
45, 20, 60, 10, 30, 50, 70, 5, 15, 25, 35
```

The following operations are then performed sequentially:

```
INSERT 55
INSERT 65
SEARCH 25
SEARCH 100
DELETE 10
DELETE 60
INSERT 75
DELETE 45
INSERT 40
SEARCH 75
```

Develop a menu-driven program using a Red-Black Tree to perform the following:

1. **Insertion** – Insert a new process while maintaining Red-Black Tree properties. **(3 Marks)**
2. **Deletion** – Terminate a process and correctly handle recoloring, rotations, and double-black cases. **(4 Marks)**
3. **Search** – Search for a given PID and report whether the process exists. **(2 Marks)**
4. **Traversals** – Display the processes using:
    - Inorder
    - Preorder

- Postorder
  (2 Marks)

5. **Minimum and Maximum** – Display the process with the smallest and largest PID. **(2 Marks)**
6. **Tree Height and Black Height** – Calculate and display the height and black height of the Red-Black Tree. **(2 Marks)**
7. **Rotation/ Recoloring Analysis** – Count and display the number of:
   - Left rotations
   - Right rotations
   - Recoloring operations

   performed during the given sequence. **(2 Marks)**
8. **Red-Black Tree Validation** – Implement a function to verify that:
   - The root is black.
   - No red node has a red child.
   - Every root-to-leaf path has the same black height.

   (3 Marks)