BITS Pilani, Pilani Campus
2nd Sem. 2017-18
CS F211 Data Structures & Algorithms
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Lab VIII- (19th Mar. to 24th Mar.)
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Topics: Binary Search Trees and AVL Trees

Exercise 1: [Expected Time: 5 + 40 + 15 + 15 + 25 =105 minutes]

a) Define a tree node with four fields:
   i. a value,
   ii. a pointer to the left sub-tree
   iii. a pointer to the right sub-tree and
   iv. height balance information, which is:
      a) negative if the left subtree is taller,
      b) positive if the right subtree is taller, and
      c) zero if the subtrees are of the same height.

   [Hint: Use bit-fields in struct so that minimum number of bits can be stored. E.g. struct { int x : 2; int y; } will direct a C compiler to assign two bits of storage for integer x. End of Hint.]

   Use a random number generator which returns an integer in range [150, 170]. Call this function 10000 time to get the key value to be inserted in each node of the tree.

b) Implement the binary search tree operations without balancing the height:
   a. *add*
   b. *find* and
   c. *delete* [**Hint**: If the value to be deleted is in a leaf node it can be freed; if it is not in a leaf node, then find the in-order successor, say s, and copy the value of s into this internal node. Then s is available for deletion and the same procedure can be applied recursively. **End of Hint**]

c) Implement the rotate operation of AVL tree such that **rotate(bt, X,Y,Z)**:
   a. orders **X**, **Y**, and **Z** as **a**, **b**, and **c**,
   b. identifies the other children of **X**, **Y**, and **Z** as **T0**, **T1**, **T2**, and **T3** in left-to-right order

   and then balances **bt** by
   a. replacing **Z** with **b** [**Hint**: This would require Z's parent. You may use an additional parameter to the procedure if necessary passing the parent. **End of Hint**.]
   b. setting **a** and **c** as the left and right children – respectively – of **b**
   c. setting **T0** and **T1** as the left and right children – respectively – of **a**
   d. setting **T2** and **T3** as the left and right children – respectively – of **c**

   and returns the modified tree.

d) Modify the *add* operation such that it:
   a. identifies the point of imbalance and
   b. invokes *rotate* with right parameters for height-balancing the binary tree.

e) Modify the *delete* operation such that it:
   a. Identifies the first point of imbalance

b. invokes rotate with right parameter for height-balancing that sub-tree
c. and repeats a. and b until the root of the binary tree is balanced.

Exercise 2: [Expected Time: 15+30 = 45 minutes]

a) [Rank Query]: Implement an inorder traversal operation on binary search trees such that **inorder(bt, K)** returns the Kth smallest element in **bt**.

b) [Range Query]: Implement a rangeSearch procedure that given a binary search tree **bt**, and range **K1..K2** of values, finds all the records in **bt** with keys in the given range. The algorithm would be based on deciding where the key of root value, say r.k, falls with respect to the range:

- If r.k > K2 then (recursively) search for the same range in the left subtree
- If r.k < K1 then (recursively) search for the same range in the right subtree.
- If K1 <= r.k <= K2 then:
  - Search for K1..(r.k) in the left subtree
  - Include r.k in the result
  - Search for (r.k)..K2 in the right subtree

  The result must be either accumulated in a non-local data structure or accumulated in a local data structure and returned from the procedure.