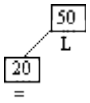
Results from Testing the AVL Tree

Below is a series of images illustrating the state of the tree after inserting nodes in the order given in AVLTreeMain.cpp. Note the effects when the key node is inserted in each of the six cases. The first diagram shows the appearance of the tree after the key node is added and before the rotations are applied. The second diagram shows how the tree looks after the rotations and adjustments to the balanceFactor in each node have been applied.

Testing Case 1 - Ancestor is NULL, i.e. balanceFactor is '=' in all of the predecessors

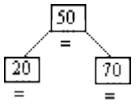
Step 1a
Inserting Node 50

Step 2a
Inserting Node 20

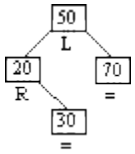


Simple Case 1: Balance factor of ancestor 50 adjusted.

Step 3a
Inserting Node 70



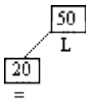
Step 4a
Inserting Node 30



Case 1: Balance factors of ancestors 20 and 50 adjusted.

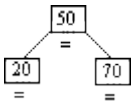
Step 1b
Inserting Node 50

Step 2b
Inserting Node 20

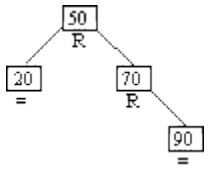


Simple Case 1: Balance factor of ancestor 50 adjusted.

Step 3b
Inserting Node 70



Step 4b
Inserting Node 90

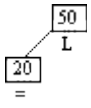


Case 1: Balance factors of ancestors 70 and 50 adjusted.

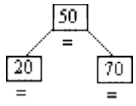
Testing Case 2 - Insertion made in the opposite subtree of the ancestor's balance factor, i.e. ancestor.balanceFactor = 'L' and insertion made in ancestor's right subtree, OR ancestor.balanceFactor = 'R' and insertion made in ancestor's left subtree

Step 1a
Inserting Node 50

Step 2a
Inserting Node 20



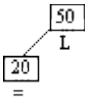
Step 3a
Inserting Node 70



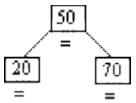
Case 2: Ancestor balance factor was L
insertion made in right sub-tree.
Ancestor's balance factor adjusted.

Step 1b
Inserting Node 50

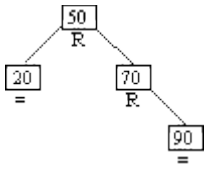
Step 2b
Inserting Node 20



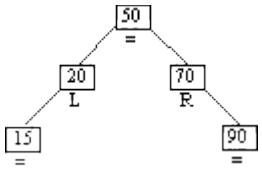
Step 3b
Inserting Node 70



Step 4b
Inserting Node 90



Step 5b
Inserting Node 15



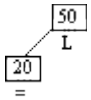
Case 2: Ancestor balance factor was R
insertion made in left sub-tree.
Ancestor's balance factor adjusted.

Testing Case 3 - Ancestor.balanceFactor = 'R' and node inserted is in the right subtree of ancestor's right child.

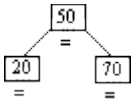
These 5 steps are common to both Case3a and Case3b.

Step 1
Inserting Node 50

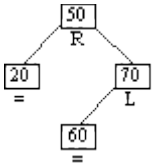
Step 2
Inserting Node 20



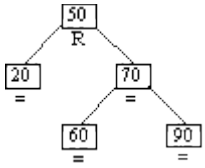
Step 3
Inserting Node 70



Step 4
Inserting Node 60

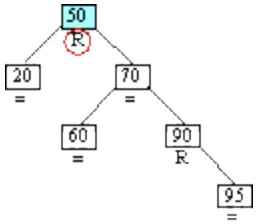


Step 5
Inserting Node 90

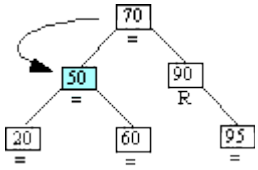


Case3a:

Step 6a
Inserting Node 95



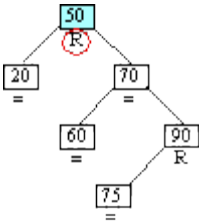
Case 3 triggered



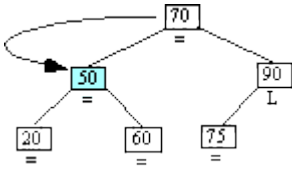
Case 3: Ancestor balance factor was R
insertion made in right sub-tree of ancestor's. right child. Single left rotation of ancestor.

Case3b:

Step 6B
Inserting Node 75



Case 3 triggered



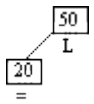
Case 3: Ancestor balance factor was R
insertion made in right sub-tree of ancestor's. right child. Single left rotation of ancestor.

Testing Case 4 - Ancestor.balanceFactor = 'L' and node inserted is in the left subtree of ancestor's left child.

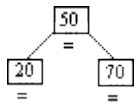
These 5 steps are common to both Case4a and Case4b.

Step 1
Inserting Node 50

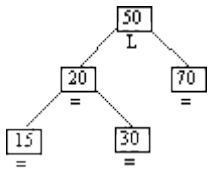
Step 2
Inserting Node 20



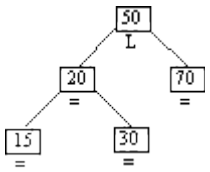
Step 3
Inserting Node 70



Step 4
Inserting Node 30

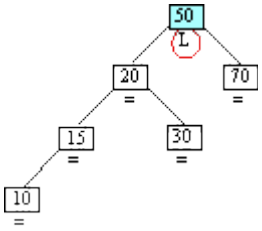


Step 5
Inserting Node 15

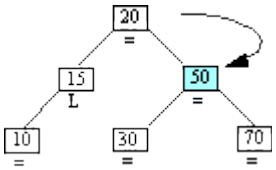


Case4a:

Step 6a
Inserting Node 10



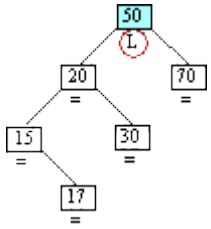
Case 4 triggered



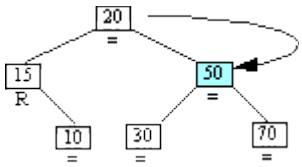
Case 4: Ancestor balance factor was L insertion made in left sub-tree of ancestor's. left child. Single right rotation of ancestor.

Case4b:

Step 6B
Inserting Node 17



Case 4 triggered



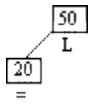
Case 4: Ancestor balance factor was L insertion made in left sub-tree of ancestor's. left child. Single right rotation of ancestor.

Testing Case 5 - Ancestor.balanceFactor = 'L' and node inserted is in the right subtree of ancestor's left child.

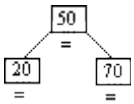
These 5 steps are common to both Case5a and Case5b.

Step 1
Inserting Node 50

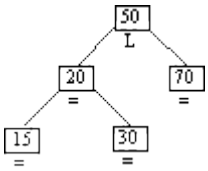
Step 2
Inserting Node 20



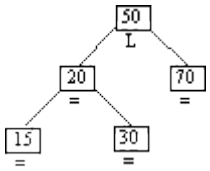
Step 3
Inserting Node 70



Step 4
Inserting Node 30

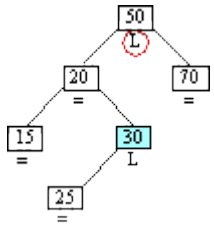


Step 5
Inserting Node 15



Case5a:

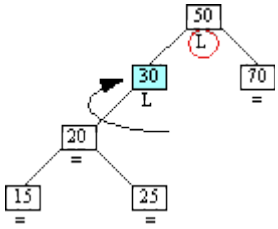
Step 6a
Inserting Node 25



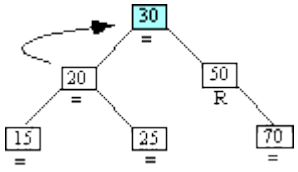
Case 5 triggered

Ancestor balance factor was L
insertion made in right sub-tree
of ancestor's left child.
Double right rotation of right child
of ancestor's left child.

Case 5-Step 1

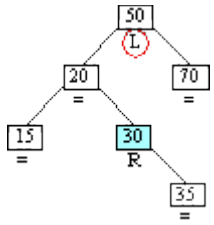


Case 5-Step 2



Case5b:

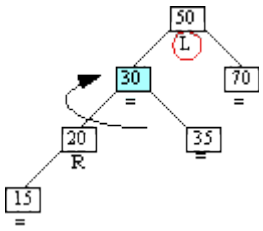
Step 6b
Inserting Node 35



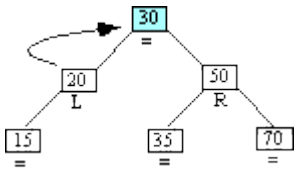
Case 5 triggered

Ancestor balance factor was L
insertion made in right sub-tree
of ancestor's left child.
Double right rotation of right child
of ancestor's left child.

Case 5-Step 1



Case 5-Step 2

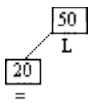


Testing Case 6 - Ancestor.balanceFactor = 'R' and node inserted is in the left subtree of ancestor's right child.

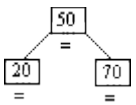
These 5 steps are common to both Case6a and Case6b.

Step 1
Inserting Node 50

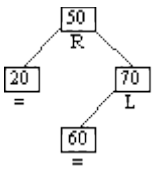
Step 2
Inserting Node 20



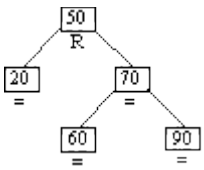
Step 3
Inserting Node 70



Step 4
Inserting Node 30

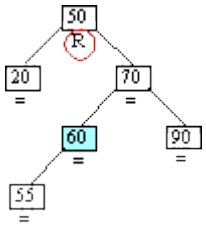


Step 5
Inserting Node 15



Case6a:

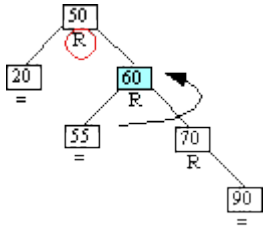
Step 6a
Inserting Node 55



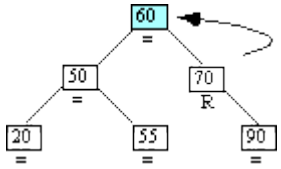
Case 6 triggered

Case 6: Ancestor balance factor was R insertion made in left sub-tree of ancestor's right child. Double left rotation of left child of ancestor's right child.

Case 6-Step 1

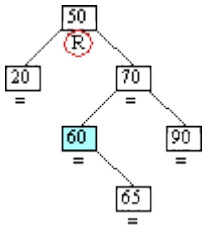


Case 6-Step 2



Case6b:

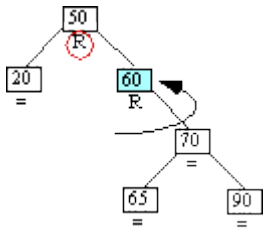
Step 6a
Inserting Node 65



Case 6 triggered

Case 6: Ancestor balance factor was R insertion made in left sub-tree of ancestor's right child. Double left rotation of left child of ancestor's right child.

Case 6-Step 1



Case 6-Step 2