Sairam INSTITUTIONS

Sri SAI RAM ENGINEERING COLLEGE
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YEAR	SEM
2	3

CS8391

DATA STRUCTURES

UNIT No. 3

NON LINEAR DATA STRUCTURES

3.3 BINARY SEARCH TREE ADT

Binary Search Tree

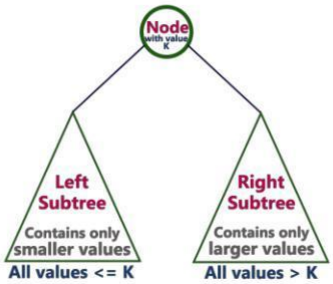
To enhance the performance of binary tree, we use a special type of binary tree known as Binary Search Tree. Binary search tree mainly focuses on the search operation in a binary tree.

- Binary Search tree can be defined as a class of binary trees, in which the nodes are arranged in a specific order. This is also called ordered binary tree.

- In a binary search tree, the value of all the nodes in the left sub-tree is less than the value of the root.

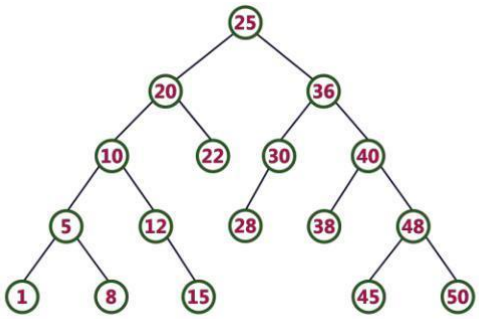
- Similarly, value of all the nodes in the right sub-tree is greater than or equal to the value of the root.

- This rule will be recursively applied to all the left and right sub-trees of the root.



Example

The following tree is a Binary Search Tree. In this tree, left subtree of every node contains nodes with smaller values and right subtree of every node contains larger values.


25
20
36
10
22
30
40
5
12
28
38
48
1
8
15
45
50

Operations on a Binary Search Tree:

The following operations are performed on a binary search tree...

- **Search**
- **Insertion**
- **Deletion**

Search Operation in BST:

In a binary search tree, the search operation is performed with O(log n) time complexity. The search operation is performed as follows...

Step 1 - Read the search element from the user.
Step 2 - Compare the search element with the value of root node in the tree.

Step 3 - If both are matched, then display "Given node is found!!!" and terminate the function
Step 4 - If both are not matched, then check whether search element is smaller or larger

than that node value.

Step 5 - If search element is smaller, then continue the search process in left subtree.

Step 6- If search element is larger, then continue the search process in right subtree.

Step 7 - Repeat the same until we find the exact element or until the search element is compared with the leaf node

Step 8 - If we reach to the node having the value equal to the search value then display "Element is found" and terminate the function.

Step 9 - If we reach to the leaf node and if it is also not matched with the search element, then display "Element is not found" and terminate the function.

Insertion Operation in BST

In a binary search tree, the insertion operation is performed with O(log n) time complexity. In binary search tree, new node is always inserted as a leaf node. The insertion operation is performed as follows...

Step 1 - Create a newNode with given value and set its left and right to NULL.

Step 2 - Check whether tree is Empty.

Step 3 - If the tree is Empty, then set root to newNode.

Step 4 - If the tree is Not Empty, then check whether the value of newNode is smaller or larger than the node (here it is root node).

Step 5 - If newNode is smaller than or equal to the node then move to its left child. If newNode is larger than the node then move to its right child.

Step 6- Repeat the above steps until we reach to the leaf node (i.e., reaches to NULL).

Step 7 - After reaching the leaf node, insert the newNode as left child if the newNode is smaller or equal to that leaf node or else insert it as right child.

Deletion Operation in BST

In a binary search tree, the deletion operation is performed with O(log n) time complexity.

Deleting a node from Binary search tree includes following three cases...

1. Case 1: **Deleting a Leaf node (A node with no children)**
2. Case 2: **Deleting a node with one child**
3. Case 3: **Deleting a node with two children**

Case 1: Deleting a leaf node

We use the following steps to delete a leaf node from BST...

- **Step 1 -** Find the node to be deleted using search operation
- **Step 2 -** Delete the node using free function (If it is a leaf) and terminate the function.

Case 2: Deleting a node with one child

We use the following steps to delete a node with one child from BST...

- **Step 1 -** Find the node to be deleted using search operation
- **Step 2 -** If it has only one child then create a link between its parent node and child node.
- **Step 3 -** Delete the node using free function and terminate the function.

Case 3: Deleting a node with two children

We use the following steps to delete a node with two children from BST...

- **Step 1 -** Find the node to be deleted using search operation
- **Step 2 -** If it has two children, then find the largest node in its left subtree (OR) the smallest node in its right subtree.
- **Step 3 -** Swap both deleting node and node which is found in the above step.
- **Step 4 -** Then check whether deleting node came to case 1 or case 2 or else goto step 2
- **Step 5 -** If it comes to case 1, then delete using case 1 logic.
- **Step 6-** If it comes to case 2, then delete using case 2 logic.
- **Step 7 -** Repeat the same process until the node is deleted from the tree.

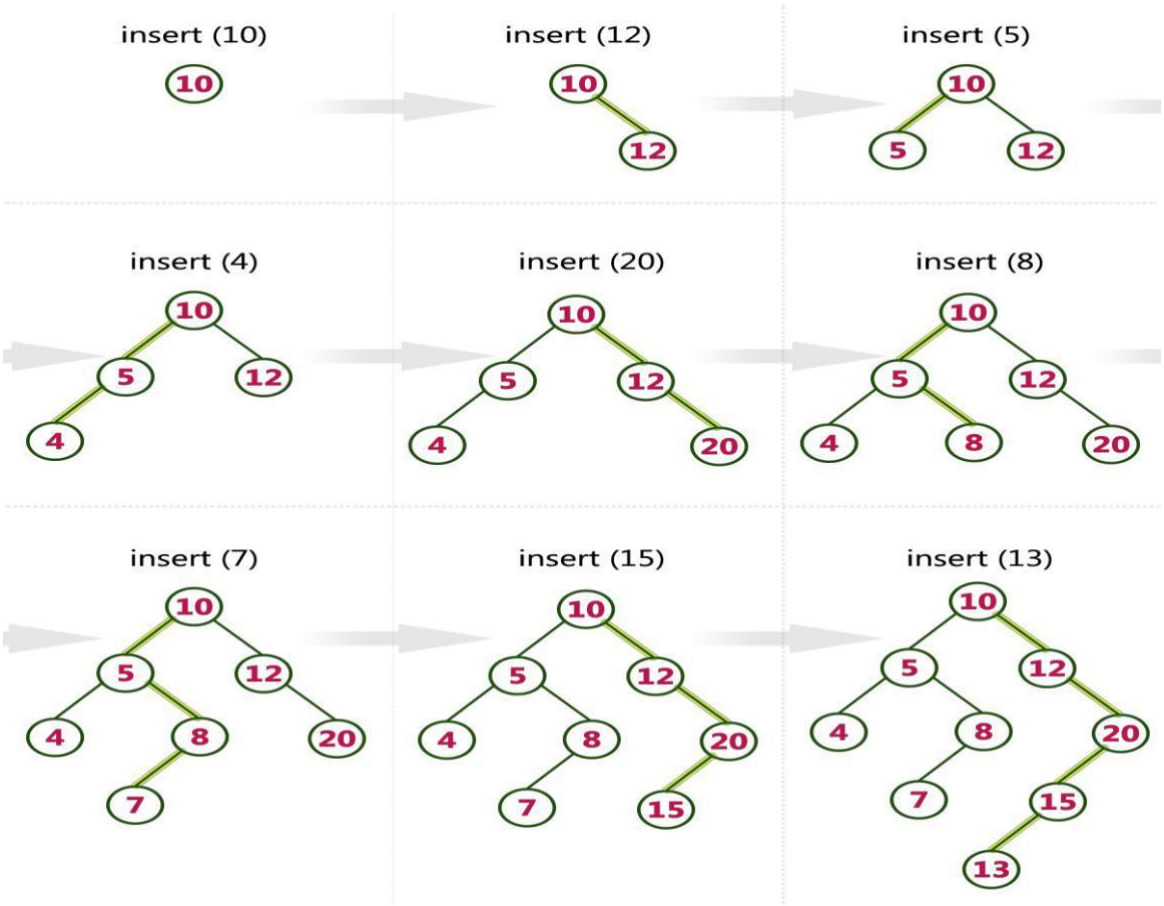
Example

Construct a Binary Search Tree by inserting the following sequence of numbers...

10,12,5,4,20,8,7,15 and 13

Above elements are inserted into a Binary Search Tree as follows...

DATA STRUCTURES



Implementation of Binary Search Tree using C Programming Language:

```
#include<stdio.h>

#include<conio.h>

#include<stdlib.h>


struct node

{

int data;

struct node *left;

struct node *right;

};

void inorder(struct node *root)

{

if(root)

{

inorder(root->left);

printf("                    %d",root->data);

inorder(root->right);

}

}

int main()

{
int n , i;

struct node *p , *q , *root;
```

```
printf("Enter the number of nodes to be insert:");
scanf("%d",&n);
printf("\nPlease enter the numbers to be insert: ");
for(i=0;i<i++)
{
p = (struct node*)malloc(sizeof(struct node));
scanf("%d",&p->data);
p->left = NULL;
p->right = NULL;
if(i == 0)
{
root = p; // root always point to the root node
}
else
{
q = root;                    // q is used to traverse the tree
while(1)
{
if(p->data > q->data)
{
if(q->right == NULL)
{
q->right = p;
break;
}
```

```
else
                                        q = q->right;
}
else
{
 if(q-                                  >left == NULL)
{
q->left = p;
break;
}
else
                                        q = q->left;
}
}
}
}

printf("\nBinary Search Tree nodes in Inorder Traversal: ");
inorder(root);
printf("\n");
return 0;
}
```