Experiment No.9
Implement Binary Search Tree ADT using Linked List.
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Experiment No. 9: Binary Search Tree Operations

Aim : Implementation of Binary Search Tree ADT using Linked List.

Objective:

1) Understand how to implement a BST using a predefined BST ADT.

2) Understand the method of counting the number of nodes of a binary tree.

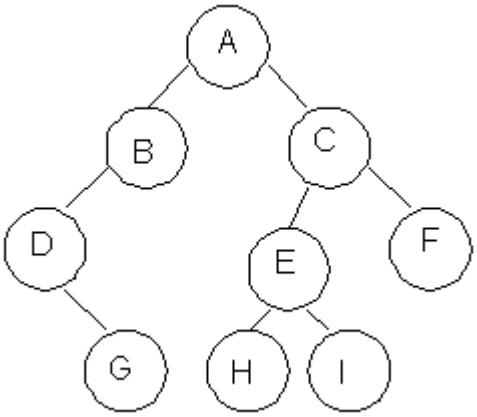
Theory:

A binary tree is a finite set of elements that is either empty or partitioned into disjoint subsets. In other words nodes in a binary tree have at most two children and each child node is referred to as left or right child.

Traversals in trees can be in one of the three ways: preorder, postorder, inorder. Preorder Traversal

Here the following strategy is followed in sequence

1. Visit the root node R
2. Traverse the left subtree of R
3. Traverse the right subtree of R



Description	**Output**
Visit Root	A
Traverse left sub tree – step to B then D	ABD
Traverse right subtree – step to G	ABDG
As left subtree is over. Visit root , which is already visited so go for right subtree	ABDGC
Traverse the left subtree	ABDGCEH
Traverse the right sub tree	ABDGCEHIF

Inorder Traversal

Here the following strategy is followed in sequence

1. Traverse the left subtree of R
2. Visit the root node R
3. Traverse the right sub tree of R

Description	**Output**
Start with root and traverse left sub tree from A-B-D	D
As D doesn't have left child visit D and go for right subtree of D which is G so visit this.	DG
Backtrack to D and then to B and visit it.	DGB
Backtrack to A and visit it	DGBA

Start with right sub tree from C-E-H and visit H	DGBAH
Now traverse through parent of H which is E and then I	DGBAHEI
Backtrack to C and visit it and then right subtree of E which is F	DGBAHEICF

Postorder Traversal

Here the following strategy is followed in sequence

1. Traverse the left subtree of R
2. Traverse the right sub tree of R
3. Visit the root node R

Description	**Output**
Start with left sub tree from A-B-D and then traverse right sub tree to get G	G
Now Backtrack to D and visit it then to B and visit it.	GD
Now as the left sub tree is over go for right sub tree	GDB
In right sub tree start with leftmost child to visit H followed by I	GDBHI
Visit its root as E and then go for right sibling of C as F	GDBHIEF
Traverse its root as C	GDBHIEFC
Finally a root of tree as A	GDBHIEFCA

Algorithm

Algorithm: PREORDER(ROOT)

Algorithm :

Function Pre-order(root)

- Start
- If root is not null then

Display the data in root

Call pre order with left pointer of root(root -> left)

Call pre order with right pointer of root(root -> right)

- Stop

Algorithm: INORDER(ROOT)

Algorithm :

Function in-order(root)

- Start
- If root is not null then

Call in order with left pointer of root (root -> left)

Display the data in root

Call in order with right pointer of root(root -> right)

- Stop

Algorithm: POSTORDER(ROOT)

Algorithm :

Function post-order (root)

- Start
- If root is not null then

Call post order with left pointer of root (root -> left)

Call post order with right pointer of root (root -> right)

Display the data in root

- Stop

Code:

```
#include<stdio.h>
#include<conio.h>
#include<malloc.h>
struct node { int data; struct node *left; struct node *right; };
struct node *tree;
void create_tree(struct node *);
struct node *insertElement(struct node *, int);
void preorderTraversal(struct node *);
```

```
 void inorderTraversal(struct node *);
void postorderTraversal(struct node *);
 struct node *findSmallestElement(struct node *);
struct node *findLargestElement(struct node *);
 struct node *deleteElement(struct node *, int);
 struct node *mirrorImage(struct node *);
int totalNodes(struct node *);
int totalExternalNodes(struct node *);
 int totalInternalNodes(struct node *);
 int Height(struct node *);
struct node *deleteTree(struct node *);
int main() {
 int option, val;
struct node *ptr; create_tree(tree);
clrscr();
 do { printf("\n ******MAIN MENU******* \n");
 printf("\n 1. Insert Element");
 printf("\n 2. Preorder Traversal");
 printf("\n 3. Inorder Traversal");
printf("\n 4. Postorder Traversal");
 printf("\n 5. Find the smallest element");
 printf("\n 6. Find the largest element");
 printf("\n 7. Delete an element");
 printf("\n 8. Count the total number of nodes");
printf("\n 9. Count the total number of external nodes");
printf("\n 10. Count the total number of internal nodes");
```

```
 printf("\n 11. Determine the height of the tree");
 printf("\n 12. Find the mirror image of the tree");
printf("\n 13. Delete the tree");
 printf("\n 14. Exit");
 printf("\n\n Enter your option : ");
scanf("%d", &option); switch(option) {
 case 1: printf("\n Enter the value of the new node : ");
scanf("%d", &val);
 tree = insertElement(tree, val);
 break;
case 2: printf("\n The elements of the tree are : \n");
preorderTraversal(tree);
 break;
case 3: printf("\n The elements of the tree are : \n");
 inorderTraversal(tree);
 break;
 case 4: printf("\n The elements of the tree are : \n");
 postorderTraversal(tree);
 break;
case 5: ptr = findSmallestElement(tree);
printf("\n Smallest element is :%d",ptr–>data);
break;
case 6: ptr = findLargestElement(tree);
 printf("\n Largest element is : %d", ptr–>data);
 break;
 case 7: printf("\n Enter the element to be deleted : ");
```

```
scanf("%d", &val);
tree = deleteElement(tree, val);
 break;
case 8: printf("\n Total no. of nodes = %d", totalNodes(tree));
 break;
case 9: printf("\n Total no. of external nodes = %d", totalExternalNodes(tree));
 break;
case 10: printf("\n Total no. of internal nodes = %d", totalInternalNodes(tree));
 break;
 case 11: printf("\n The height of the tree = %d",Height(tree));
 break;
 case 12:tree = mirrorImage(tree);
break;
 case 13: tree = deleteTree(tree);
 break;
 }
 }while(option!=14);
 getch();
 return 0;
} void create_tree(struct node *tree) {
tree = NULL;
} struct node *insertElement(struct node *tree, int val) {
struct node *ptr, *nodeptr, *parentptr;
 ptr = (struct node*)malloc(sizeof(struct node));
ptr–>data = val;
ptr–>left = NULL;
```

```
 ptr–>right = NULL;
 if(tree==NULL) { tree=ptr;
tree–>left=NULL;
 tree–>right=NULL;
} else { parentptr=NULL;
 nodeptr=tree;
 while(nodeptr!=NULL) {
parentptr=nodeptr;
 if(valdata) nodeptr=nodeptr–>left;
else nodeptr = nodeptr–>right;
 } if(valdata) parentptr–>left = ptr;
else parentptr–>right = ptr;
 } return tree;
 } void preorderTraversal(struct node *tree)
if(tree != NULL)
{ printf("%d\t", tree–>data);
preorderTraversal(tree–>left);
 preorderTraversal(tree–>right);
 }
 }
 void inorderTraversal(struct node *tree) {
if(tree != NULL) {
 inorderTraversal(tree->left);
 printf("%d\t", tree->data);
inorderTraversal(tree->right);
 }
```

```
}
void postorderTraversal(struct node *tree) {
 if(tree != NULL) {
 postorderTraversal(tree->left);
 postorderTraversal(tree->right);
 printf("%d\t", tree->data);
 }
 struct node *findSmallestElement(struct node *tree) {
 if( (tree == NULL) || (tree->left == NULL))
return tree;
 else
return findSmallestElement(tree ->left);
 } struct node *findLargestElement(struct node *tree)
{ if( (tree == NULL) || (tree->right == NULL))
 return tree;
 else
return findLargestElement(tree->right);
} struct node *deleteElement(struct node *tree, int val) {
 struct node *cur, *parent, *suc, *psuc, *ptr;
if(tree–>left==NULL) {
 printf("\n The tree is empty ");
 return(tree);
 } parent = tree;
cur = tree–>left;
while(cur!=NULL && val!= cur–>data) {
 parent = cur; cur = (valdata)? cur–>left:cur–>right; }
```

```
 if(cur == NULL) {
 printf("\n The value to be deleted is not present in the tree");
 return(tree);
 } if(cur–>left == NULL) ptr = cur–>right;
 else
if(cur–>right == NULL)
 ptr = cur–>left;
 else {
// Find the in–order successor and its parent
 psuc = cur;
cur = cur–>left;
 while(suc–>left!=NULL) {
 psuc = suc;
 suc = suc–>left; }
if(cur==psuc) {
// Situation 1
 suc–>left = cur–>right;
 } else {
 // Situation 2
suc–>left = cur–>left;
psuc–>left = suc–>right;
suc–>right = cur–>right;
 } ptr = suc;
 } // Attach ptr to the parent node
 if(parent–>left == cur)
parent–>left=ptr;
```

```
else parent–>right=ptr;
free(cur);
return tree;
} int totalNodes(struct node *tree)
{ if(tree==NULL)
return 0;
else
return(totalNodes(tree–>left) + totalNodes(tree–>right) + 1);
} int totalExternalNodes(struct node *tree) {
if(tree==NULL)
return 0;
else if((tree–>left==NULL) && (tree–>right==NULL))
return 1;
else
return (totalExternalNodes(tree–>left) + totalExternalNodes(tree–>right));
} int totalInternalNodes(struct node *tree) {
if( (tree==NULL) || ((tree–>left==NULL) && (tree–>right==NULL)))
return 0;
else
return (totalInternalNodes(tree–>left) + totalInternalNodes(tree–>right) + 1); }
int Height(struct node *tree)
{ int leftheight, rightheight;
if(tree==NULL)
return 0;
else
{ leftheight = Height(tree–>left);
```

```
 rightheight = Height(tree–>right);
 if(leftheight > rightheight)
return (leftheight + 1);
 else
return (rightheight + 1);
}
 }
 struct node *mirrorImage(struct node *tree) {
struct node *ptr; if(tree!=NULL) {
 mirrorImage(tree–>left);
 mirrorImage(tree–>right);
 ptr=tree–>left;
 ptr–>left = ptr–>right;
 tree–>right = ptr;
}
 } struct node *deleteTree(struct node *tree) {
 if(tree!=NULL) {
deleteTree(tree–>left);
 deleteTree(tree–>right);
 free(tree);
 }
}
```

Output:

```
*******MAIN   MENU*******
1. Insert Element
2. Preorder Traversal
3. Inorder Traversal
4. Postorder Traversal
5. Find the smallest element
6. Find the largest element
7. Delete an element
8. Count the total number of nodes
9. Count the total number of external nodes
10. Count the total number of internal nodes
11. Determine the height of the tree
12. Find the mirror image of the tree
13. Delete the tree
14. Exit
Enter your option : 1
Enter the value of the new node : 1
Enter the value of the new node : 2
Enter the value of the new node : 4
Enter your option : 3
2    1    4
Enter your option : 14
```

Conclusion:

Write a function in C program to count the number of nodes in a binary search tree?

```
#include <stdio.h>
#include <stdlib.h>

// Definition for a BST node
struct Node {
    int data;
    struct Node* left;
    struct Node* right;
};

// Function to create a new BST node
struct Node* createNode(int data) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    newNode->data = data;
    newNode->left = newNode->right = NULL;
    return newNode;
```

```
}

// Function to insert a new node into the BST
struct Node* insert(struct Node* root, int data) {
    if (root == NULL)
        return createNode(data);
    if (data < root->data)
        root->left = insert(root->left, data);
    else if (data > root->data)
        root->right = insert(root->right, data);
    return root;
}

// Function to count the number of nodes in the BST
int countNodes(struct Node* root) {
    if (root == NULL)
        return 0;
    return 1 + countNodes(root->left) + countNodes(root->right);
}

int main() {
    struct Node* root = NULL;

    // Insert elements into the BST
    root = insert(root, 10);
    root = insert(root, 5);
    root = insert(root, 15);
    root = insert(root, 3);
    root = insert(root, 7);
    root = insert(root, 12);
    root = insert(root, 18);

    // Count the number of nodes in the BST
```

```
    int nodeCount = countNodes(root);
    printf("Number of nodes in the BST: %d\n", nodeCount);

    return 0;
}
```