Splay Tree | Set 3 (Delete)

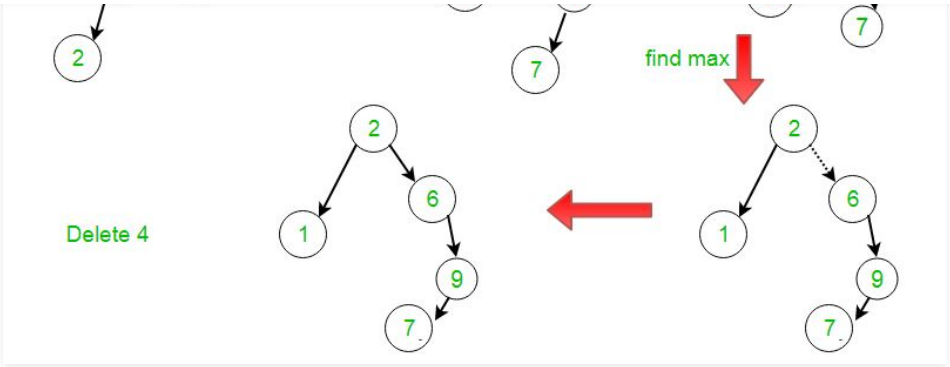
Difficulty Level : Hard • Last Updated : 03 Dec, 2019

It is recommended to refer following post as prerequisite of this post.

Splay Tree | Set 1 (Search)

Following are the different cases to delete a key **k** from splay tree.

1. If **Root is NULL:** We simply return the root.
2. Else Splay the given key k. If k is present, then it becomes the new root. If not present, then last accessed leaf node becomes the new root.
3. If new root's key is not same as **k**, then return the root as **k** is not present.
4. Else the key **k** is present.
   - Split the tree into two trees **Tree1** = root's left subtree and **Tree2** = root's right subtree and delete the root node.
   - Let the root's of **Tree1** and **Tree2** be **Root1** and **Root2** respectively.
   - If **Root1** is NULL: Return **Root2**.
   - Else, Splay the maximum node (node having the maximum value) of **Tree1**.
   - After the Splay procedure, make **Root2** as the right child of **Root1** and return **Root1**.




```c
// C implementation to delete a node from Splay Tree
#include<stdio.h>
#include<stdlib.h>

// An AVL tree node
struct node
{
    int key;
    struct node *left, *right;
};

/* Helper function that allocates a new node with the given key and
    NULL left and right pointers. */
struct node* newNode(int key)
{
    struct node* node = (struct node*)malloc(sizeof(struct node));
    node->key   = key;
    node->left  = node->right  = NULL;
    return (node);
}

// A utility function to right rotate subtree rooted with y
// See the diagram given above.
struct node *rightRotate(struct node *x)
{
    struct node *y = x->left;
    x->left = y->right;
    y->right = x;
    return y;
}

// A utility function to left rotate subtree rooted with x
// See the diagram given above.
struct node *leftRotate(struct node *x)
{
```

```
// This function brings the key at root if key is present in tree.
// If key is not present, then it brings the last accessed item at
// root.  This function modifies the tree and returns the new root
struct node *splay(struct node *root, int key)
{
    // Base cases: root is NULL or key is present at root
    if (root == NULL || root->key == key)
        return root;

    // Key lies in left subtree
    if (root->key > key)
    {
        // Key is not in tree, we are done
        if (root->left == NULL) return root;

        // Zig-Zig (Left Left)
        if (root->left->key > key)
        {
            // First recursively bring the key as root of left-left
            root->left->left = splay(root->left->left, key);

            // Do first rotation for root, second rotation is
            // done after else
            root = rightRotate(root);
        }
        else if (root->left->key < key) // Zig-Zag (Left Right)
        {
            // First recursively bring the key as root of left-right
            root->left->right = splay(root->left->right, key);

            // Do first rotation for root->left
            if (root->left->right != NULL)
                root->left = leftRotate(root->left);
        }

        // Do second rotation for root
        return (root->left == NULL)? root: rightRotate(root);
    }
    else // Key lies in right subtree
    {
        // Key is not in tree, we are done
        if (root->right == NULL) return root;

        // Zag-Zig (Right Left)
        if (root->right->key > key)
        {
            // Bring the key as root of right-left
```

```
        else if (root->right->key < key)// Zag-Zag (Right Right)
        {
            // Bring the key as root of right-right and do
            // first rotation
            root->right->right = splay(root->right->right, key);
            root = leftRotate(root);
        }

        // Do second rotation for root
        return (root->right == NULL)? root: leftRotate(root);
    }
}

// The delete function for Splay tree. Note that this function
// returns the new root of Splay Tree after removing the key
struct node* delete_key(struct node *root, int key)
{
    struct node *temp;
    if (!root)
        return NULL;

    // Splay the given key
    root = splay(root, key);

    // If key is not present, then
    // return root
    if (key != root->key)
        return root;

    // If key is present
    // If left child of root does not exist
    // make root->right as root
    if (!root->left)
    {
        temp = root;
        root = root->right;
    }
```



```
    /*Note: Since key == root->key,
    so after Splay(key, root->lchild),
    the tree we get will have no right child tree
    and maximum node in left subtree will get splayed*/
```

```
    }

    // free the previous root node, that is,
    // the node containing the key
    free(temp);

    // return root of the new Splay Tree
    return root;

}

// A utility function to print preorder traversal of the tree.
// The function also prints height of every node
void preOrder(struct node *root)
{
    if (root != NULL)
    {
        printf("%d ", root->key);
        preOrder(root->left);
        preOrder(root->right);
    }
}

/* Driver program to test above function*/
int main()
{
    // Splay Tree Formation
    struct node *root = newNode(6);
    root->left = newNode(1);
    root->right = newNode(9);
    root->left->right = newNode(4);
    root->left->right->left = newNode(2);
    root->right->left = newNode(7);

     int key = 4;

    root = delete_key(root, key);
    printf("Preorder traversal of the modified Splay tree is \n");
    preOrder(root);
    return 0;
}
```

Output:

https://www.geeksforgeeks.org/splay-tree-set-1-insert/
http://courses.cs.washington.edu/courses/cse326/01au/lectures/SplayTrees.ppt

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