CS2023 - Data Structures and Algorithms
In-class Lab Exercise

Week 6

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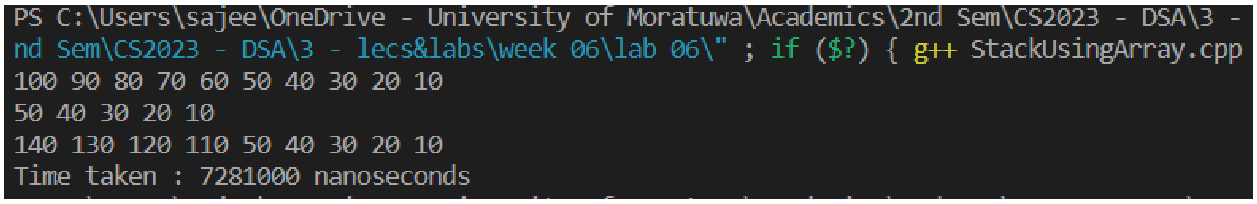
Github Repo link:
https://github.com/veejask-41/210554M-CS-2023-Data_Structures_And_Algorithms/tree/main/week%2006/lab%2006

Implementation of Stack using Array

```
#include <iostream>
#include <chrono>
using namespace std;

// implementing stack using array
class Stack
{
    int *stack;
    int top;
    int capacity;

public:
    Stack(int size)
    {
        stack = new int[size];
        top = 0;
        capacity = size;
    }

    // insert element
    void push(int el)
    {
        if (top == capacity)
        {
            cout << "Stack Overflow" << endl;
            return;
        }
        stack[top] = el;
        top++;
    }

    // delete element
    int pop()
    {
        if (isEmpty())
        {
            cout << "Stack Underflow" << endl;
            return 0;
        }
        top--;
        return stack[top];
    }

    bool isEmpty()
    {
        return top == 0;
    }

    bool isFull()
    {
        return top == capacity;
    }

    int stackTop()
    {
        if (isEmpty())
        {
            cout << "Stack is empty" << endl;
            return 0;
        }
        return stack[top - 1];
    }

    void display()
    {
        for (int i = top - 1; i >= 0; i--)
        {
            cout << stack[i] << " ";
        }
        cout << endl;
    }
};

int main()
{
    auto start_time = chrono::steady_clock::now();

    // implementing stack and methods
    Stack myStack(10);
    myStack.push(10);
    myStack.push(20);
    myStack.push(30);
    myStack.push(40);
    myStack.push(50);
    myStack.push(60);
    myStack.push(70);
    myStack.push(80);
    myStack.push(90);
    myStack.push(100);
    myStack.display();
    myStack.pop();
    myStack.pop();
    myStack.pop();
    myStack.pop();
    myStack.pop();
    myStack.display();
    myStack.push(110);
    myStack.push(120);
    myStack.push(130);
    myStack.push(140);
    myStack.display();

    auto end_time = chrono::steady_clock::now();
    auto time_taken =
    chrono::duration_cast<chrono::nanoseconds>(end_time -
    start_time).count();
    cout << "Time taken : " << time_taken << " nanoseconds" << endl;
    return 0;
}
```

CLI output



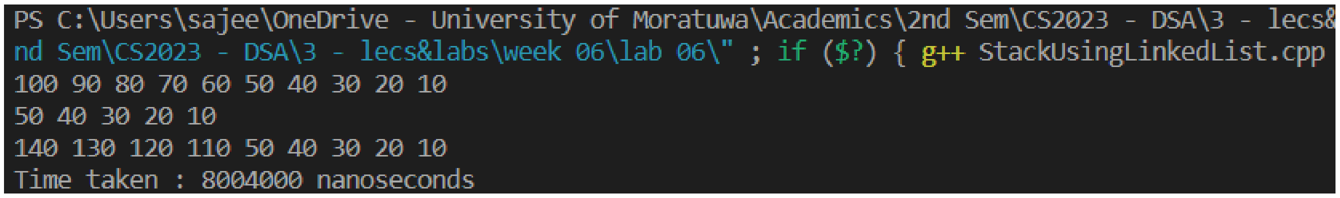
```
PS C:\Users\sajee\OneDrive - University of Moratuwa\Academics\2nd Sem\CS2023 - DSA\3 -
nd Sem\CS2023 - DSA\3 - lecs&labs\week 06\lab 06\" ; if ($?) { g++ StackUsingArray.cpp
100 90 80 70 60 50 40 30 20 10
50 40 30 20 10
140 130 120 110 50 40 30 20 10
Time taken : 7281000 nanoseconds
```

Implementing Stack using Linked List

```
#include <iostream>
#include <chrono>

using namespace std;

// node of linked list
struct Node
{
    int data;
    Node *next;
};

// implementing stack using linked list
class Stack
```

```
{
    Node *top;

    // constructor
public:
    Stack()
    {
        top = NULL;
    }

    // push to top
    void push(int el)
    {
        Node *temp = new Node;
        temp->data = el;
        temp->next = top;
        top = temp;
    }

    // popping from top
    int pop()
    {
        if (isEmpty())
        {
            cout << "Stack Underflow" << endl;
            return 0;
        }
        Node *temp = top;
        top = top->next;
        int el = temp->data;
        delete temp;
        return el;
    }

    // checking if the stack is empty
    bool isEmpty()
    {
        return top == NULL;
    }

    // checking if the stack is full
    bool isFull()
    {
        Node *temp = new Node;
        if (temp == NULL)
        {
            delete temp;
            return true;
        }
        delete temp;
        return false;
    }

    // finding the top element
    int stackTop()
    {
        if (isEmpty())
        {
            cout << "Stack is empty" << endl;
            return 0;
        }
        return top->data;
    }

    // printing the stack
    void display()
    {
        if (isEmpty())
        {
            cout << "Stack is empty" << endl;
            return;
        }
        Node *temp = top;
        while (temp != NULL)
        {
            cout << temp->data << " ";
            temp = temp->next;
        }
        cout << endl;
    }
};

int main()
{
    // start clock
    auto start_time = chrono::steady_clock::now();

    // implementing stack and methods
    Stack myStack;
    myStack.push(10);
    myStack.push(20);
    myStack.push(30);
    myStack.push(40);
    myStack.push(50);
    myStack.push(60);
    myStack.push(70);
    myStack.push(80);
    myStack.push(90);
    myStack.push(100);
    myStack.display();
    myStack.pop();
    myStack.pop();
    myStack.pop();
    myStack.pop();
    myStack.pop();
    myStack.display();
    myStack.push(110);
    myStack.push(120);
    myStack.push(130);
    myStack.push(140);
    myStack.display();

    // end clock
    auto end_time = chrono::steady_clock::now();
    auto time_taken =
    chrono::duration_cast<chrono::nanoseconds>(end_time -
    start_time).count();
    cout << "Time taken : " << time_taken << " nanoseconds" << endl;

    return 0;
}
```

CLI output



```
PS C:\Users\sajee\OneDrive - University of Moratuwa\Academics\2nd Sem\CS2023 - DSA\3 - lecs&
nd Sem\CS2023 - DSA\3 - lecs&labs\week 06\lab 06\" ; if ($?) { g++ StackUsingLinkedList.cpp
100 90 80 70 60 50 40 30 20 10
50 40 30 20 10
140 130 120 110 50 40 30 20 10
Time taken : 8004000 nanoseconds
```

Discussion

Implementing stack data structure using array can be simple and efficient in memory, but the size of the stack is fixed at initialization. Unlike array-based stacks, linked list – based stacks are dynamic. We don't have to define the size of stack at the initialization. But linked lists require more memory to store overhead for storing pointer for each element. And they may have inefficient access of elements.

Since in both type of implementations, the element is pushed and popped from front or beginning, the time complexity for both push() and pop() operations in both implementations are O(1). Hence, it's proved by the CLI output we get, that the time taken to execute both type of implementations is approximately equal.

But, in addition, we have to consider the memory efficiency, as we said in some cases, the array-based stack will require less time to access elements in stack.

So, the implementation type which has to be implemented is entirely depended on the context. If we can initially define the size of the stack, we can use array-based implementation as it also has faster accessibility to the elements. But if we need a dynamic stack, we can use linked-list-based stack structure.