Module 05: Programming in C++

Stack and its Applications

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Module Objectives

- Understanding implementation and use of stack in C
- Understanding stack in C++ standard library and its use

Module Outline

- Stack in C
  - Reverse a String
  - Evaluate a Postfix Expression
- Stack in C++
  - Reverse a String
  - Evaluate a Postfix Expression

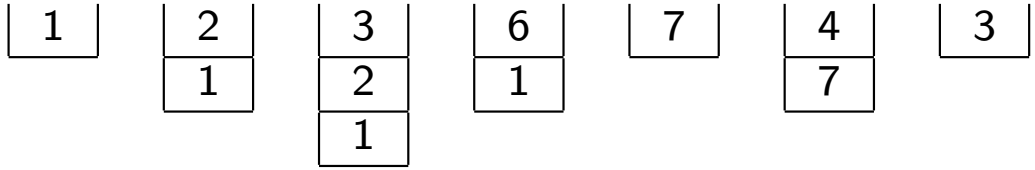
Understanding Stack in C

- Stack is a LIFO (last-In-First-Out) container that can maintain a collection of arbitrary number of data items – all of the same type
- To create a stack in C we need to:
  - Decide on the data type of the elements
  - Define a structure (container) (with maximum size) for stack and declare a top variable in the structure
  - Write separate functions for `push`, `pop`, `top`, and `isempty` using the declared structure
- Note:
  - Change of the data type of elements, implies re-implementation for all the stack codes
  - Change in the structure needs changes in all functions
- Unlike `sin`, `sqrt` etc. function from C standard library, we do not have a ready-made stack that we can use

Common C programs using stack

Some common C programs that use stack:

- Reversing a string
  - Input: ABCDE
  - Output: EDCBA
- Evaluation of postfix expression
  - Input: 1 2 3 * + 4 - (for 1 + 2 * 3 - 4)
  - Output: 3
    Stack states:



- Identification of palindromes (w/ and w/o center-marker)
- Conversion of an infix expression to postfix
- Depth-first Search (DFS)

Program 05.01: Reversing a string


```
// FileName: Reverse_String.c

#include <stdio.h>

typedef struct stack {
    char data [100];
    int top;
} stack;

int empty (stack *p) {
    return  (p->top  == -1);
}

int top (stack *p) {
    return  p -> data [p->top];
}

void push (stack *p, char x) {
    p -> data [++(p -> top)] = x;
}

void pop (stack *p) {
    if (!empty(p)) {
        (p->top) = (p->top) -1;
    }
}
```

```
void main() {
    stack s;
    s.top = -1;

    char ch, str[10] = "ABCDE";

    int i, len = sizeof(str);

    for(i = 0; i < len; i++) {
        push(&s, str[i]);
    }

    printf ("Reversed String: ");

    while (!empty(&s)){
        printf("%c ", top(&s));
        pop(&s);
    }
}
```

Reversed String: EDCBA

Program 05.02: Postfix Expression Evaluation


```
// FileName: PostFix_Evaluation.c

#include<stdio.h>

typedef struct stack {
    char data [100];
    int top;
} stack;

int empty (stack *p) {
    return  (p->top  == -1);
}

int top (stack *p) {
    return  p -> data [p->top];
}

void push (stack *p, char x) {
    p -> data [++(p -> top)] = x;
}

void pop (stack *p) {
    if (!empty(p)) {
         (p->top) = (p->top) -1;
   }
}
```

```
void main() {
    stack s;
    s.top = -1;

    // Postfix expression: 1 2 3 * + 4 -
    char postfix[] = {'1','2','3','*','+','4','-'};

    int i, op1, op2;

    for(i = 0; i < 7; i++) {
        char ch = postfix[i];
        if (isdigit(ch)) push(&s, ch-'0');
        else {
            op2 = top(&s); pop(&s);
            op1 = top(&s); pop(&s);
            switch (ch) {
                case '+':push(&s, op1 + op2);break;
                case '-':push(&s, op1 - op2);break;
                case '*':push(&s, op1 * op2);break;
                case '/':push(&s, op1 / op2);break;
            }
        }
    }
    printf("Evaluation %d\n", top(&s));
}
```

Evaluation 3

Understanding Stack in C++

- C++ standard library provide a ready-made stack for any type of elements
- To create a stack in C++ we need to:
  - Include the `stack` header
  - Instantiate a stack with proper element type (like `char`)
  - Use the functions of the stack objects for stack operations

Program 05.03: Reverse a String in C++


```
// FileName: Reverse_String_c++.cpp
#include<iostream>
#include<string.h>
#include<stack>
using namespace std;

int main() {
    char str[10]= "ABCDE";
    stack<char> s;
    int i;

    for(i = 0; i < strlen(str); i++)
        s.push(str[i]);

    cout << "Reversed String: ";

    while (!s.empty()) {
        cout << s.top();
        s.pop();
    }

    return 0;
}
```

- No codes for creating stack
- No initialization
- Clean interface for stack functions
- Available in library – well-tested

```
// FileName: Reverse_String.c


int main() {
    char str[10] = "ABCDE";
    stack s; s.top = -1;
    int i;

    for(i = 0; i < strlen(str); i++)
        push(&s, str[i]);

    printf ("Reversed String: ");

    while (!empty(&s)){
        printf("%c ", top(&s));
        pop(&s);
    }

    return 0;
}
```

- Lot of code for creating stack
- top to be initialized
- Cluttered interface for stack functions
- Implemented by user – error-prone

Program 05.04: Postfix Evaluation in C++


```
// FileName:Postfix_Evaluation_c++.cpp
#include <iostream>
#include <stack>
using namespace std;

int main() {
    // Postfix expression: 1 2 3 * + 4 -
    char postfix[] = {'1','2','3','*','+','4','-'}, ch;
    stack<int> s;

    for(int i = 0; i < 7; i++) {
         ch = postfix[i];
         if (isdigit(ch)) { s.push(ch-'0'); }
         else {
             int op1 = s.top(); s.pop();
             int op2 = s.top(); s.pop();
             switch(ch) {
                 case '*': s.push(op2 * op1); break;
                 case '/': s.push(op2 / op1); break;
                 case '+': s.push(op2 + op1); break;
                 case '-': s.push(op2 - op1); break;
             }
        }
    }
    cout << "\nEvaluation " << s.top();
    return 0;
}
```

Module Summary

- C++ standard library provides ready-made stack. It works like a data type
- Any type of element can be used for C++ stack
- Similar containers as available in C++ standard library include:
  - `queue`
  - `deque`
  - `list`
  - `map`
  - `set`
  - ... and more

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