Data Structure and Algorithms

Lecture 7-8

Stacks

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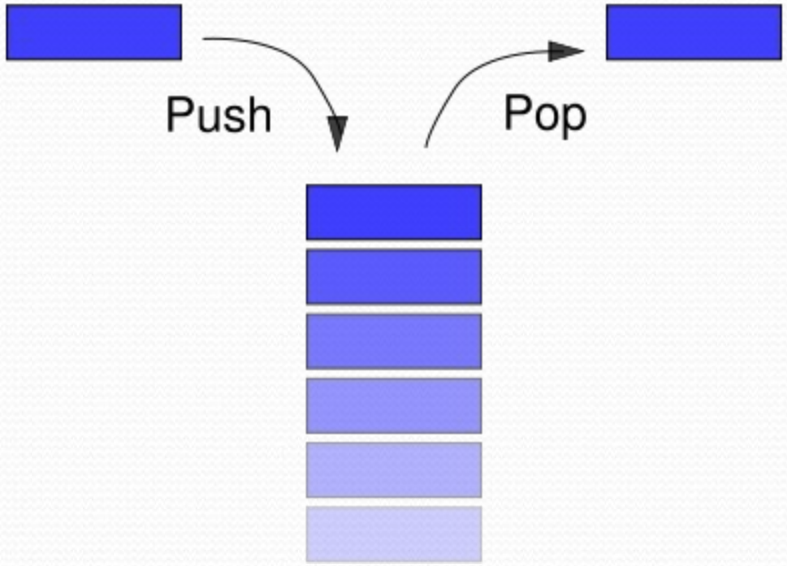
Stacks

- A stack is a list in which insertion and deletion take place at the same end
  - This end is called top
  - The other end is called bottom
- Stacks are known as LIFO (Last In, First Out) lists.
  - The last element inserted will be the first to be retrieved
- E.g. a stack of Plates, books, boxes etc.

Insertion and deletion on stack



Stack applications

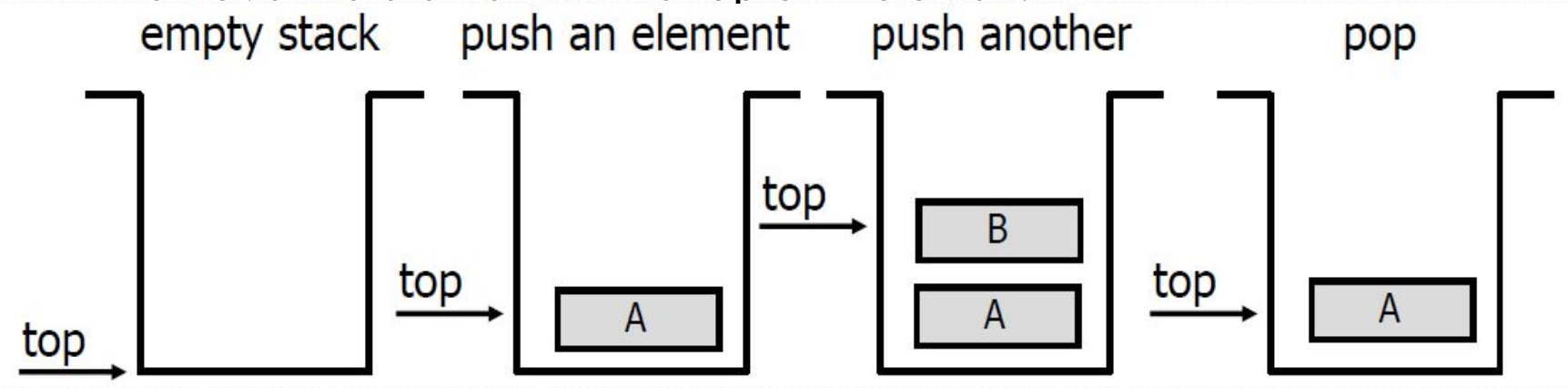
- "Back" button of Web Browser
  - History of visited web pages is pushed onto the stack and popped when "back" button is clicked
- "Undo" functionality of a text editor
- Reversing the order of elements in an array
- Saving local variables when one function calls another, and this one calls another, and so on.

Operation On Stack

- Creating a stack
- Checking stack---- either empty or full
- Insert (PUSH) an element in the stack
- Delete (POP) an element from the stack
- Access the top element
- Display the elements of stack

Push and Pop

- Primary operations: Push and Pop
- Push
  - Add an element to the top of the stack.
- Pop
  - Remove the element at the top of the stack.



Stack-Related Terms

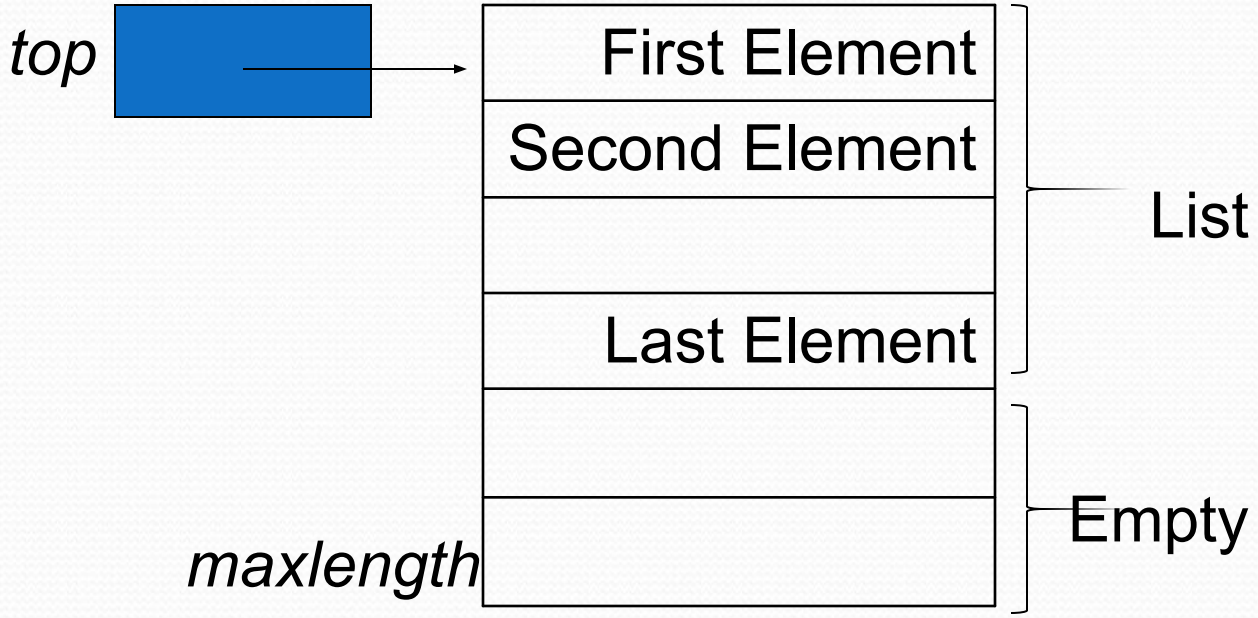
- Top
  - A pointer that points the top element in the stack.
- Stack Underflow
  - When there is no element in the stack, the status of stack is known as stack underflow.
- Stack Overflow
  - When the stack contains equal number of elements as per its capacity and no more elements can be added, the status of stack is known as stack overflow

Stack Implementation

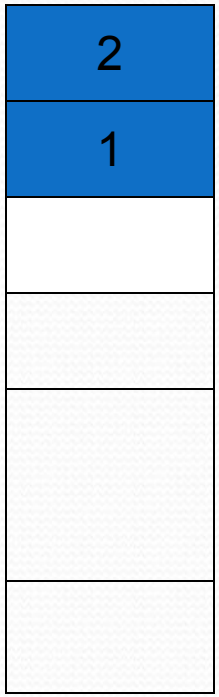
- Implementation can be done in two ways
  - Static implementation
  - Dynamic Implementation
- Static Implementation
  - Stacks have **fixed size**, and are implemented as **arrays**
  - It is also inefficient for utilization of memory
- Dynamic Implementation
  - Stack **grow in size** as needed, and implemented as **linked lists**
  - Dynamic Implementation is done through pointers
  - The memory is efficiently utilize with Dynamic Implementations

Static Implementation

- Elements are stored in contiguous cells of an array.
- New elements can be inserted to the top of the list.



Static Implementation



Problem with this implementation

- Every PUSH and POP requires moving the entire array up and down.

Static Implementation

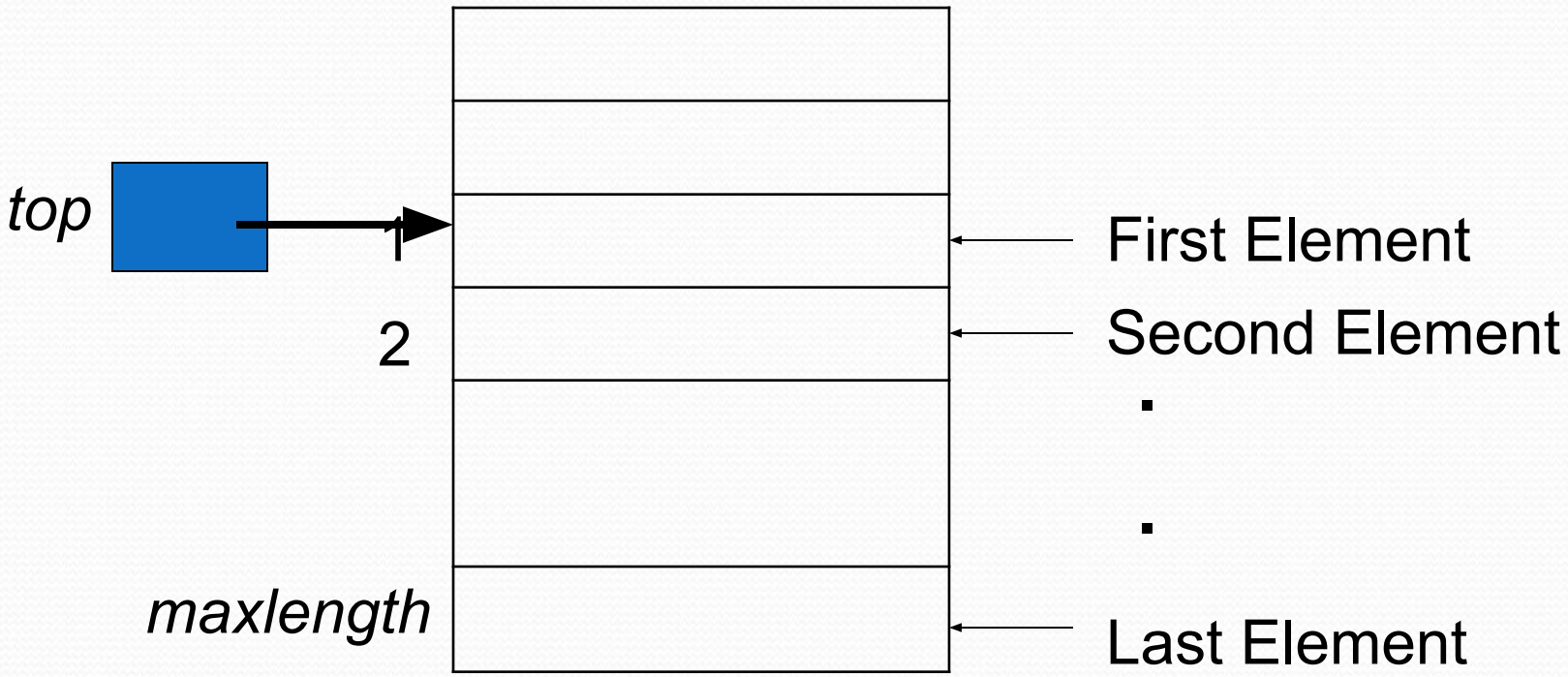
Since, in a stack the insertion and deletion take place only at the top, so…

A better Implementation:

- Anchor the bottom of the stack at the bottom of the array
- Let the stack grow towards the top of the array
- *Top* indicates the current position of the first stack element.

Static Implementation

A better Implementation:



```
#include<stdio.h>
#include<conio.h>
#include<stdlib.h>
#include <iostream.h>
#define length 10
int top=-1;
int stack[length];
void main()
{
 int ch;
 do{
 cout << endl << "1.push";
 cout << endl << "2.pop";
 cout << endl << "3.exit";
 cout << endl << "enter
  choice";
 cin >> ch;
```

```
                                switch(ch)
                                       }
                                 :case 1
                            ;()cout<<push
                             ;()listStack
                                  ;break
                                 :case 2
              cout << "data poped= " <<
                                  ;()pop
                            ;()listStack
                                  ;break
                         ;case 3:exit(0)
                                       {

                                ;while(1) {

                                          {
```

A sample Program using Array

```
int push()
{
  int data;
  if(top+1==length)
  {
     cout << "stack overflow
  \n Cannot enter new data";
   return -1;
  }
  top++;
  cout << "enter the data ";
  cin >> data;
  stack[top]=data;
   return stack[top]
  }
```

```
                                ()int pop
                                      }
                        ;int tempVar
if(top==-1)//we can also make
                              ()isEmpty
                                      }
          cout << "stack is
           ;"underflow (Empty)
                ;return -1
                                      {
           ;tempVar=stack[top]
                           ;--top
              ;return(tempVar)
                                    {

                     ()void listStack
                                      }
   cout << endl << "The stack
                    ; is" << endl
      for(int i=top;i>=0;i--)
 ;cout << stack[i] << endl
                                      {
```

```
#define max 5 // size of the
Stack
struct stack
{
   int top,a[max];
};
void push(struct stack *p1)
{
   int x;
   if(p1->top==max-1) //
//Stack is Full
{printf("stack overflow\n");
Return;}
  p1->top++; //incr the top
  cout<<"enter a no\n";
  cin>>x;
  p1->a[p1->top]=x; //insert
element
  cout<<"succ. pushed\n "<<x;
  return;
}
```

```
{
void pop(struct stack *p2)
}
;int y
if(p2->top==-1) // is Empty
}
;"cout<<"stack underflow\n
;return
{
;y=p2->a[p2->top]
;p2->a[p2->top]=0
;cout<<"%d succ. poped\n"<<y
;--p2->top
;return
{
```

```
void display(struct stack
*p3)
{
  int i;
  if(p3->top==-1)
  {
    cout<<"stack is empty\n";
    return;}

  for(i=0;i<=p3->top;i++)
  {
    cout<<p3->a[i];
  }
  return;
}

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

```
do
}
cout<<"1:push\n2:pop\n3:display
;":\n4:exit\n choice
;cin>>c

switch(c)
}
;case 1:push(&s)
;break
;case 2:pop(&s)
;break
;case 3:display(&s)
;break
;"case 4:cout<<"pgm ends\n
;break
default: cout<<"wrong
;"choice\n
;break
{
;while(c!=4){
{
```

A Simple Stack Class

```
class IntStack{
    private:
      int *stackArray;
      int stackSize;
      int top;
   public:
      IntStack(int);
      bool isEmpty();
      bool isFull();
      void push();
      void pop();
      void displayStack();
      void displayTopElement();
};
```

Constructor

```
IntStack::IntStack(int size)
{
   stackArray = new int[size];
  stackSize = size;
  top = -1;
}
```

Push( )

```
void IntStack::push()
{
   clrscr();
   int num;
   if(top>=stackSize)
       cout<<"stack Overflow"<<endl;
   else
   {
    cout<<"Enter Number=";
    cin>>num;
    top++;
      stackArray[top]=num;
   }
}
```

Pop( )

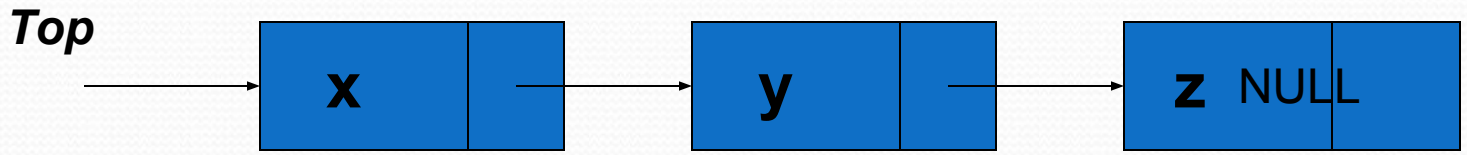
```
void IntStack::pop()
{
    clrscr();
   if(top == -1)
    cout<<"Stack Underflow"<<endl;
   else
   {
    cout<<"Number Deleted From the stack=";
      cout<<stackArray[top];
      top--;
   }
   getche();
}
```

Main( )

```
void main ()
{
  IntStack stack(5);
   int choice;
   do
   {
    cout<<“Menu"<<endl;
      cout<<"1-- PUSH"<<endl;
      cout<<"2-- POP"<<endl;
      cout<<"3– DISPLAY "<<endl;
      cout<<"4-- Exit"<<endl;
      cout<<"Enter choice=";
      cin>>choice;
      switch(choice)
{
      case 1:
              stack.push();  break;
      case 2:
              stack.pop();  break;
      case 3:
              stack.displayStack();
             break;
}
   }while(choice!=4);
   getche();
}
```

Dynamic Implementation of Stacks

- As we know that dynamic stack is implemented using linked-list.
- In dynamic implementation stack can expand or shrink with each PUSH or POP operation.
- PUSH and POP operate only on the first/top cell on the list.



Dynamic Implementation of Stack

Class Definition

```
class ListStack{
    private:
            struct node{
            int num;
            node *next;
        }*top;
   public:
      ListStack(){ top=NULL;}
      void push();
      void pop();
      void display();
};
```

Push( ) Function

- This function creates a new node and ask the user to enter the data to be saved on the newly created node.

```
void ListStack::push()
{
   node *newNode;
   newNode= new node;
   cout<<“Enter number to add on stack";
   cin>> newNode->num;
   newNode->next=top;
   top=newNode;
}
```

Pop( ) Function

```
void ListStack::pop()
{
    node *temp;
    temp=top;
    if(top==NULL)
      cout<<"Stack UnderFlow"<<endl;
    else
    {
      cout<<"deleted Number from the stack =";
      cout<<top->num;
      top=top->next;
      delete temp;
    }
}
```

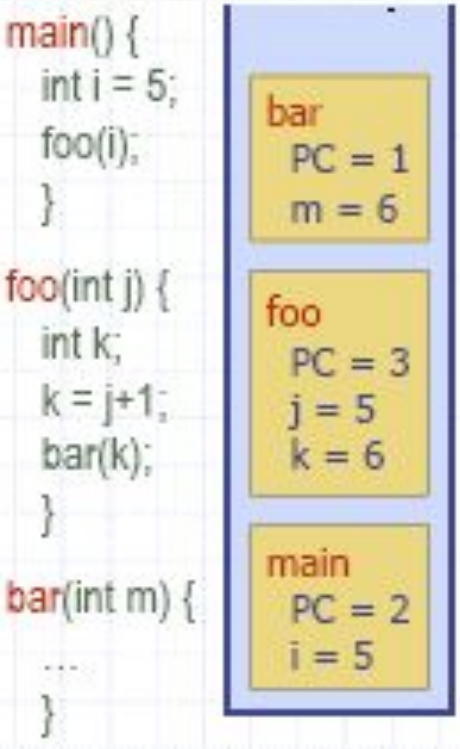
Main( ) Function

```
void main()
{
    clrscr();
   ListStack LS;
    int choice;
    do{
       cout<<"Menu "<<endl;
       cout<<"1.Push" <<endl;
       cout<<"2.Pop"<<endl;
       cout<<"3.Show"<<endl;
       cout<<"4.EXIT"<<endl;
       cin>>choice;
```

```
switch(choice){
    case 1:
       LS.push();
       break;
    case 2:
       LS.pop();
       break;
    case 3:
    LS.display();
       break;
    }
    }while(choice!=4);
}
```

C++ Run-time Stack

- The C++ run-time system keeps track of the chain of active functions with a stack
- When a function is called, the run-time system pushes on the stack a frame containing
  - Local variables and return value
  - Program counter, keeping track of the statement being executed
- When a function returns, its frame is popped from the stack and control is passed to the method on top of the stack



Pointers

"new" & "delete" Operators

Dynamic Variables: 'new' operator

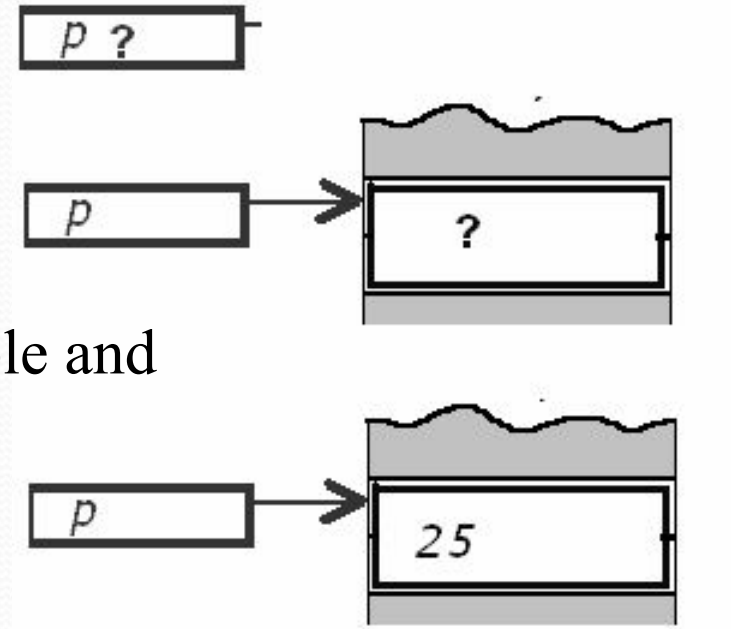
A **dynamic variable** is created and destroyed while the program is running

int *p ;

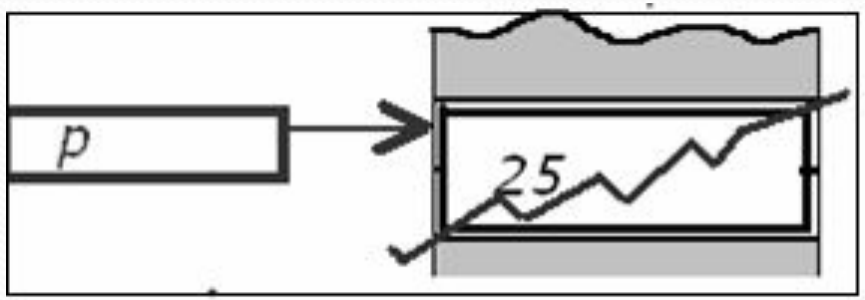
p = **new** int ;

creates a new dynamic integer variable and leaves p to point to this variable

*p = 25 ;



Dynamic Variables: ‘delete’ operator



delete p ; destroys the dynamic variable pointed by p
After delete p, p becomes an undefined pointer variable: **a dangling pointer.**
Take care: before using * again, be sure p points to something and is not a dangling pointer. Otherwise unpredictable effects.