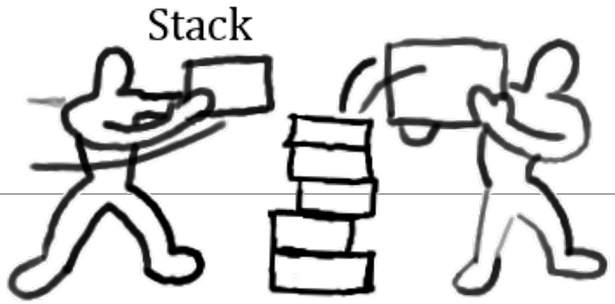
01418231
Data Structures

LECTURE-3-STACK AND APPLICATIONS



Powered by: Assit.Prof.Jirawan Charoensuk,Ph.d.

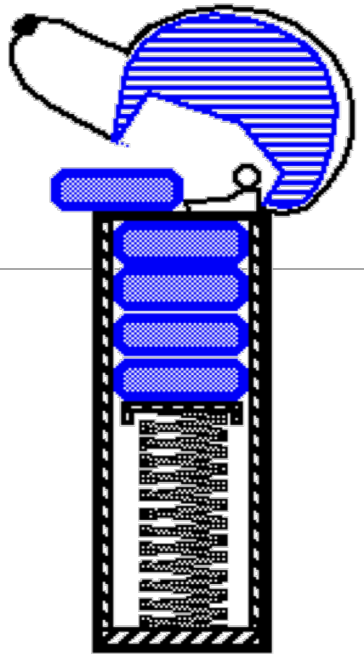
Reference: picture

Agenda

- What is Stack ?
- What is the properties of stack ?
- Applications of Stack
- Summary

https://th.aliexpress.com/item/33006540510.html

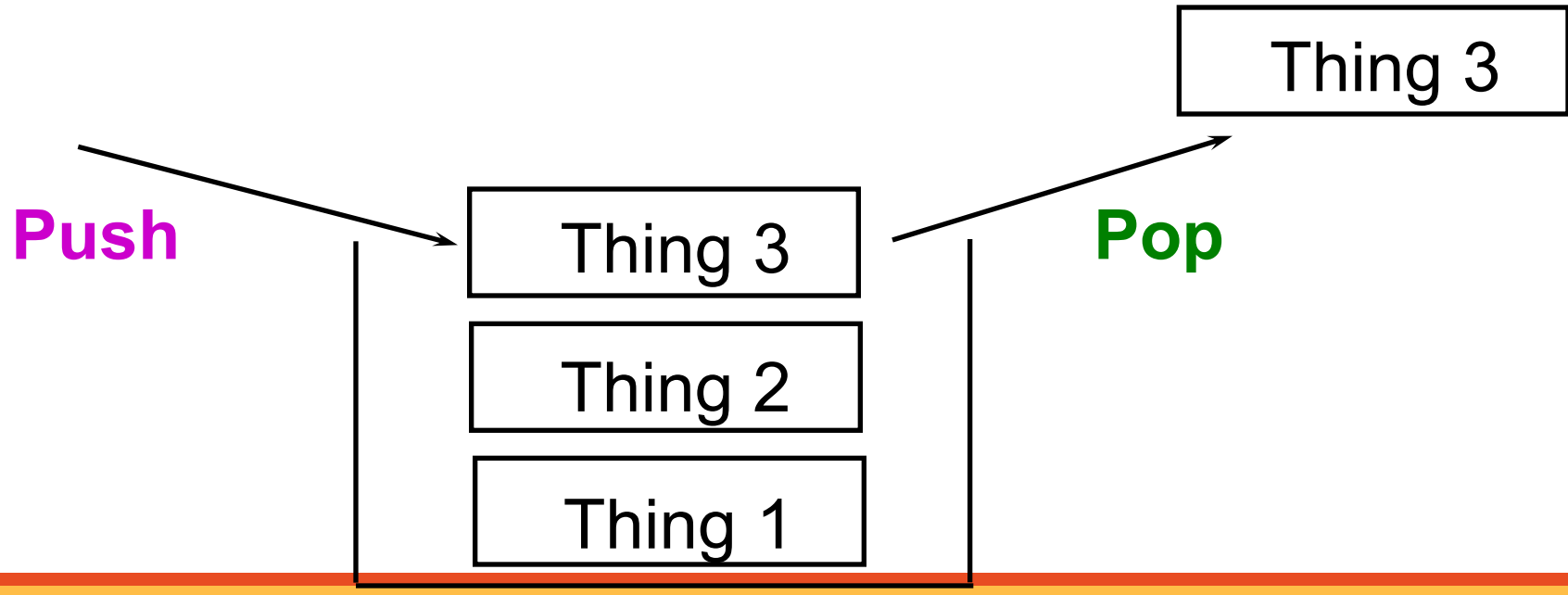
What is Stack ?



Stacks

A stack is a container of objects that are inserted and removed according to the last-in-first-out (LIFO) principle.

- Object can only be inserted to the top ("_____")
- Object can only be removed the top ("_____")



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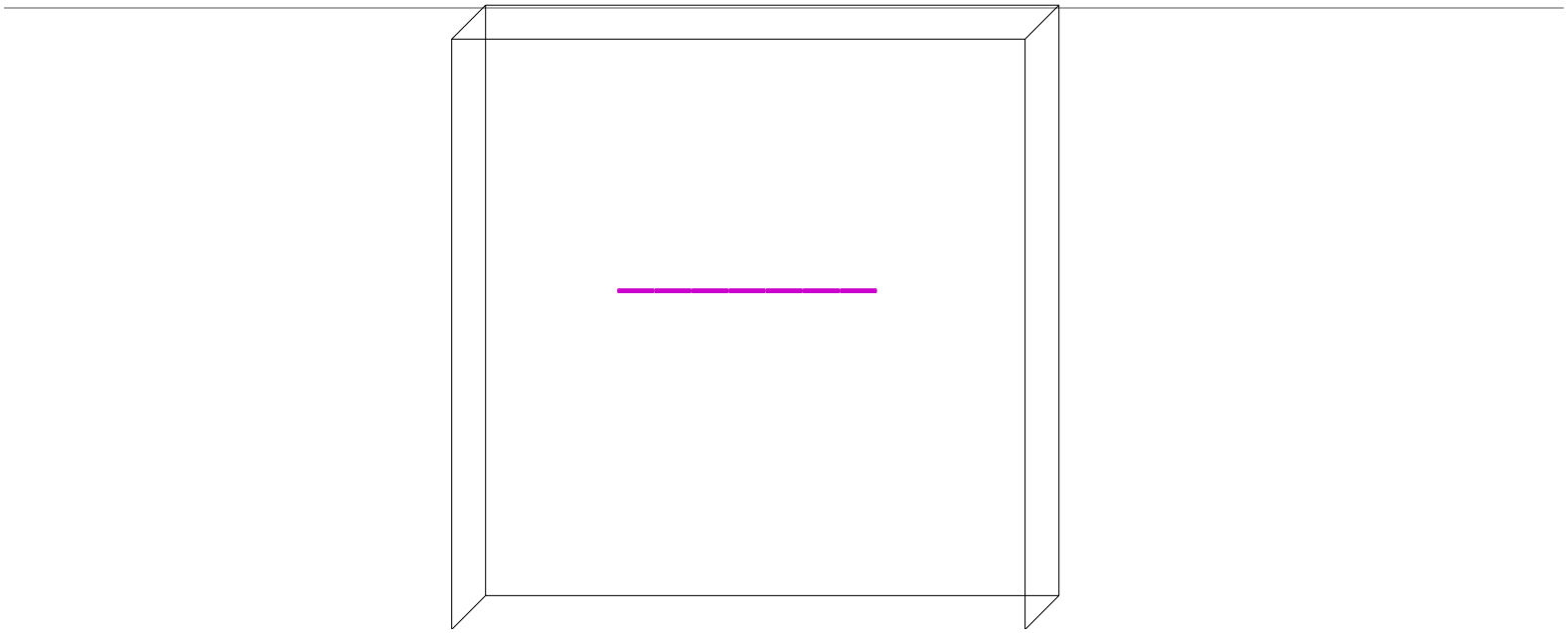

A data structure for storing items which are to be accessed in last-in first-out order (LIFO).

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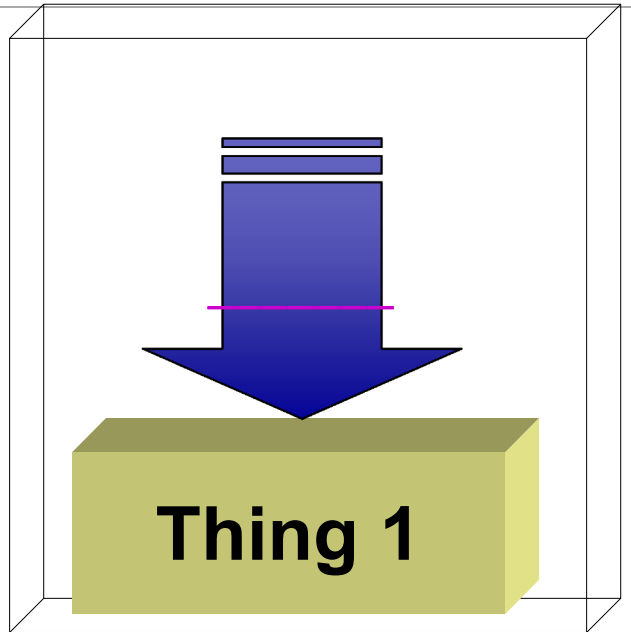

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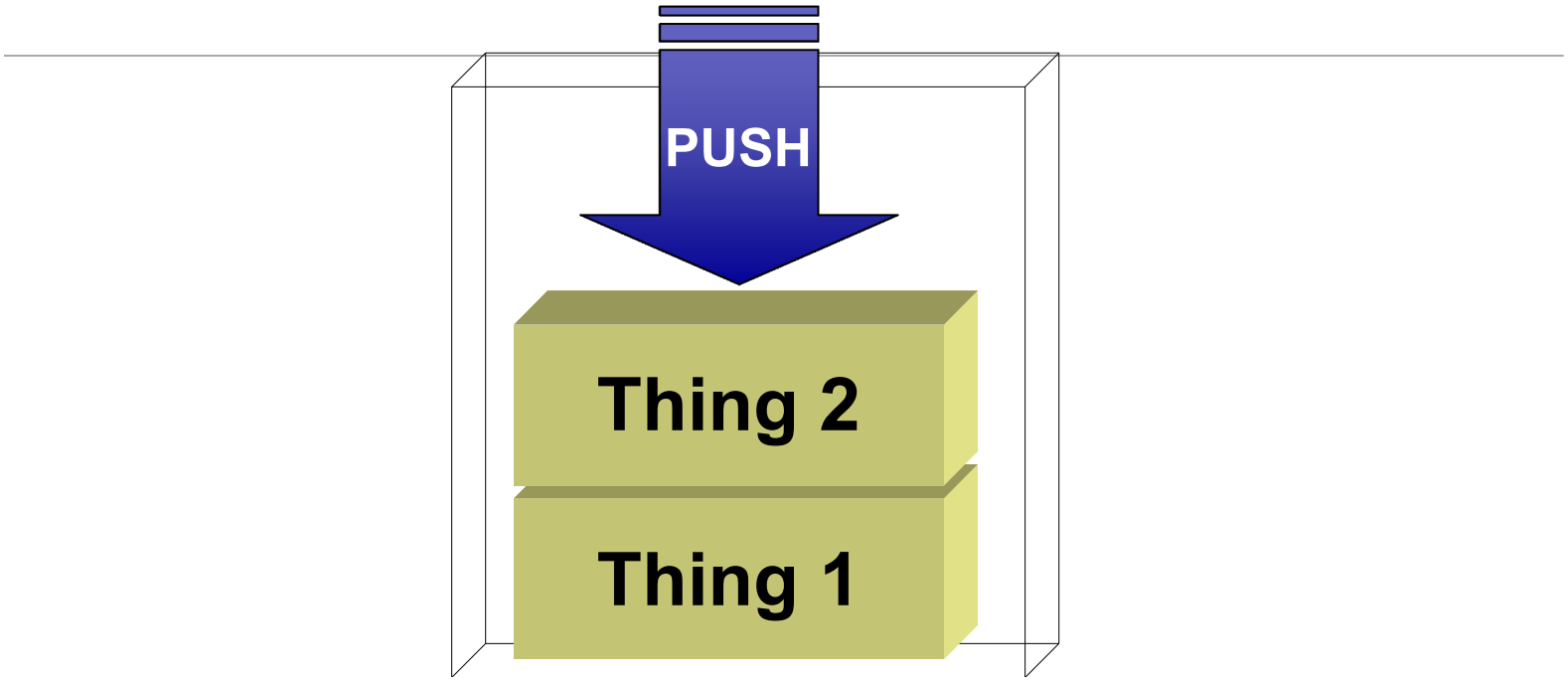

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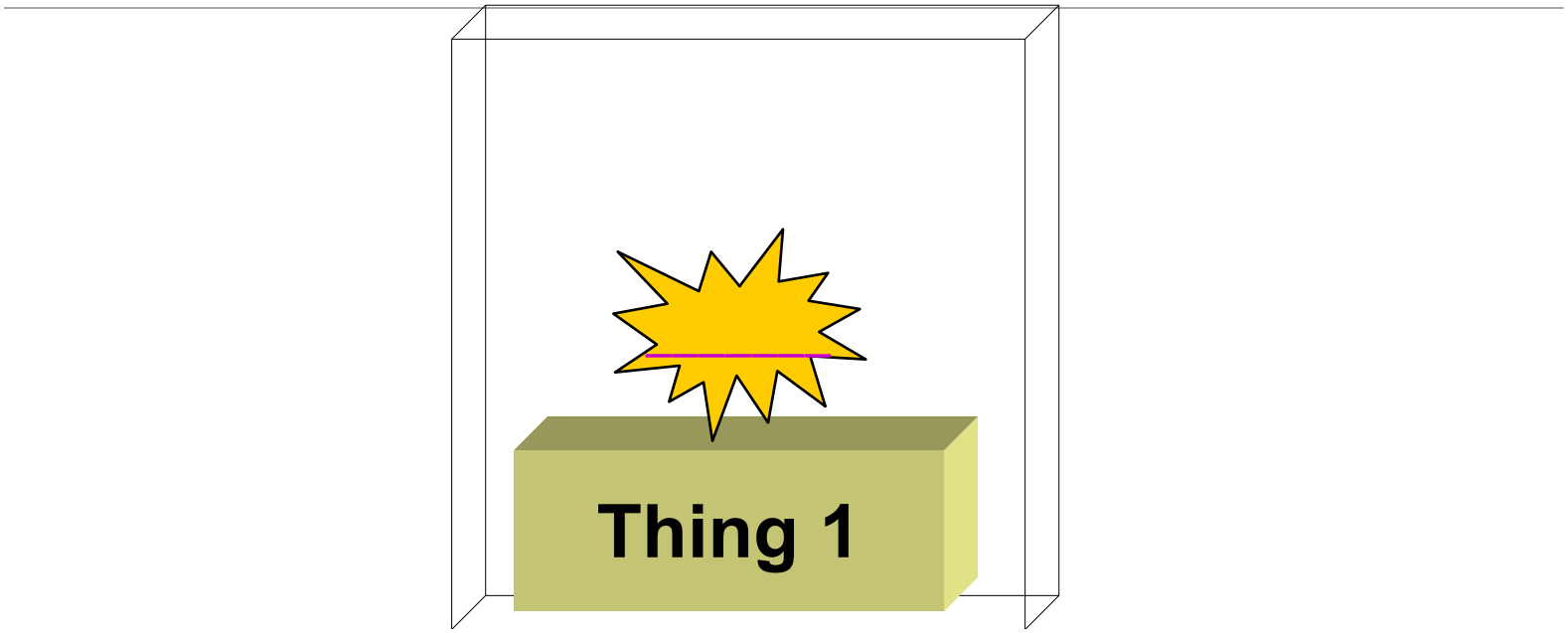

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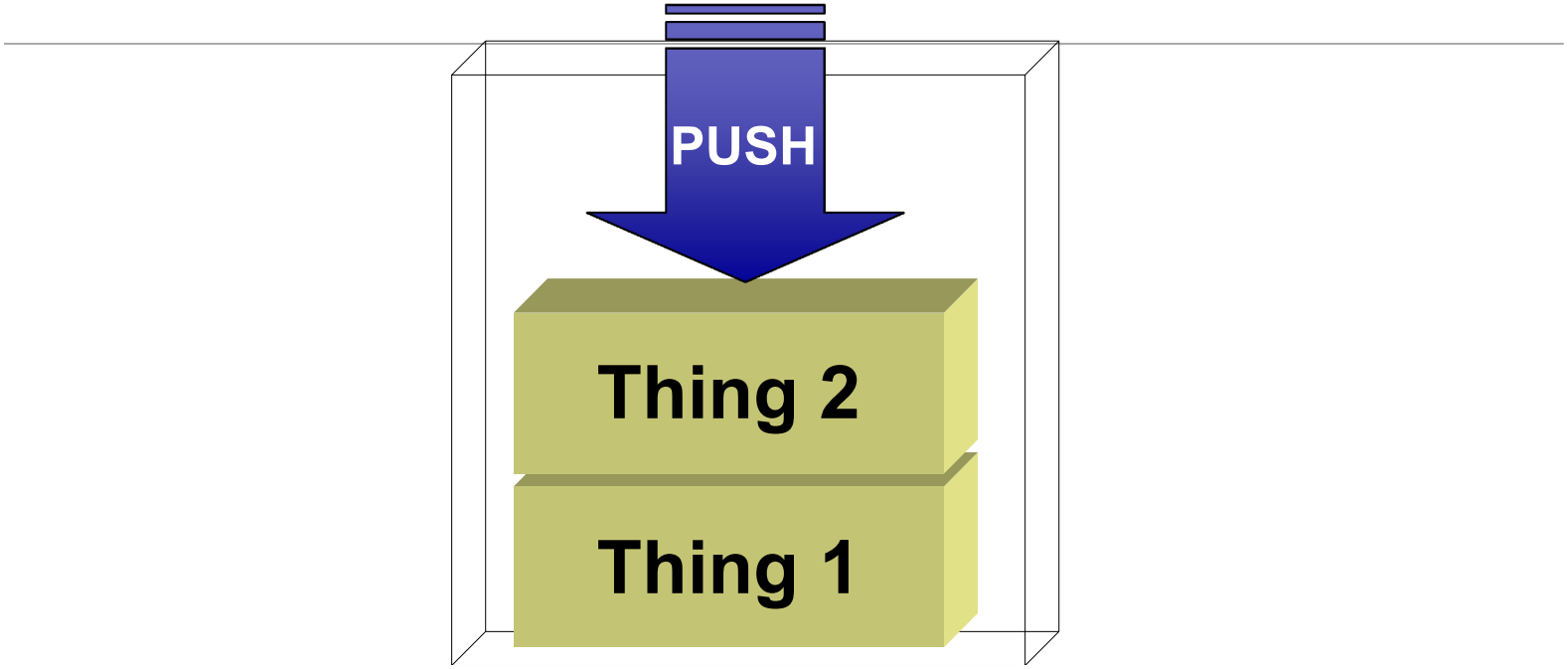

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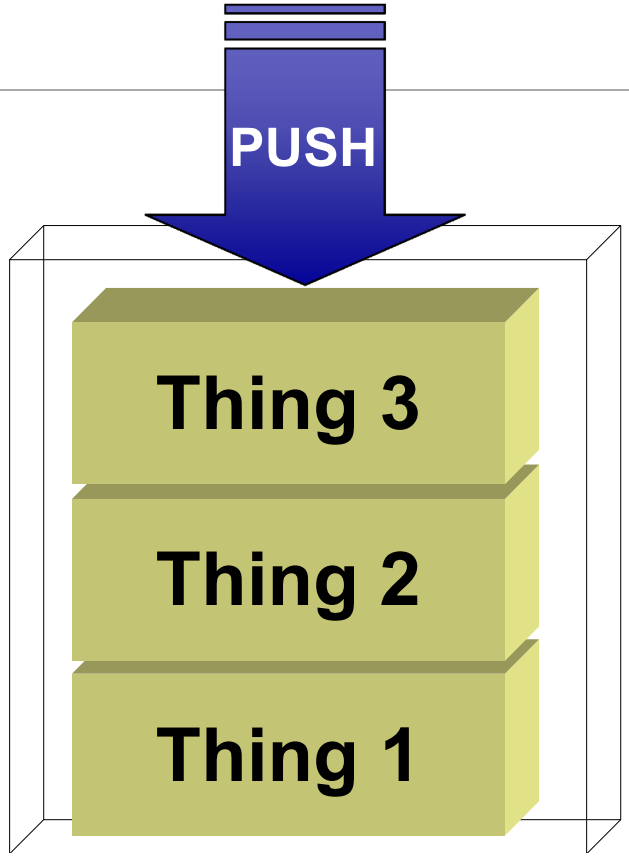

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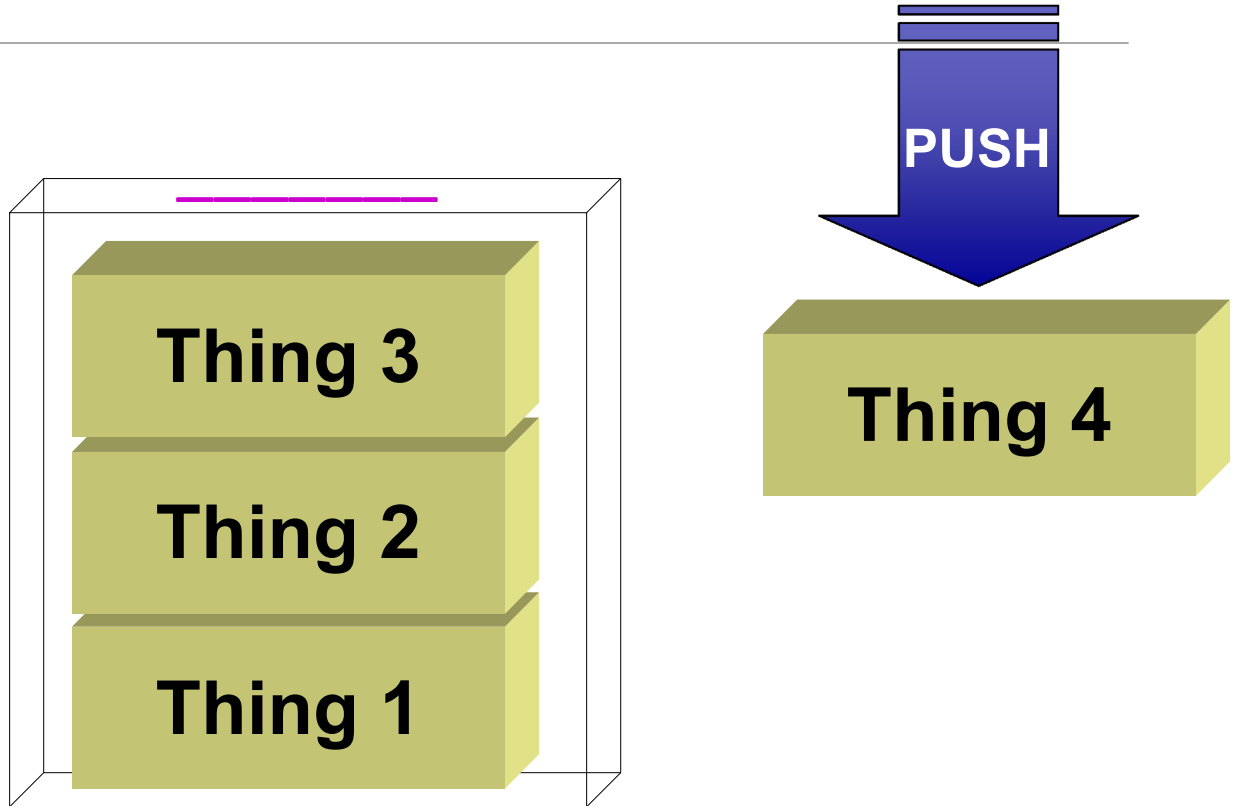

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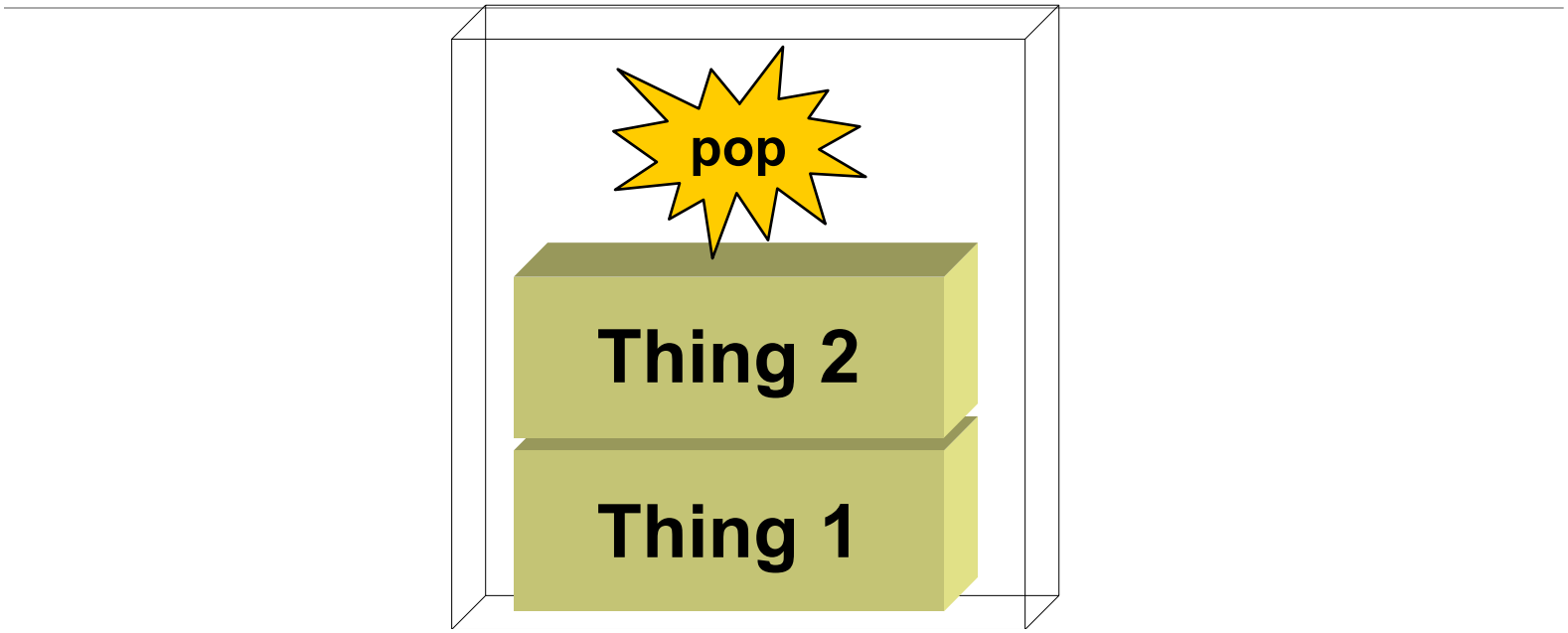

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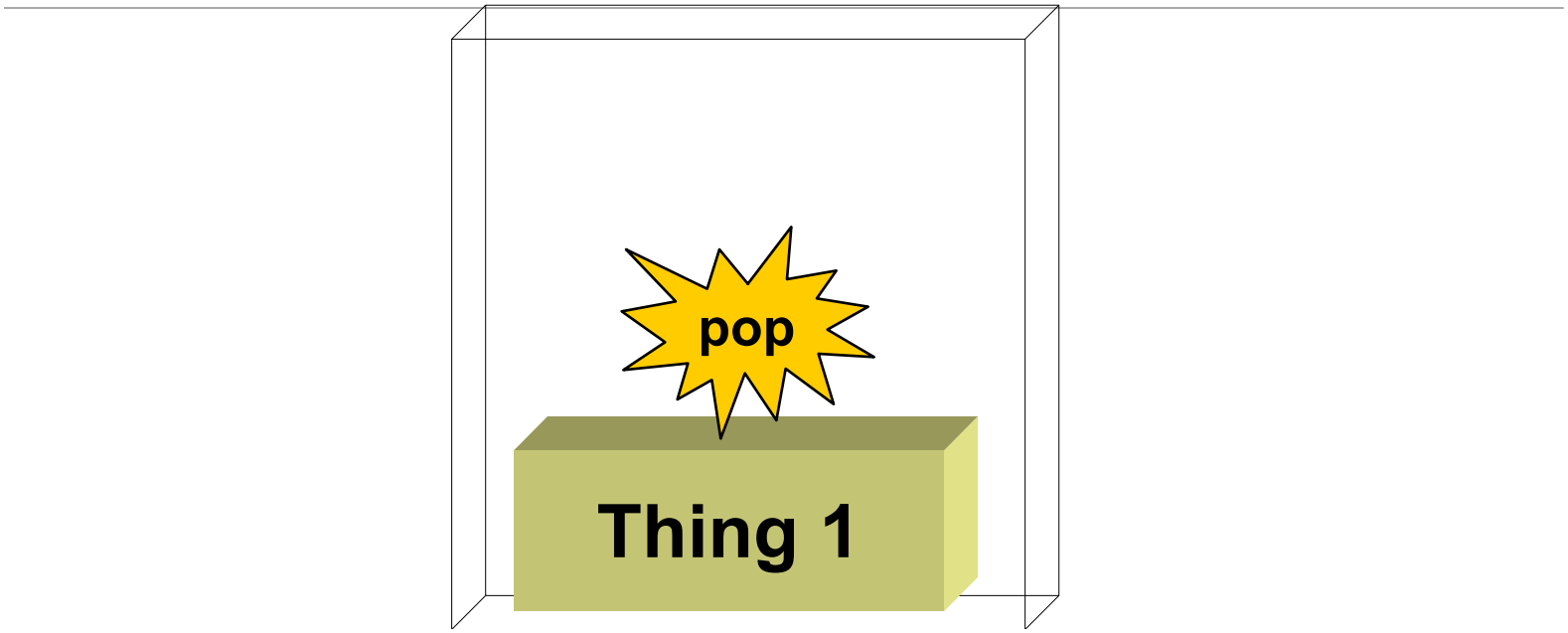

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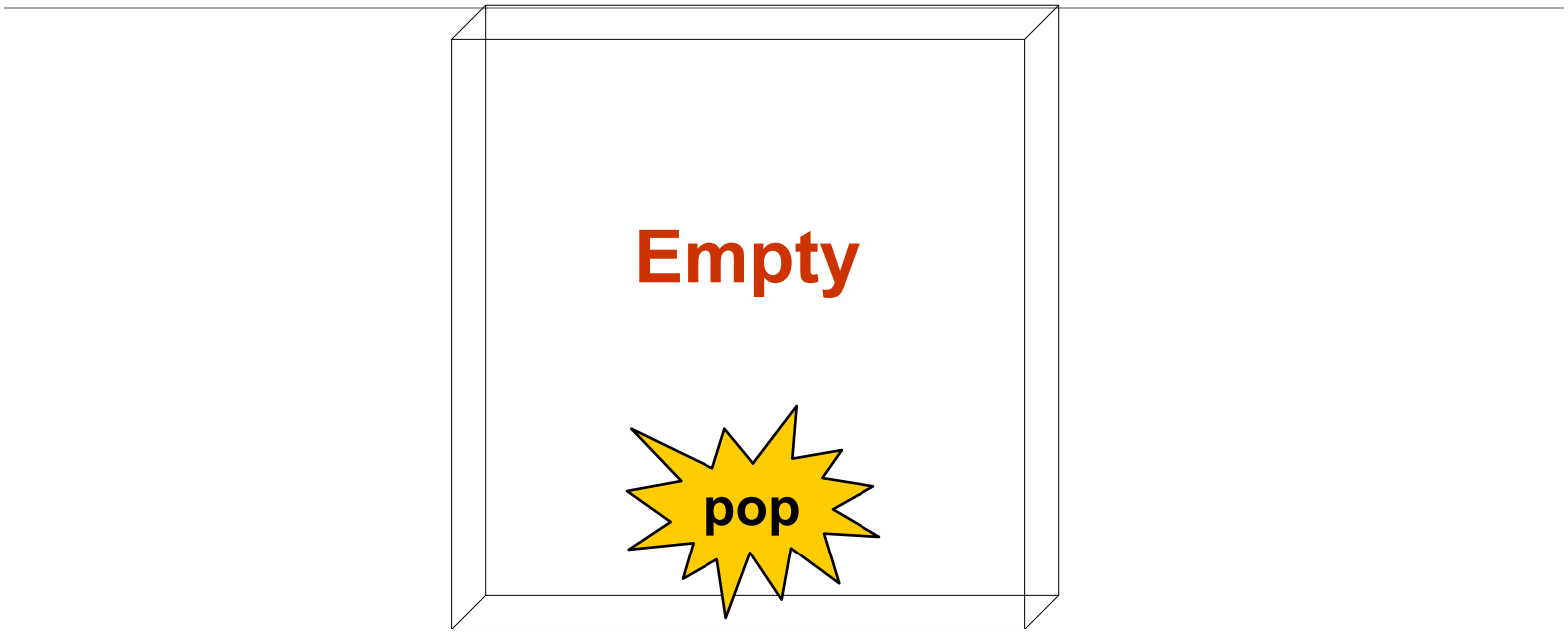


A data structure for storing items which are to be accessed in last-in first-out order (LIFO).

What is the properties of stack ?

Properties

Idea: a “Last In, First Out” (LIFO) data structure

Function:

- _____: Add to top of stack
- _____: Remove from top of stack and return that top value
- _____: Return topmost item
- _____: is it full?
- _____: is it empty?
- _____: empty stack
- _____ : Return the number of object in stack

Stack

The Stack as a Logical Data Structure

The stack is an idea

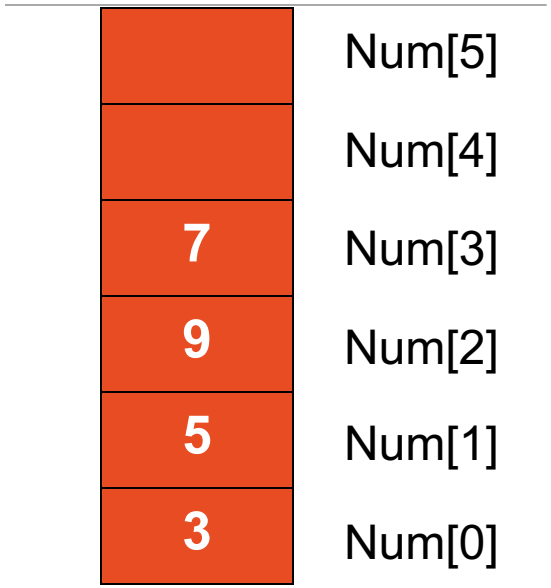
It implies a set of logical behaviors

It can be implemented various ways

- Static implement : array
- Dynamic implement: linked list

Stacks: Static Implementation

- A simple ways of implement ADT stack
- Add object from left to right
- Using index of array to calculate and refer to position or size of stack



- **Top =**
- **Size =**

Stacks: Static Implementation

The array and record storing

- Stack element may be "_____"
- Can't use "_____", if stack is full
- Must declare Top variable

Stack Operations using Array

Initial setting

Step 1: Define a constant **'SIZE'** of array.

Step 2: Declare all the **functions** used in stack implementation.

Step 3: Create a one dimensional array with fixed size (**int stack[SIZE]**)

Step 4: Define a integer variable **'top'** and initialize with **'-1'**. (**int top = -1**)

```
1.  #define SIZE 5

2.  void push(int);
3.  void pop();
4.  void display();

5.  int stack[SIZE],
6.  int top = -1;
```

http://btechsmartclass.com/DS/U2_T2.html

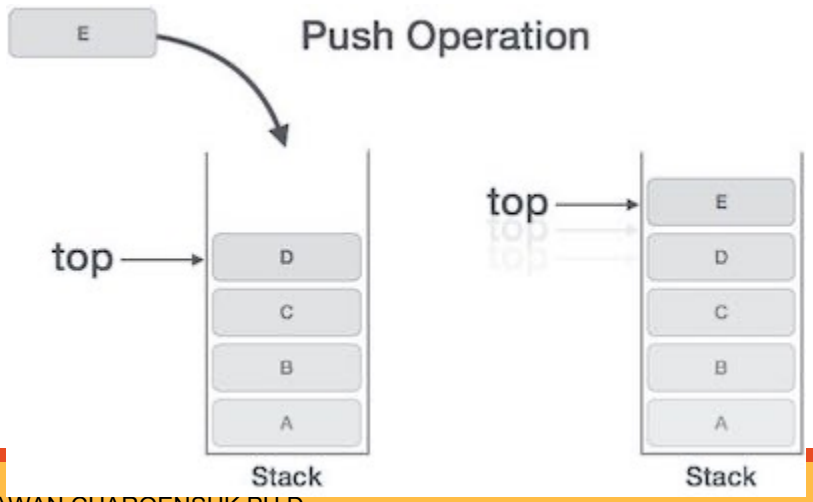
push(value) - Inserting value into the stack

Step 1: Check whether **stack** is **FULL**. (**top == SIZE-1**)

Step 2: If it is _____, then display **"Stack is FULL!!! "** and terminate the function.

Step 3: If it is _____, then increment **top** value by one (**top++**) and set stack[top] to value (**stack[top] = value**).

```
void push(int value){
  if(top == SIZE-1)
    printf("\nStack is Full!!! ");
  else{
    top++;
    stack[top] = value;
    printf("\nInsertion success!!!");
  }
}
```



https://www.tutorialspoint.com/data_structures_algorithms/stack_algorithm.htm

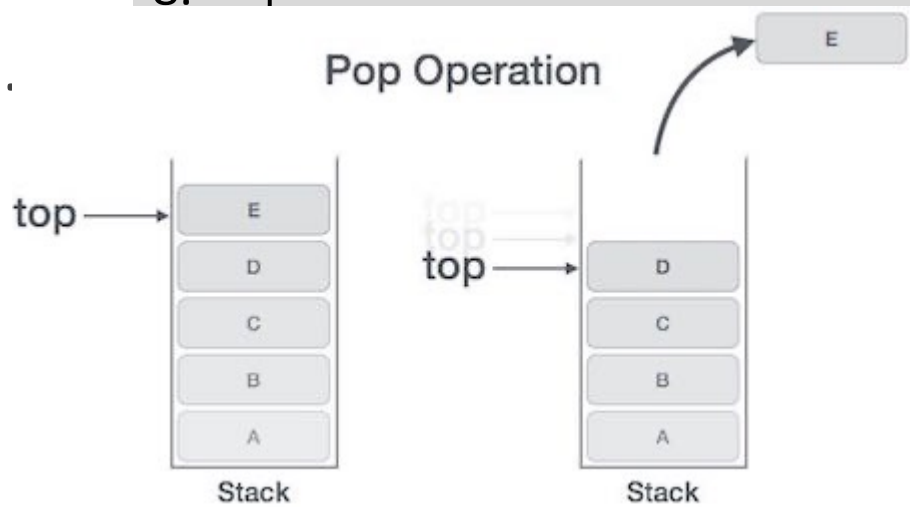
pop() - Delete a value from the Stack

Step 1: Check whether **stack** is **EMPTY**. (**top == -1**)

Step 2: If it is _____, then display **"Stack is EMPTY!!!"** and terminate the function.

Step 3: If it is _____, then delete **stack[top]** and decrement **top** value by one (**top--**).

```
void pop(){
  if(top == -1)
    printf("\nStack is Empty!!! ");
  else{
      printf("\nDeleted : %d",
      stack[top]);
    top--;
  }
}
```



https://www.tutorialspoint.com/data_structures_algorithms/stack_algorithm.htm

display() - Displays the elements of a Stack

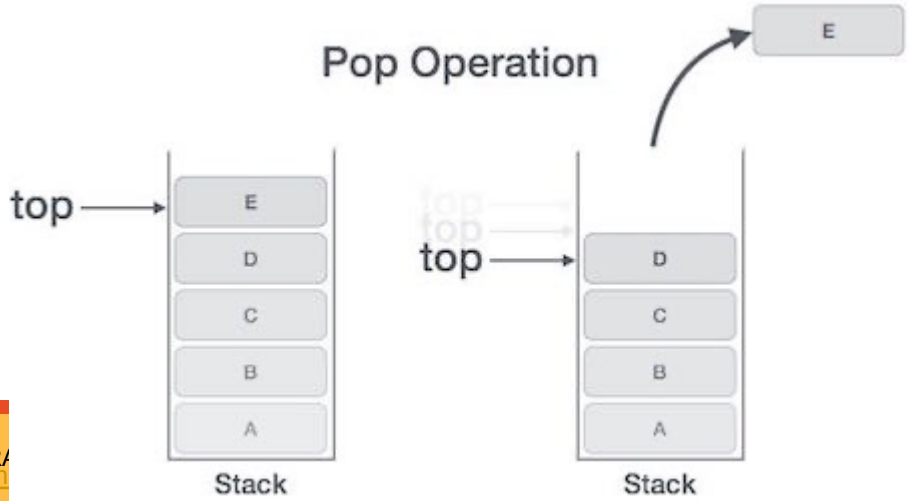
Step 1: Check whether **stack** is **EMPTY**. (**top == -1**)

Step 2: If it is _____, then display **"Stack is EMPTY!!!"** and terminate the function.

Step 3: If it is _____, then define a variable '**i**' and initialize with top. Display **stack[i]** value and decrement **i** value by one (**i--**).

Step 3: Repeat above step until **i** value becomes '0'.

```
void display(){
  if(top == -1)
    printf("\nStack is Empty!!!");
  else{
    int i;
    printf("\nStack elements are:\n");
    for(i=top; i>=0; i--)
   printf("%d\n",stack[i]);
  }
}
```



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

#define SIZE 5

void push(int);
void pop();
void display();

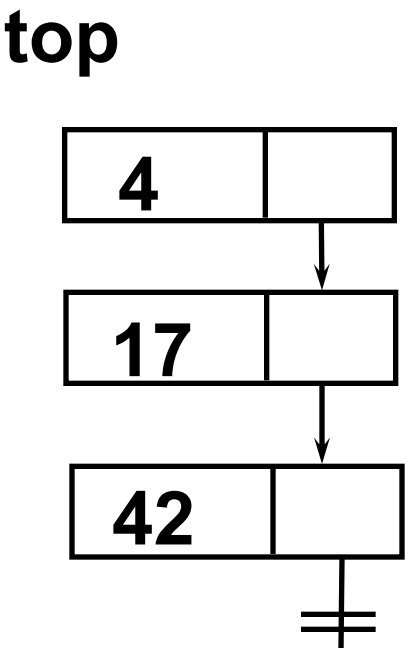
int stack[SIZE], top = -1;
main()
{
  int value, choice;
  while(1){
    printf("\n\n***** MENU *****\n");
    printf("1. Push\n2. Pop\n3. Display\n4. Exit");
    printf("\nEnter your choice: ");
    scanf("%d",&choice);
    switch(choice){
      case 1: printf("Enter the value to be insert: ")
            scanf("%d",&value);
            push(value);display();
            break;
      case 2: pop(); display();
            break;
      case 3: display();
            break;
     case 4: exit(0);
      default: printf("\nWrong selection!!! Try again!!!");
    }
  }
}
```

```
30. void push(int value){
31.    if(top == SIZE-1)
32.       printf("\nStack is Full!!!\n\n");
33.    else{
34.       top++;
35.       stack[top] = value;
36.       printf("\nInsertion success!!!\n\n");
37.    }
38. }
39. void pop(){
40.    if(top == -1)
41.       printf("\nStack is Empty!!!\n\n");
42.    else{
43.       printf("\nDeleted : %d", stack[top]);
44.       top--;
45.    }
46. }
```

```
47. void display(){
48.    if(top == -1)
49.       printf("\nStack is Empty!!!\n\n");
50.    else{
51.       int i;
52.       printf("\nStack elements are:\n\n");
53.       for(i=top; i>=0; i--)
54.         printf("%d\n",stack[i]);
55.    }
56. }
```

Stacks: Dynamic Implementation

A linked list with restricted set of operations to change its state: only modified from one to end



Defining the Node Type

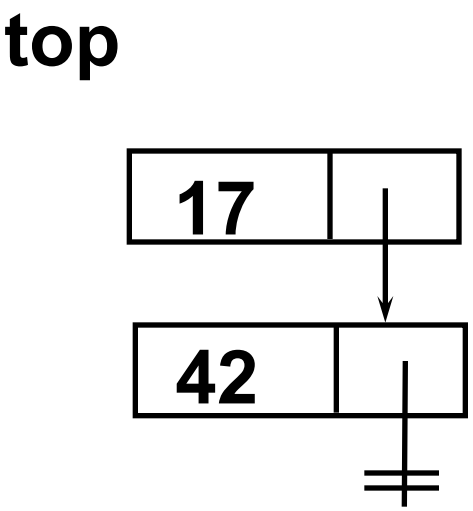
This is the simple data structure we will use in the following example

```
Node defines a record
  data isoftype Num
  next isoftype Ptr
endrecord  // Node
```

```
struct node
{
  int data;
  struct node *next;
};
```

Push

1. Create new node
2. Add it to the front



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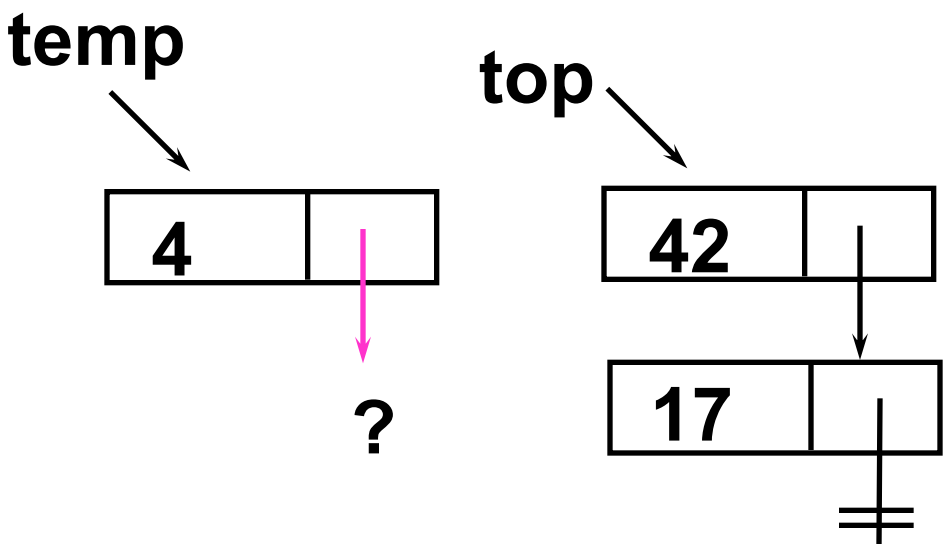

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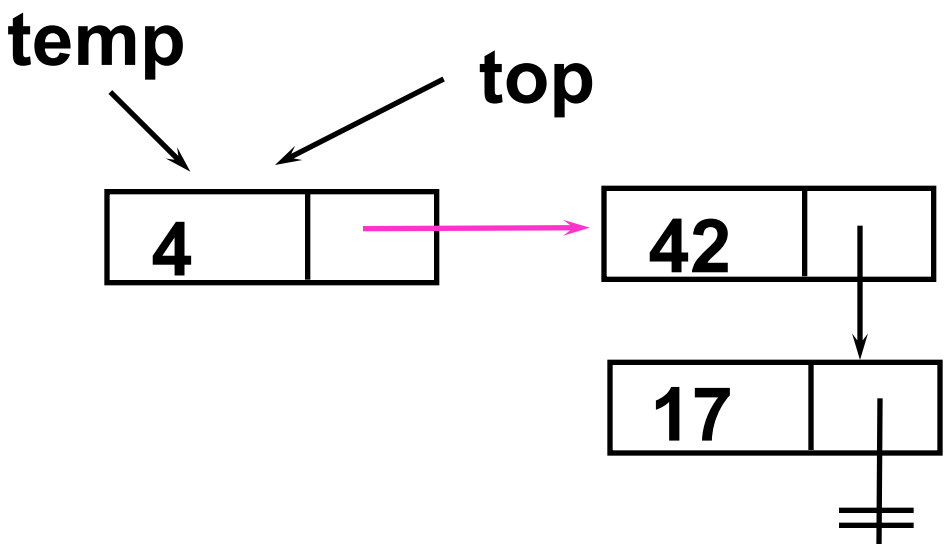
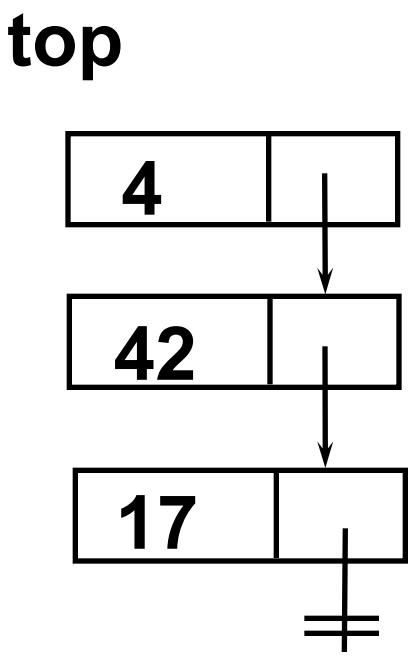


Push

```
Procedure Push (value isoftype in Num,
    top isoftype in/out Ptr)
  // Push one value onto stack
  temp isoftype Ptr
  temp = newNode
  temp->data = value
  temp->next = top
  top = temp
endprocedure // Push
```

Pop

1. Capture the first value (to return)
2. Remove the first node (move top to next)



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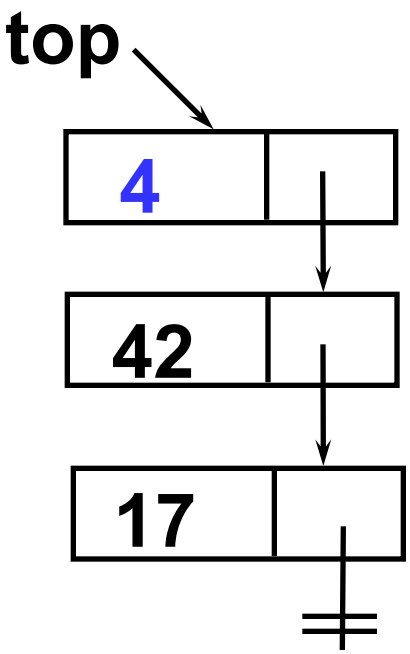

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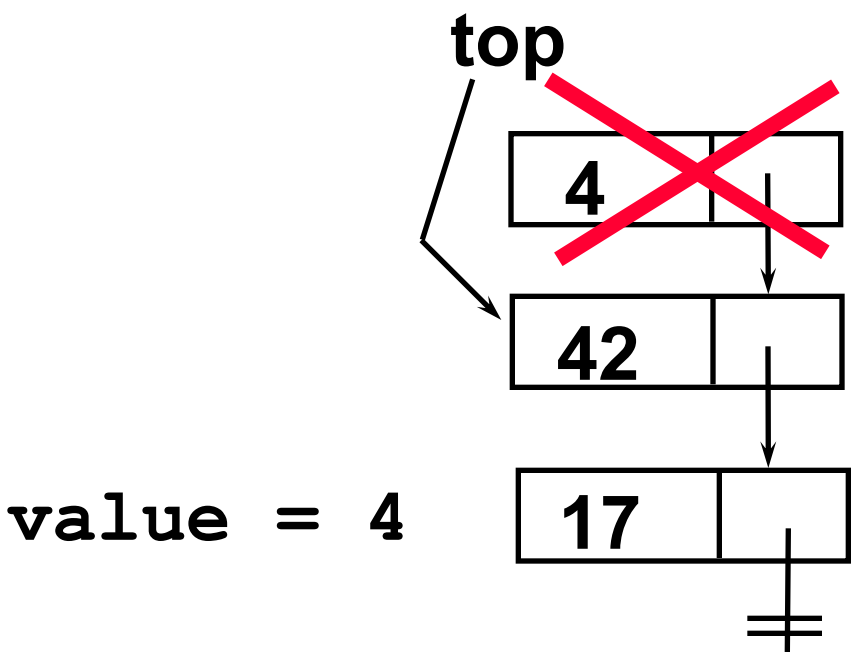

Pop

```
Procedure Pop (value isoftype out Num, top isoftype in/out Ptr ,
    result isoftype out Boolean)  // Pop an element off the stack
  if(top == NULL) then
    result = FALSE
  else
    result = TRUE
    value = top->data
    top = top->next
  endif
End procedure  // Pop
```

Algorithm Fragment

```
...
top isoftype Ptr
OK isoftype Boolean
N isoftype Num
top = NULL
Push(42, top)
Push(2, top)
Pop(N, top, OK)
if(OK) then
  print(N)
endif
```

```
Push(7, top)
Pop(N, top, OK)
Pop(N, top, OK)
...
```

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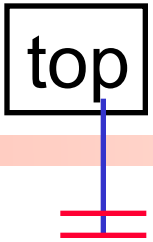
N =



```
Procedure Push
    (value isoftype in Num,
     top isoftype in/out Ptr)
  temp isoftype Ptr
  temp = new(Node)
  temp->data = value
  temp->next = top
  top = temp
endprocedure
```

```
  print(N)
endif
Push(7, top)
Pop(N, top, OK)
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.
```

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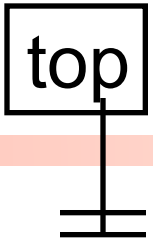
N =



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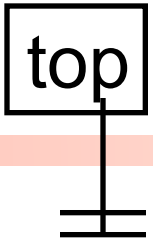

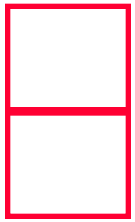

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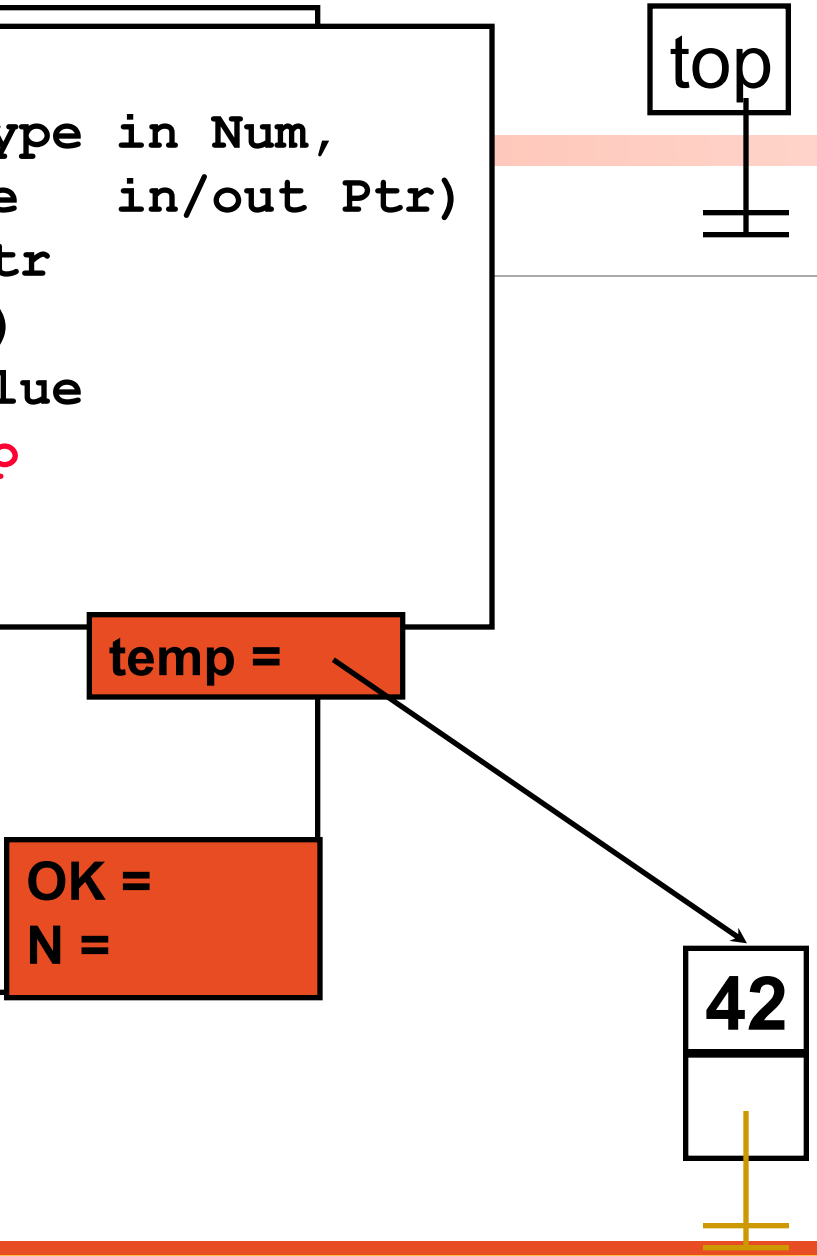

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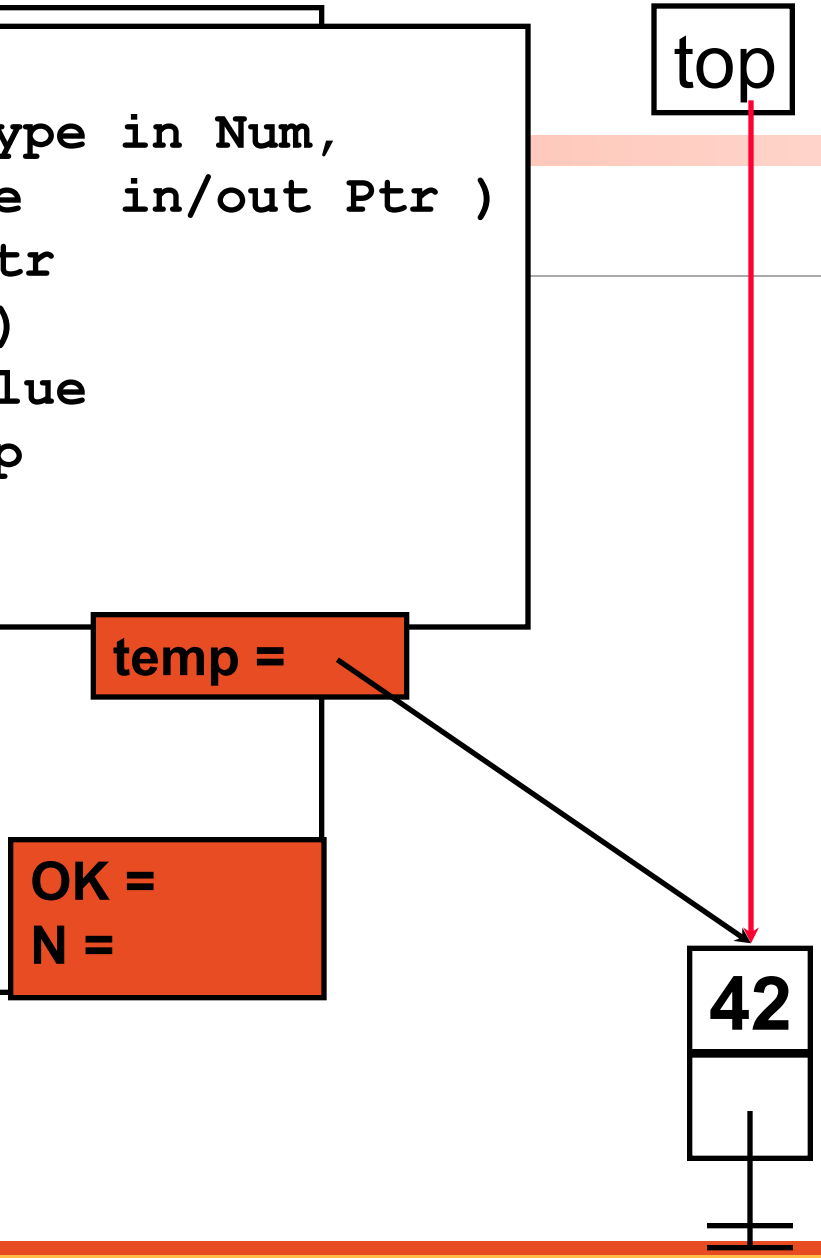

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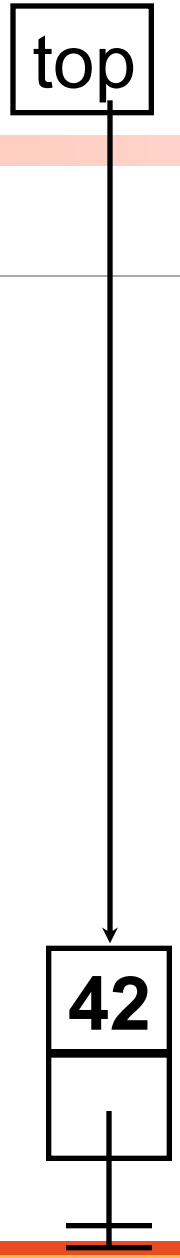

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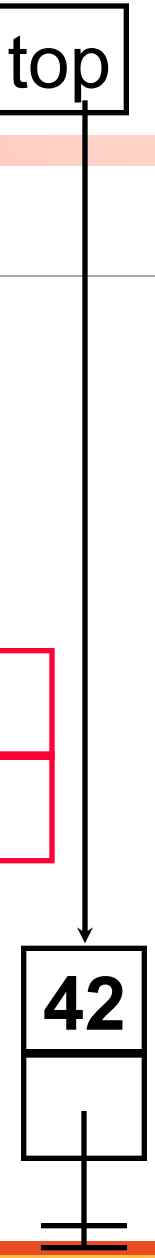

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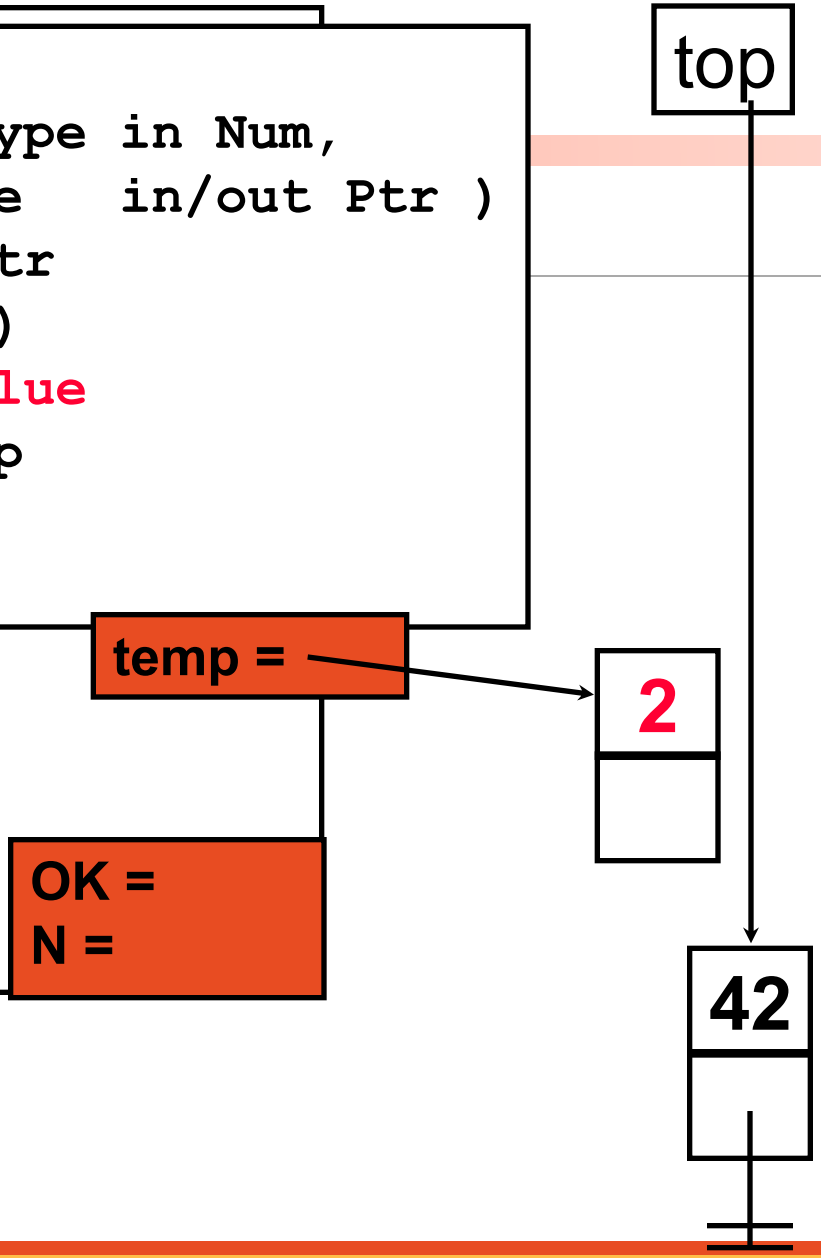

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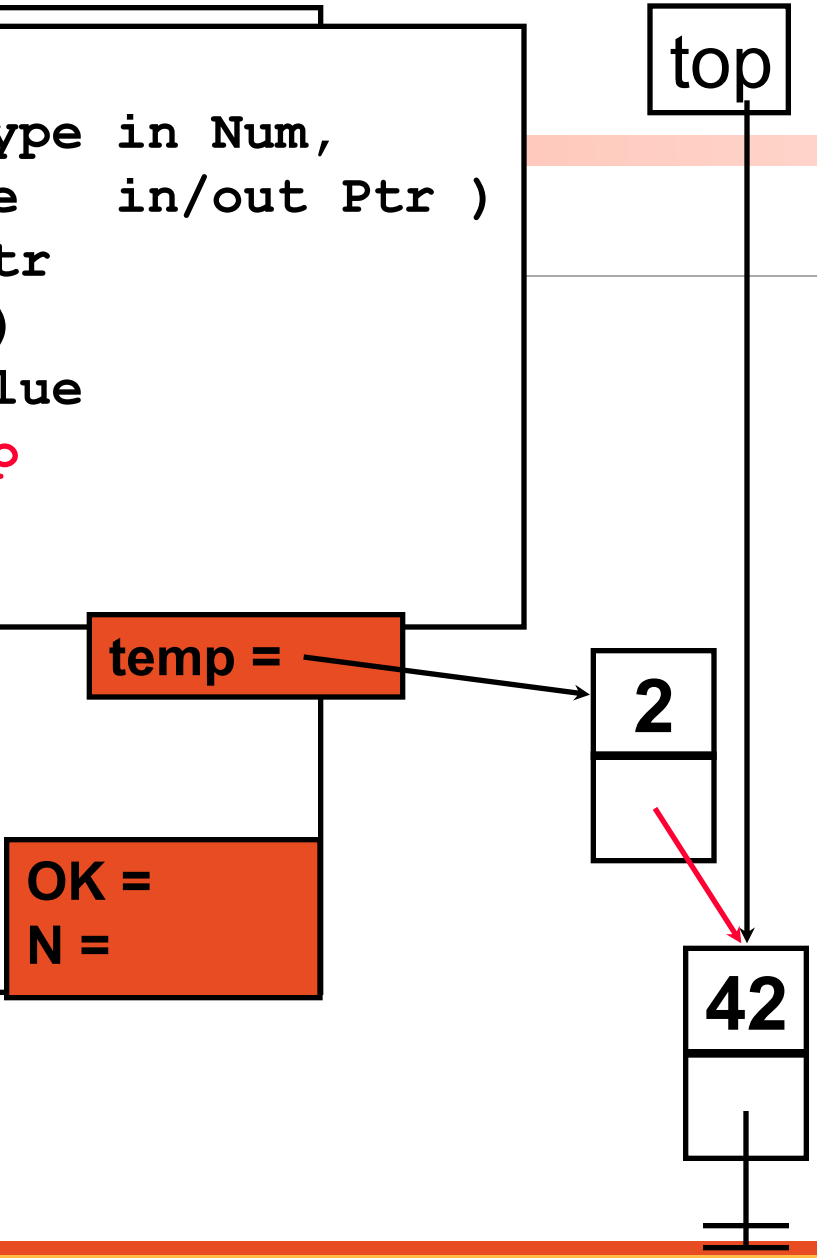
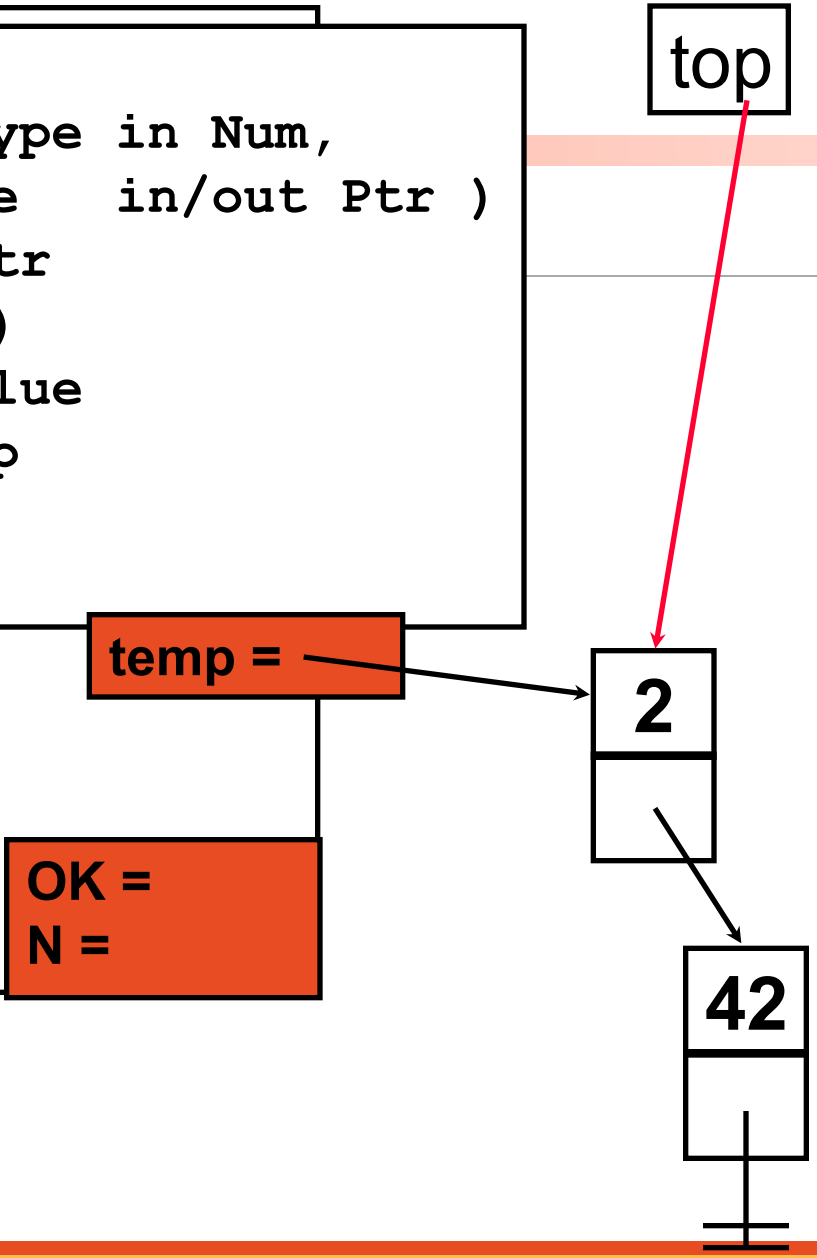
.
```



```
Procedure Push
     (value isoftype in Num,
      top isoftype   in/out Ptr )
  temp isoftype Ptr
  temp = new(Node)
  temp->data = value
  temp->next = top
  top = temp
endprocedure
```

```
endif
Push(7, top)
Pop(N, top, OK)
Pop(N, top, OK)
.
```

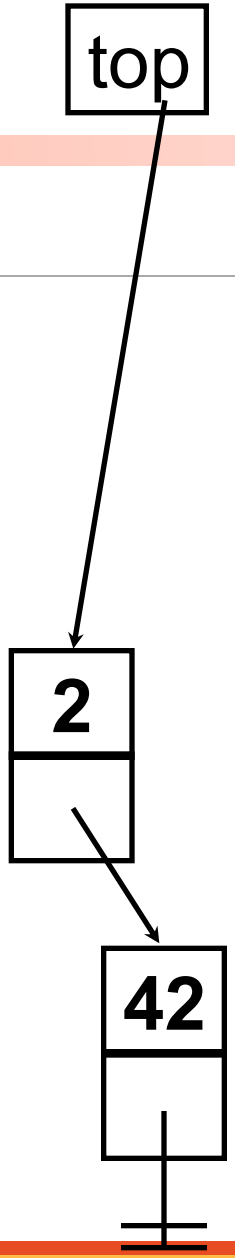


```
Procedure Pop
  value isoftype out Num,
  top isoftype   in/out Ptr,
  result isoftype out Boolean)
 if(top = NULL) then
  result = FALSE
 else
  result = TRUE
  value = top->data
  top = top->next
 endif
endprocedure
```

```
Pop(N, top, OK)
.
```

value =
result =

OK =
N =

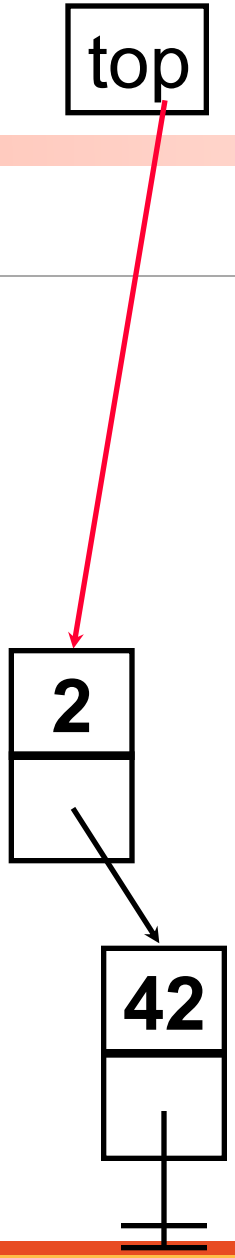


```
Procedure Pop
  value isoftype out Num,
  top isoftype   in/out Ptr,
  result isoftype out Boolean)
 if(top = NULL) then
  result = FALSE
 else
  result = TRUE
  value = top->data
  top = top->next
 endif
endprocedure
```

```
Pop(N, top, OK)
.
```

value =
result =

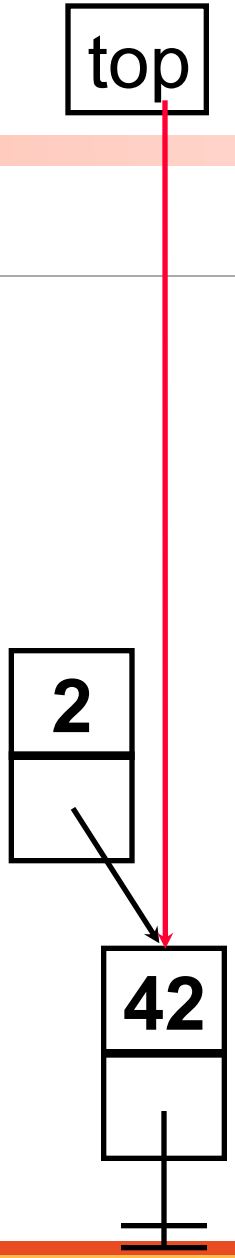
OK =
N =



```
Procedure Pop
   value isoftype out Num,
   top isoftype   in/out Ptr,
   result isoftype out Boolean)
  if(top = NULL) then
   result = FALSE
  else
   result = TRUE
   value = top->data
   top = top->next
  endif
endprocedure
Pop(N, top, OK)
.
```

value = 2
result = T

OK =
N =

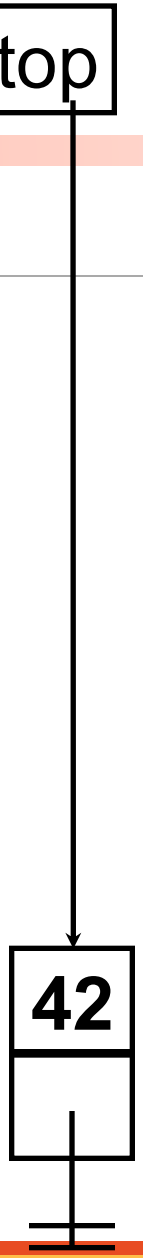


```
Procedure Pop
  value isoftype out Num,
  top isoftype   in/out Ptr,
  result isoftype out Boolean)
 if(top = NULL) then
  result = FALSE
 else
  result = TRUE
  value = top->data
  top = top->next
 endif
endprocedure
```

```
Pop(N, top, OK)
.
```

value = 2
result = T

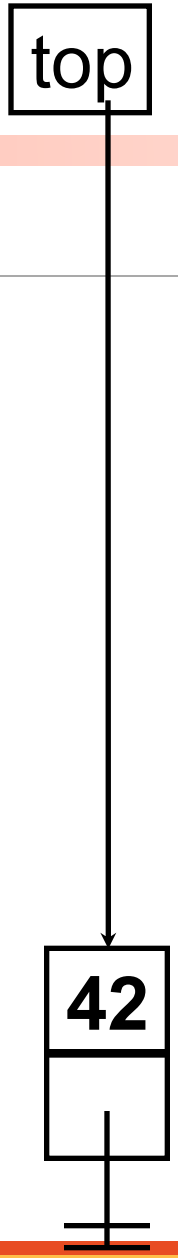
OK =
N =



```
.
top isoftype Ptr
OK isoftype Boolean
N isoftype Num
top = NULL
Push(42, top)
Push(2, top)
Pop(N, top, OK)
if(OK) then
 print(N)
endif
Push(7, top)
Pop(N, top, OK)
Pop(N, top, OK)
.
```

OK = T
N = 2

2



```
.
top isoftype Ptr
OK isoftype Boolean
N isoftype Num
top = NULL
Push(42, top)
Push(2, top)
Pop(N, top, OK)
if(OK) then
 print(N)
endif
Push(7, top)
Pop(N, top, OK)
Pop(N, top, OK)
.
```

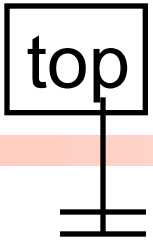
OK = T
N = 2

```
.
top isoftype Ptr
OK isoftype Boolean
N isoftype Num
top = NULL
Push(42, top)
Push(2, top)
Pop(N, top, OK)
if(OK) then
 print(N)
endif
Push(7, top)
Pop(N, top, OK)
Pop(N, top, OK)
.
```

OK = T
N = 7

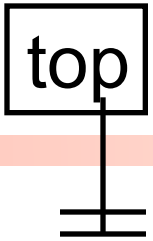
```
.
top isoftype Ptr
OK isoftype Boolean
N isoftype Num
top = NULL
Push(42, top)
Push(2, top)
Pop(N, top, OK)
if(OK) then
 print(N)
endif
Push(7, top)
Pop(N, top, OK)
Pop(N, top, OK)
.
```

OK = T
N = 42



```
.
top isoftype Ptr
OK isoftype Boolean
N isoftype Num
top = NULL
Push(42, top)
Push(2, top)
Pop(N, top, OK)
if(OK) then
 print(N)
endif
Push(7, top)
Pop(N, top, OK)
Pop(N, top, OK)
.
```

OK = T
N = 42



```
#include <stdio.h>
#include <stdlib.h>
struct node
{
  int data;
  struct node *next;
}*top = NULL;

void push(int);
void pop();
void display();
```

```
main()
{
  int choice, value;
  printf("\n:: Stack using Linked List ::\n");
  while(1){
    printf("\n****** MENU ******\n");
    printf("1. Push\n2. Pop\n3. Display\n4. Exit\n");
    printf("Enter your choice: ");
    scanf("%d",&choice);
    switch(choice){
        case 1: printf("Enter the value to be insert: ");
                scanf("%d", &value);
                push(value);display();
                break;
        case 2: pop(); display();break;
        case 3: display(); break;
        case 4: exit(0);
        default: printf("\nWrong selection!!! Please try again!!!\n");
    }
  }
}
```

```
void push(int value)
{
    struct node *newnode;
    newnode = malloc(sizeof(struct node));

    newnode->data = value;
    if(top == NULL)
        newnode->next = NULL;
    else
        newnode->next = top;
    top = newnode;
    printf("\nInsertion is Success!!!\n");
}
```

```
void pop()
{
  if(top == NULL)
    printf("\nStack is Empty!!!\n");
  else{
    struct node *temp = top;
    printf("\nDeleted element: %d\n", temp->data);
    top = temp->next;
    free(temp);
  }
}
```

```
void display()
{
  if(top == NULL)
    printf("\nStack is Empty!!!\n");
  else{
    struct node *temp = top;
    while(temp->next != NULL){
      printf("%d--->",temp->data);
      temp = temp -> next;
    }
    printf("%d--->NULL\n\n",temp->data);
  }
}
```

Summary

Abstract data type (ADT) is composed of

- A collection of data
- A set of operations on that data

The ADT stack operations have a last-in, first-out (LIFO) behavior

Stack can be implemented by arrays or linked lists

Summary

The ADT stack operations have a last-in, first-out (LIFO) behavior

Stack can be implemented by arrays or linked lists

Function:

- Push: Add to top of stack
- Pop: Remove from top of stack and return that top value
- Top: Return topmost item
- Is_Full: is it full?
- Is_Empty: is it empty?
- Initialize: empty stack
- Size_of_object : Return the number of object in stack

01418231 Data Structures

STACK APPLICATIONS

Agenda

Application areas use stacks:

- Bracket Checker
- Convert Infix to Postfix
- Evaluation of arithmetic expression
- Call Nested Procedures

Agenda

Application areas use stacks:

- Bracket Checker {[(.....)]}
- Convert Infix to Postfix
- Evaluation of arithmetic expression
- Call Nested Procedures

Bracket Matching Problem

Ensures that pairs of brackets are properly matched

- Example: `{a,(b+f[4])*3,d+f[5]}`

- **Bad Examples:**

```
(..)..)    // too many closing brackets

(..(..)    // too many open brackets

[..(..]..)   // mismatched brackets
```

Push Open Bracket in stack -> { , [, (

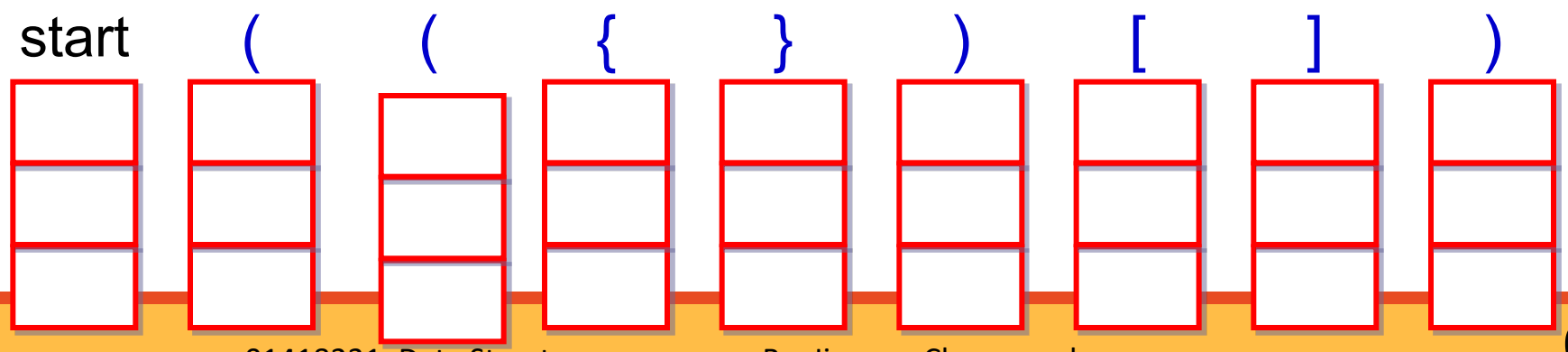
If operand is Close Bracket -> },],) check on top of stack

- if (it is the same type) then Pop stack
- else print “error”

Print result

- if (stack null) then print “OK”
- else print data in stack

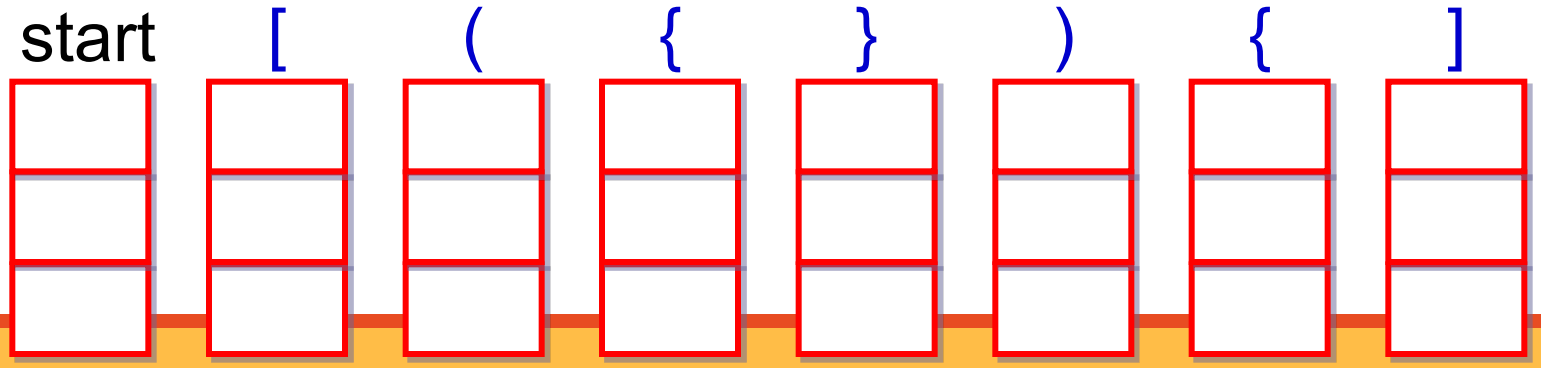
input : (({})[])



1. Push Open Bracket in stack -> { , [, (
2. If operand is Close Bracket -> },],) check on top of stack
   - if it is the same type then Pop stack
   - else print “error”

   Print result
   - if stack null then print “OK”
   - else print data in stack

input : [({}){])



Agenda

Application areas use stacks:

- Bracket Checker
- Convert Infix to Postfix
- Evaluation of arithmetic expression
- Call Nested Procedures

Arithmetic expression

Infix

- operand1 operator operand2

  1 + 2

Prefix

- operator operand1 operand2

  + 1 2

Postfix

- operand1 operand2 operator

  1 2 +

Arithmetic expression

Infix	Prefix	Postfix
A+B	+AB	AB+
(A+B)*C	*+ABC	AB+C*
A+(B*C)		
(A+B)/(C*D)		

Infix -> Postfix

อ่านนิพจน์ infix เข้าสู่โปรแกรมทีละ 1 ตัวอักษร

1) ถ้าข้อมูลที่อ่านเข้ามาเป็น operand ให้นำไปเป็น output

2) ถ้าข้อมูลที่อ่านเข้ามาเป็น (ให้ push (ลง stack

3) ถ้าข้อมูลที่อ่านเข้ามาเป็น) ให้ pop ข้อมูลออกจาก stack ไปเป็นผลลัพธ์ จนกว่าข้อมูลที่ pop ออกมาเป็น (ตัดวงเล็บปิด,เปิด ออกไป

Infix -> Postfix

4) **ถ้าข้อมูลที่อ่านเข้ามาเป็น operator** ให้ตรวจสอบว่า

- **ถ้า stack ว่าง** ให้ทำการ push operator ตัวนั้นลง stack
- **ถ้า stack ไม่ว่าง**
  1. นำไปเปรียบเทียบกับ operator ที่ top of stack
  2. ถ้าที่อ่านเข้ามามี priority น้อยกว่าหรือเท่ากันกับ top
     - pop operator ใน stack ไปที่ผลลัพธ์
  3. ถ้าที่อ่านเข้ามามี priority มากกว่า top หรือเจอ (
     - push operator ที่อ่านเข้ามาลง stack

5) **ถ้าหมดข้อมูล** ให้ pop สิ่งที่เหลือในสแตกออกไปที่ผลลัพธ์

Infix to Postfix expression A+B*C

Input (infix)	operator stack	output (postfix)

(A+B)*C

Input (infix)	operator stack	output (postfix)

INFIX : A + B * (C – D / E) / F

Input (infix)	operator stack	output (postfix)

INFIX : A + B * (C – D / E) / F

Input (prefix)	operator stack	output (postfix)

Agenda

Application areas use stacks:

- **Bracket Checker**
- **Convert Infix to Postfix**
- **Evaluation of arithmetic expression**
  - 2+3*4
- **Call Nested Procedures**

Evaluatio

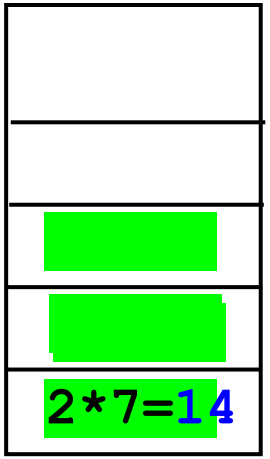
Initialize stack
For each item read.
If (it is an operand) then
push on the stack
If it is an operator then
pop arguments from stack;
perform operation;
push result onto the stack

Expr

Expr	
2	`s.push(2)`
3	`s.push(3)`
4	`s.push(4)`

+	`arg2=s.topAndPop()`
	`arg1=s.topAndPop()`
	`s.push(arg1+arg2)`

*	`arg2=s.topAndPop()`
	`arg1=s.topAndPop()`
	`s.push(arg1*arg2)`



Stack

Evaluation of arithmetic expression

- 623+-4+

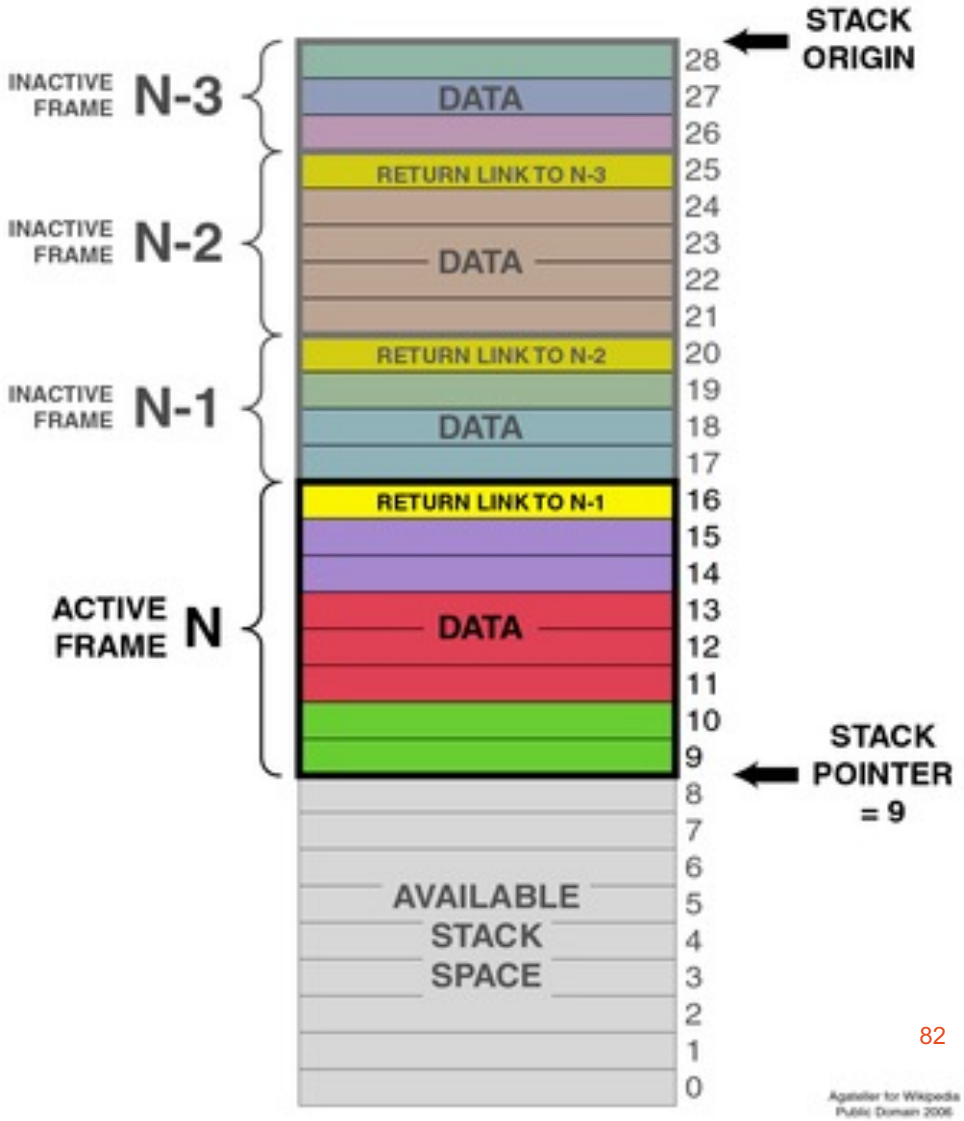
Input (postfix)	Operand 1	Operand 2	value	Operand stack

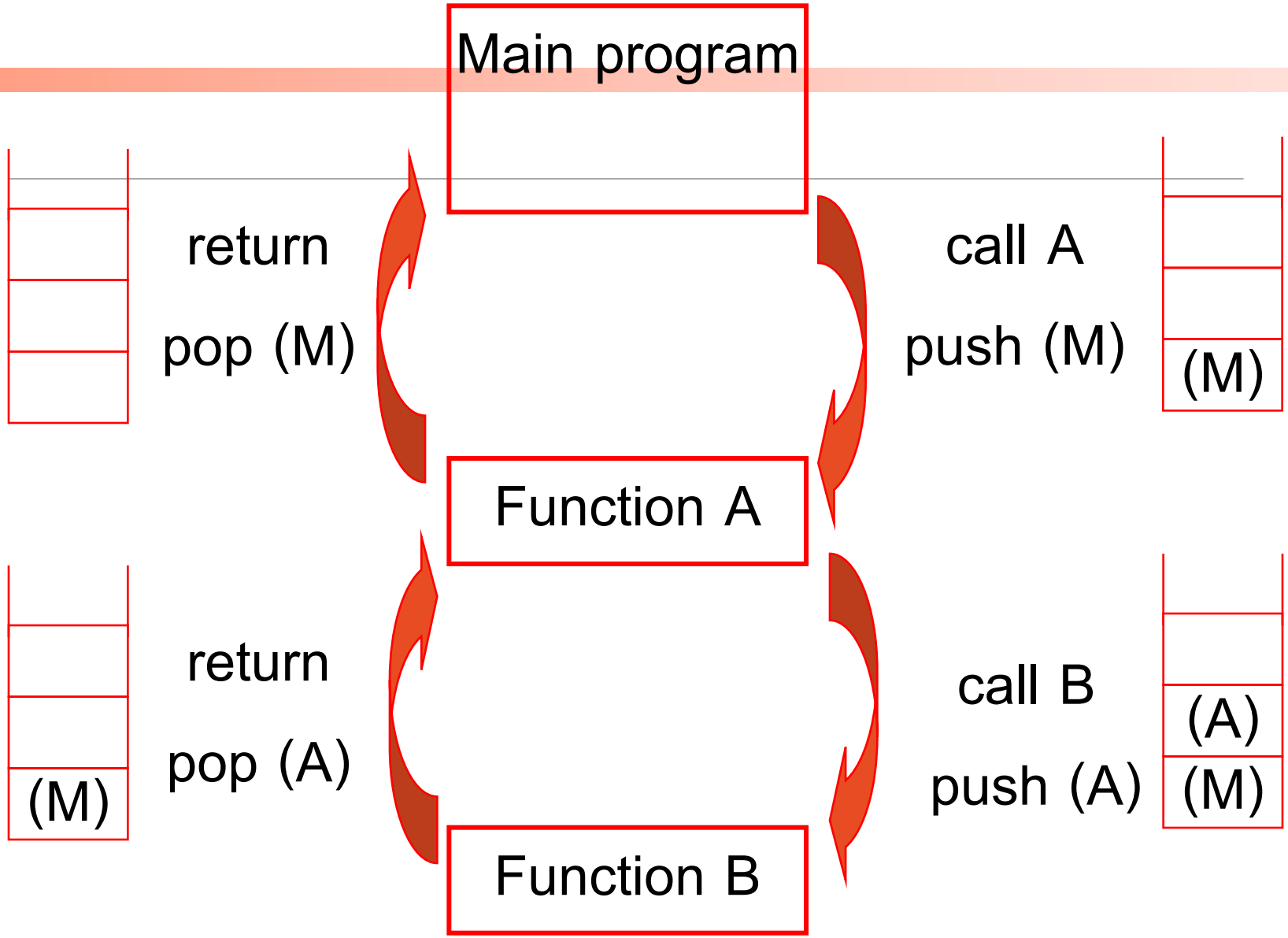
Agenda

Application areas use stacks:

- Bracket Checker
- Convert Infix to Postfix
- Evaluation of arithmetic expression
- Call Nested Procedures

Call Nested Procedures




Main program
return
pop (M)
call A
push (M)
(M)
Function A
return
pop (A)
(M)
call B
push (A)
(A)
(M)
Function B

Summary

Stack has many applications

- Bracket Checker
- Convert Infix to Postfix
- Evaluation of arithmetic expression
- Call Nested Procedures

Question