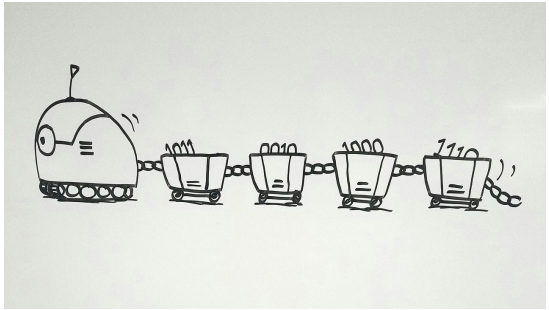


Linked List

From Scratch… :)

Asst. Prof. Ashwini Mathur (CSSP)

Definition

A linked list is a way to store a collection of elements. Like an array these can be character or integers. Each element in a linked list is stored in the form of a node.

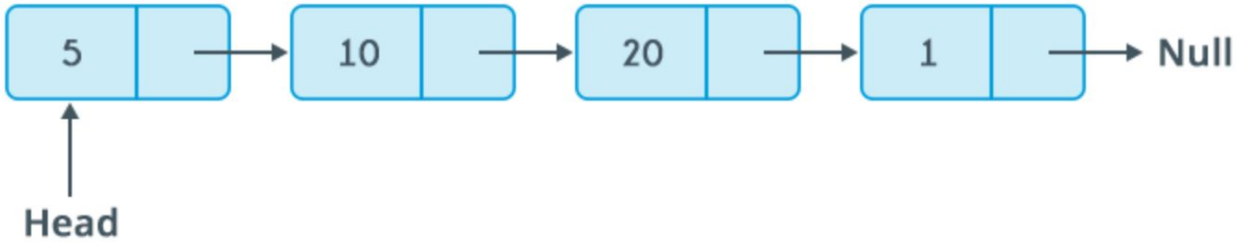
Node:

A node is a collection of two sub-elements or parts. A **data** part that stores the element and a **next** part that stores the link to the next node.

NODE

A node is a collection of two sub-elements or parts. A data part that stores the element and a next part that stores the link to the next node.

Linked List:



A linked list is formed when many such nodes are linked together to form a chain. Each node points to the next node present in the order. The first node is always used as a reference to traverse the list and is called **HEAD**. The last node points to **NULL**.

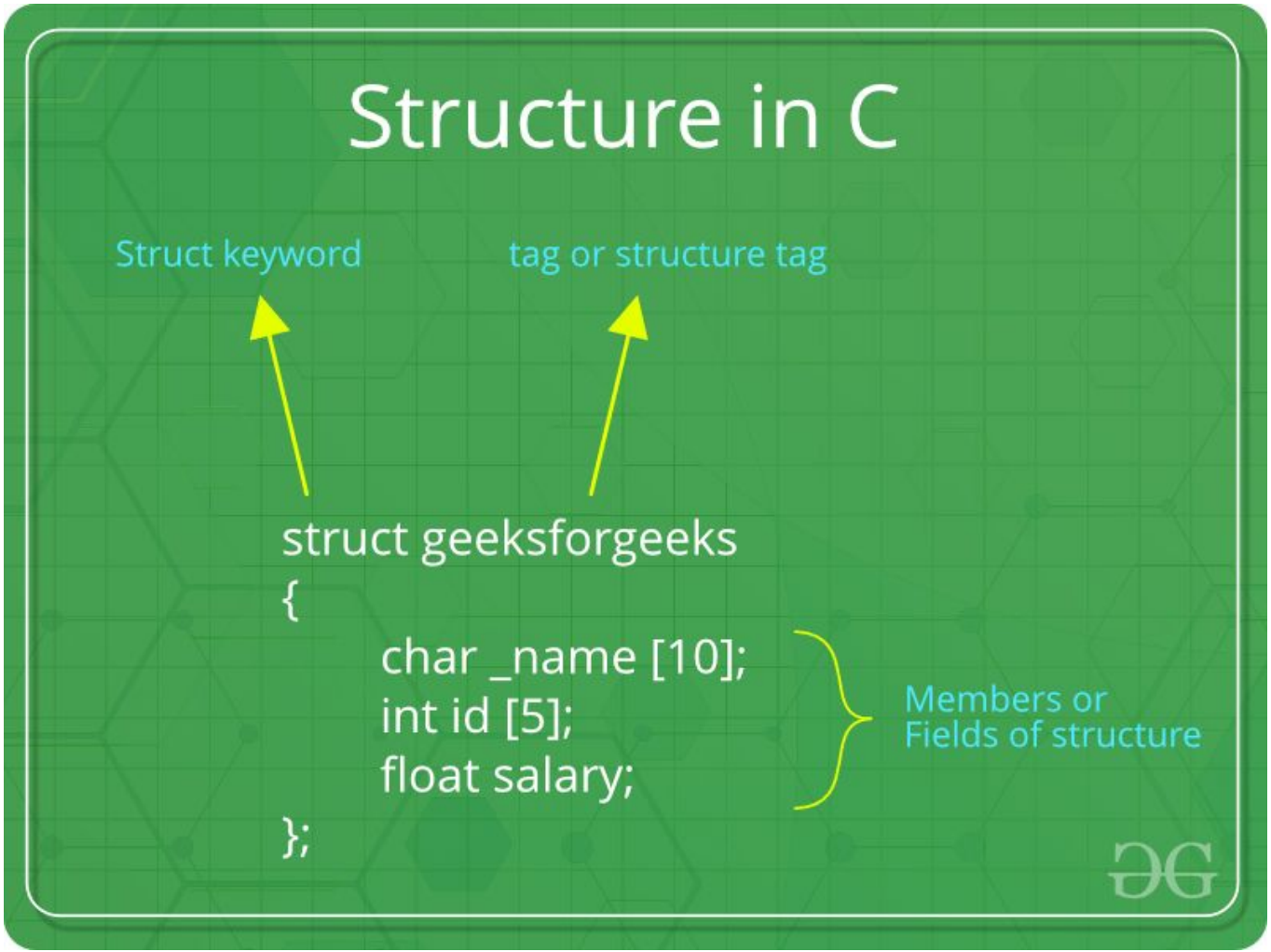
Declaring a Linked list :

In C language, a linked list can be implemented using structure and pointers .

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

The above definition is used to create every node in the list. The **data** field stores the element and the **next** is a pointer to store the address of the next node.

Structure in C



```
ptr = (cast-type*) malloc(byte-size)
```

For Example:

```
ptr = (int*) malloc(100 * sizeof(int));
```

Noticed something unusual with next?

In place of a data type, struct Linked List is written before next. That's because its a self-referencing pointer. It means a pointer that points to whatever it is a part of. Here next is a part of a node and it will point to the next node.

Creating a Node:

Let's define a data type of `struct LinkedList`to make code cleaner.

```
typedef struct LinkedList *node; //Define node as pointer of data type struct
LinkedList

node createNode(){
     node temp; // declare a node
     temp = (node)malloc(sizeof(struct LinkedList)); // allocate memory using malloc()
     temp->next = NULL;// make next point to NULL
     return temp;//return the new node
}
```

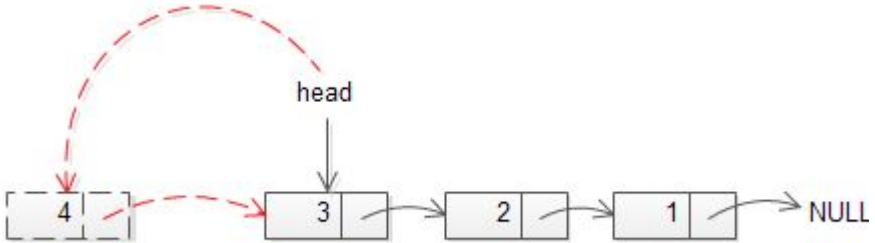
typedef is used to define a data type in C.

malloc() is used to dynamically allocate a single block of memory in C, it is available in the header file `stdlib.h`.

sizeof() is used to determine size in bytes of an element in C. Here it is used to determine size of each node and sent as a parameter to `malloc`.

The above code will create a node with data as value and next pointing to NULL.

Add a node into an empty linked list



Add a new node at the beginning of a non-empty linked list

Let's see how to add a node to the linked list:

```
node addNode(node head, int value){
    node temp,p;// declare two nodes temp and p
    temp = createNode();//createNode will return a new node with data = value and next
pointing to NULL.
    temp->data = value; // add element's value to data part of node
    if(head == NULL){
        head = temp;      //when linked list is empty
    }
    else{
        p  = head;//assign head to p
        while(p->next != NULL){
            p = p->next;//traverse the list until p is the last node.The last node
always points to NULL.
        }
        p->next = temp;//Point the previous last node to the new node created.
    }
    return head;
}
```

Here the new node will always be added after the last node. This is known as **inserting a node at the rear end**.

Food for thought

This type of linked list is known as **simple or singly linked list**. A simple linked list can be traversed in only one direction from **head** to the last node.

The last node is checked by the condition :

```
p->next = NULL;
```

Here `->` is used to access **next** sub element of node p. **NULL** denotes no node exists after the current node , i.e. its the end of the list.

Traversing the list:

The linked list can be traversed in a while loop by using the **head** node as a starting reference:

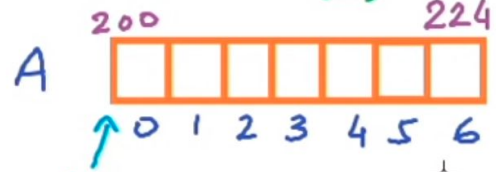
```
node p;
p = head;
while(p != NULL){
    p = p->next;
}
```

Array vs Linked List

1) Cost of accesing an element

Array

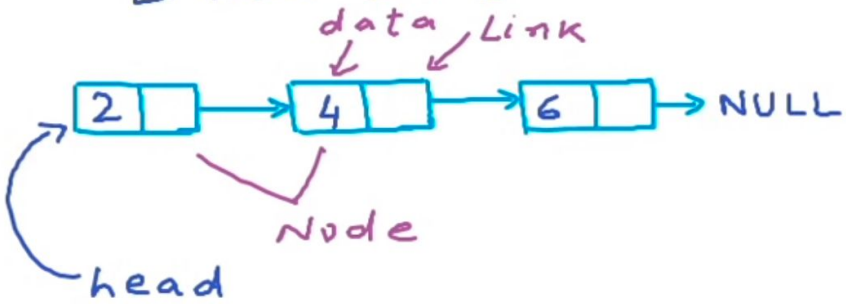
Constant time - O(1)



base address = 200

Address of A[i]

Linked List



Average case : O(n)

Array vs Linked List

Array

2) Memory requirements

- Fixed size

A

7 x 4 = 28 bytes

Linked List

- No unused memory
- extra memory for pointer variables

8 x 3 = 24 bytes

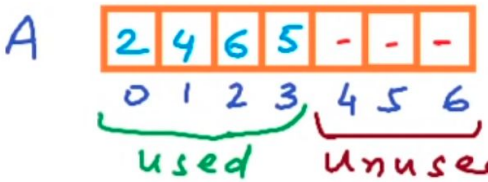
Array vs Linked List

Array

Linked List

2) Memory requirements

- Fixed size



7 x 4 = 28 bytes

- NO unused memory
- extra memory for pointer variables

8 x 3 = ~~24~~ 32 bytes

Stack using linked list

Stack using Linked List

- Stack is a data structure which follows LIFO i.e. Last-In-First-Out method.
- The data/element which is stored last in the stack i.e. the element at top will be accessed first.
- Both insertion & deletion takes place at the top.

Stack using Linked List

- When we implement stack using array :
  1. We create an array of predefined size & we cannot increase the size of the array if we have more elements to insert.
  2. If we create a very large array, we will be wasting a lot of memory space.

- So to solve this lets try to implement Stack using Linked list where we will dynamically increase the size of the stack as per the requirement.

Stack using Linked List

Linked list is a linear data structure which is made up of nodes connected together by pointers.
Each node has two main parts

1. Data
2. Link

Data - contains the data/value to be stored.
Link – contains address of the next node.

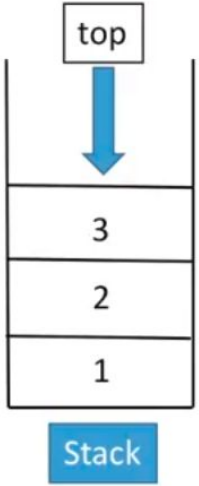
(Note : each Node is created Dynamically)

NODE

So using a linked list we can create a Stack of variable size.
And depending on our need we can increase or decrease the size of the Stack.

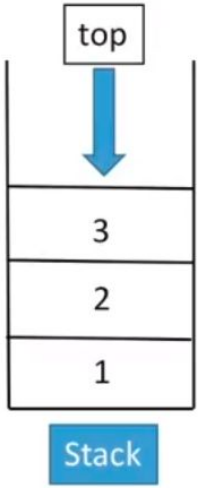
Stack using Linked List

```
Insert at start
  Node *ptr = new Node();
  ptr->data = value;
  ptr->link = top;
  top = ptr;
```



1. head can be called top
2. Push (insert element in stack) = insert node at starting of linked list

Stack using Linked List

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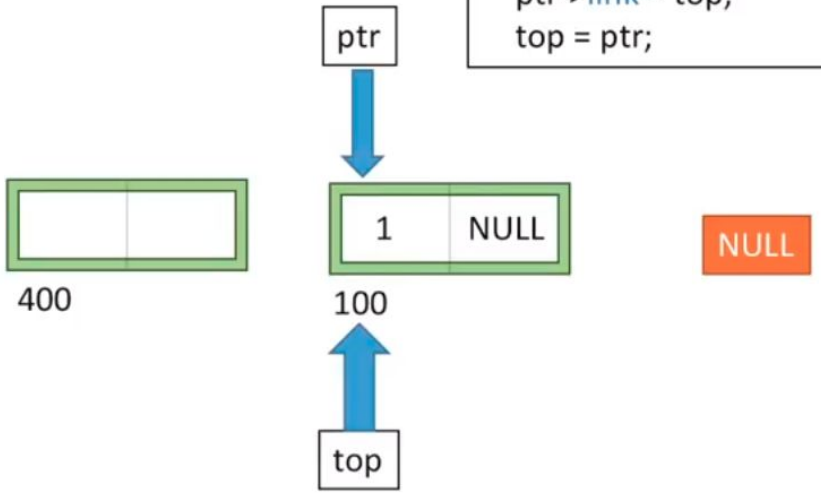

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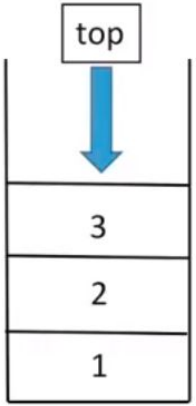

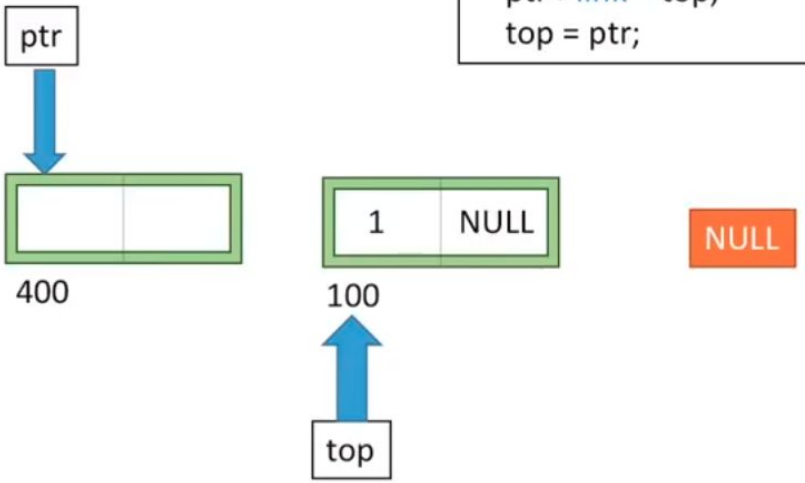

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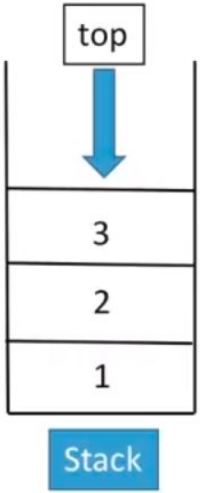

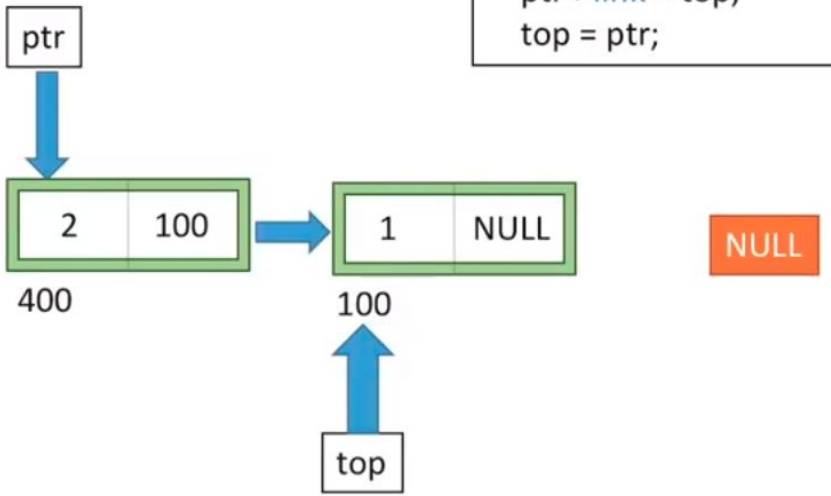

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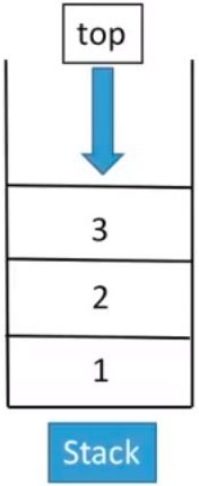

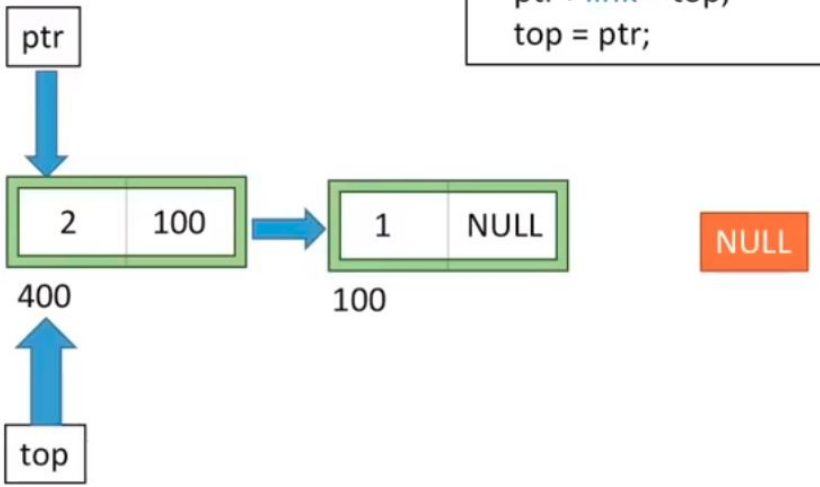

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Stack using Linked List

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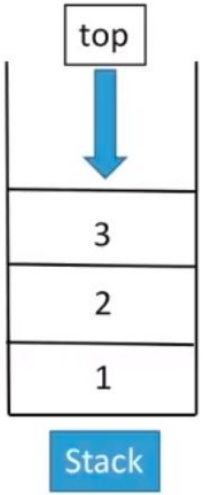
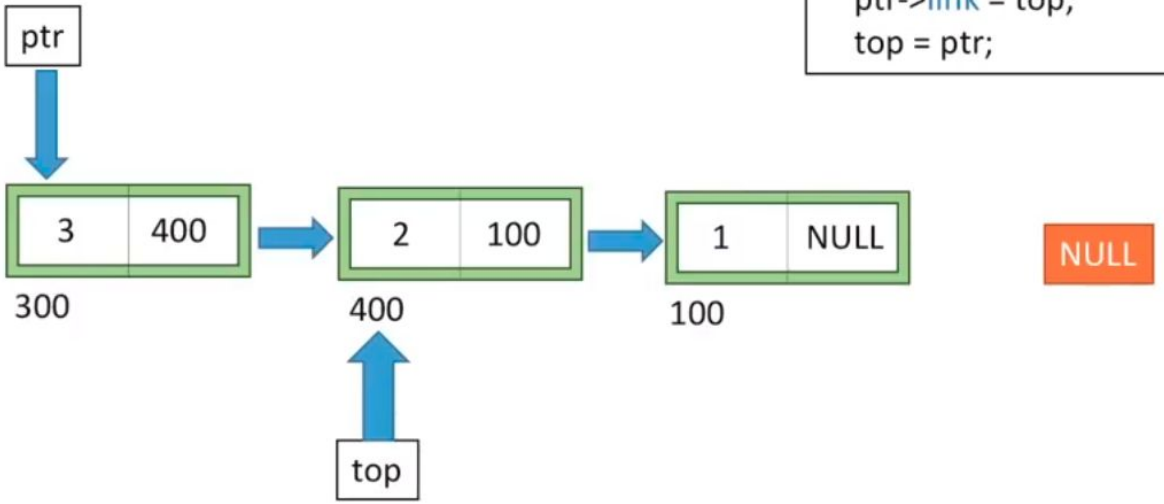
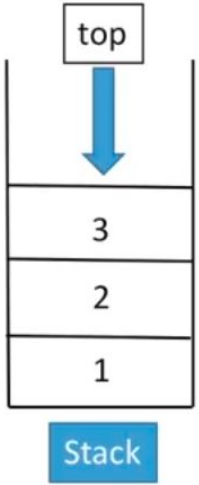


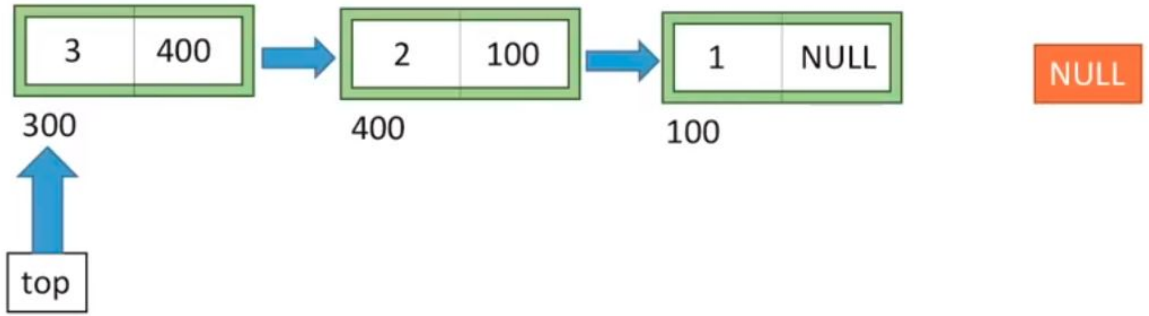


1. head can be called top
2. Push (insert element in stack) = insert node at starting of linked list

Stack using Linked List

```
Delete from start
(If linked list is not empty)
Node  *ptr = top;
      top = top -> link;
      delete(ptr);
```





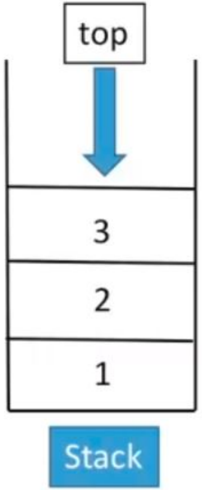
1. head can be called top
2. Push (insert element in stack) = insert node at starting of linked list
3. Pop (delete element from stack) = delete node from starting of linked list

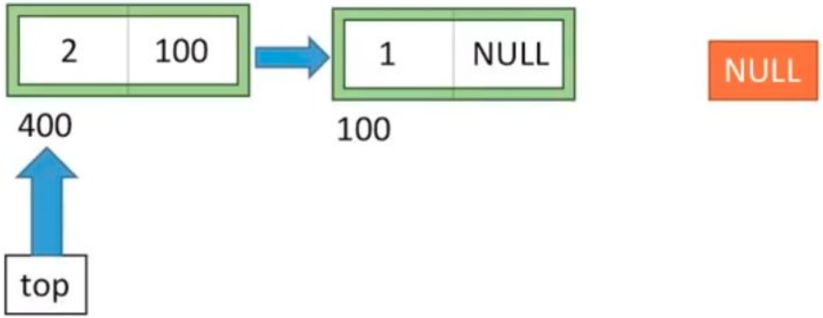
Stack using Linked List

<u>Delete from start</u>

(If linked list is not empty)

```
Node *ptr = top;
      top = top -> link;
      delete(ptr);
```

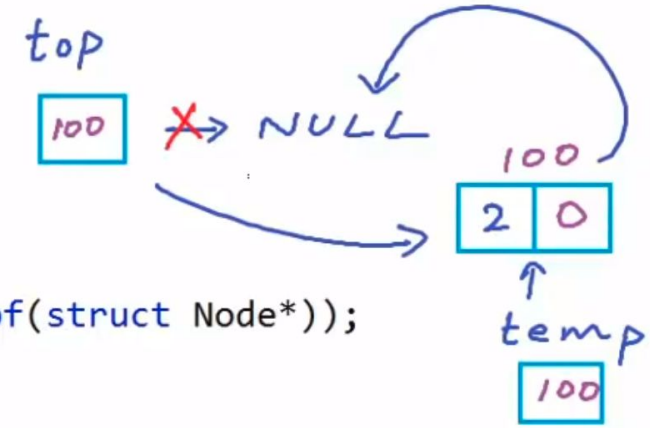




1. head can be called top
2. Push (insert element in stack) = insert node at starting of linked list
3. Pop (delete element from stack) = delete node from starting of linked list

Stack – Linked List implementation

```
struct Node {
    int data;
    struct Node* link;
};
struct Node* top = NULL;
void Push(int x) {
    struct Node* temp =
      (struct Node*)malloc(sizeof(struct Node*));
    temp->data = x;
    temp->link = top;
    top = temp;
}
```



Push(2)

```
struct Node* top = NULL;
void Push(int x) {
    struct Node* temp =
      (struct Node*)malloc(sizeof(struct Node*));
    temp->data = x;
    temp->link = top;
    top = temp;
}
void Pop() {
    struct Node *temp;
    if(top == NULL) return;
    temp = top;
    top = top->link;
    free(temp);
}
```