VTC Academy

Think Ahead, Beyond Boundaries

DATA STRUCTURES AND ALGORITHMS

LESSON 2

List Abstract Data Types and Linked Lists

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2. Generic Operation on the List
3. Introduction to Linked List
4. Implement Basic Operation of Linked List
    - Insert
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List Abstract Data Type (List ADT)

- List ADT is a dynamic ordered tuple of homogenous elements
  - A0, A1, A2, … , AN-1
  - where Ai is the i-th element of list
- The position of Ai is i ; positions range from 0 to N-1 inclusive
- The size of list is N (a list with no elements is called an “empty list”)

Generic Operations on a List

insert(e, position)	//insert e into the list at the specified position
remove(e)	//remove e from the list if present
find(e)	//return position of the first occurrence of e
findKth(int k)	//return the element in the specified position
isEmpty()	//return true if the list has no elements

Array Implementation of a List ADT

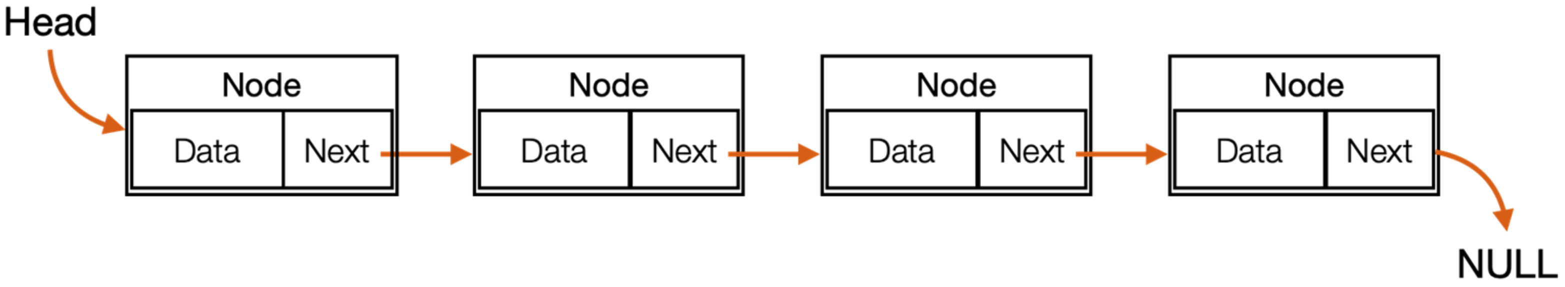
- Use an array to store the element of the list.
- Also, array have a fixed capacity, but can fix with implementation.
- You must implement the actual code of above methods:
    - insert(e, position) //insert e into the list at the specified position
    - remove(e) //remove e from the list if present
    - find(e) //return position of the first occurrence of e
    - findKth(int k) //return the element in the specified position
    - isEmpty() //return true if the list has no elements

Linked List

- A linked list is a sequence of data structures, which are connected together via links.
- Linked List is a sequence of links which contains items. Each link contains a connection to another link. Linked list is the second most-used data structure after array
- The important terms to understand the concept of Linked List:
  - Link – Each link of a linked list can store a data called an element
  - Next – Each link of a linked list contains a link to the next link called Next
  - LinkedList – A Linked List contains the connection link to the first link called First

Linked List Representation

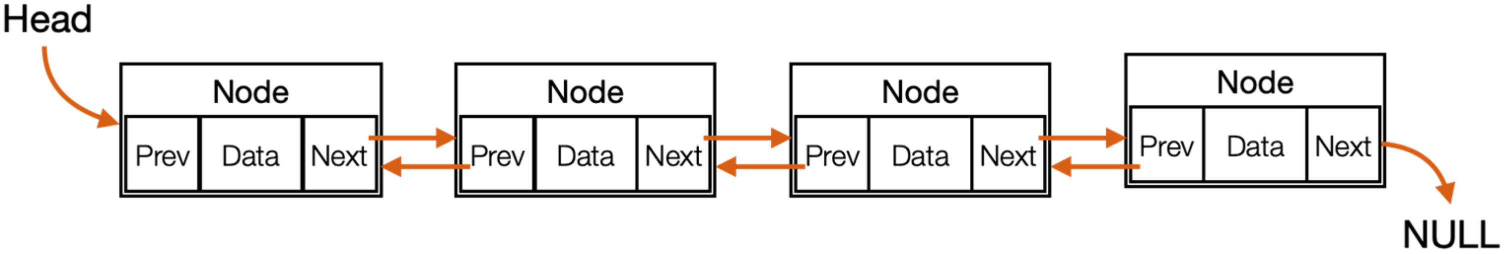
- Linked list can be visualized as a chain of nodes, where every node points to the next node



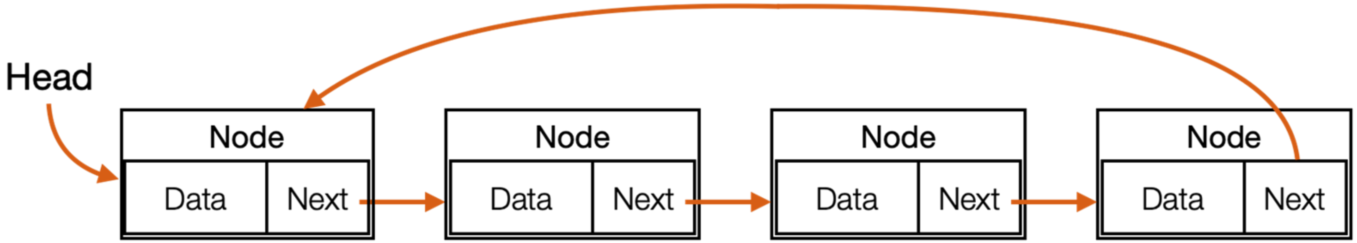
- As per the above illustration, following are the important points to be considered.
  - Linked List contains a link element called first
  - Each link carries a data field(s) and a link field called next
  - Each link is linked with its next link using its next link
  - Last link carries a link as null to mark the end of the list

Types of Linked List

- Simple Linked List – Item navigation is forward only (See above figure).
- Doubly Linked List – Items can be navigated forward and backward.



- Circular Linked List – Last item contains link of the first element as next and the first element has a link to the last element as previous.



Basic Operations

- Insertion – Adds an element at the beginning of the list
- Display – Displays the complete list
- Deletion – Deletes an element at the beginning of the list
- Delete – Deletes an element using the given key
- Search – Searches an element using the given key

Linked List Implementation

- Singly Linked List

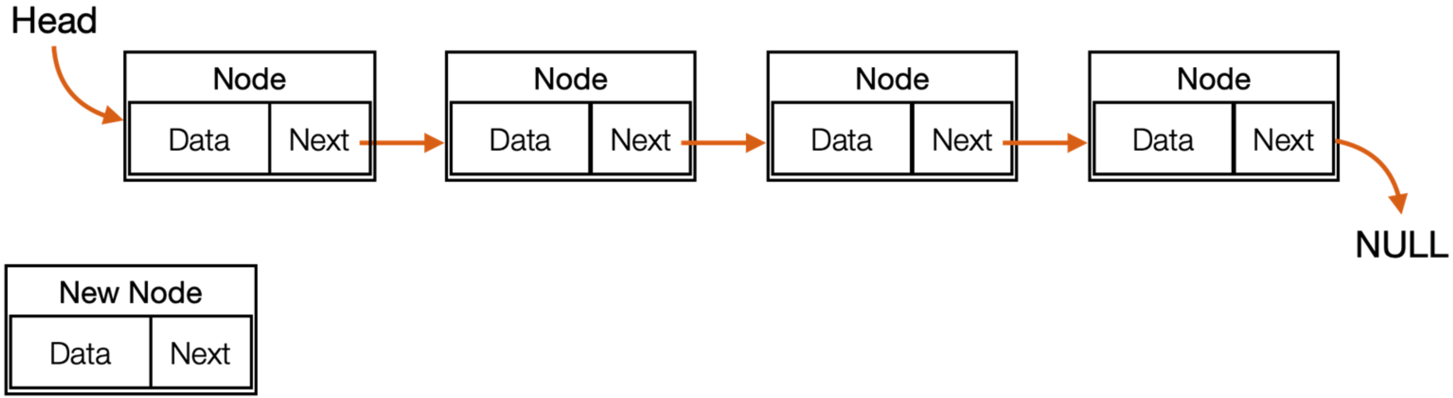
```
struct node {
        int data;
        struct node *next;
}
```

- Doubly Linked List

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

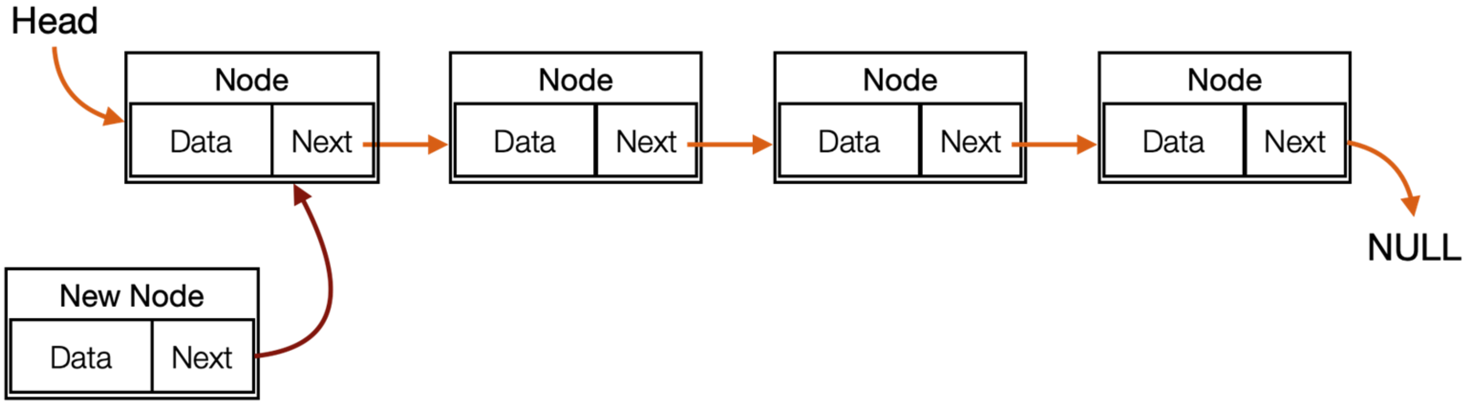
Insert - Step 1

- Adds an element at the beginning of the list



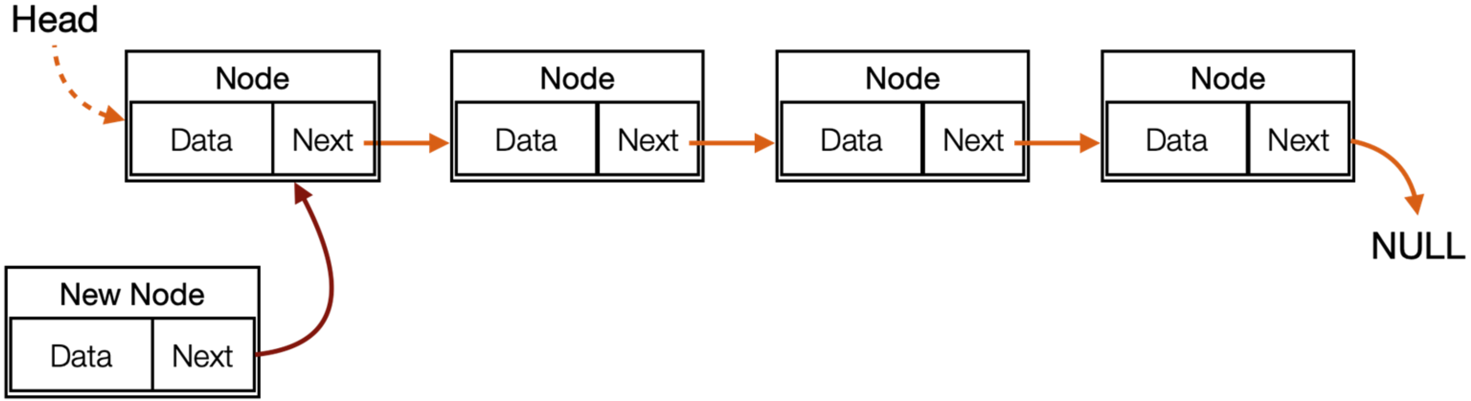
Insert – Step 2

- Adds an element at the beginning of the list



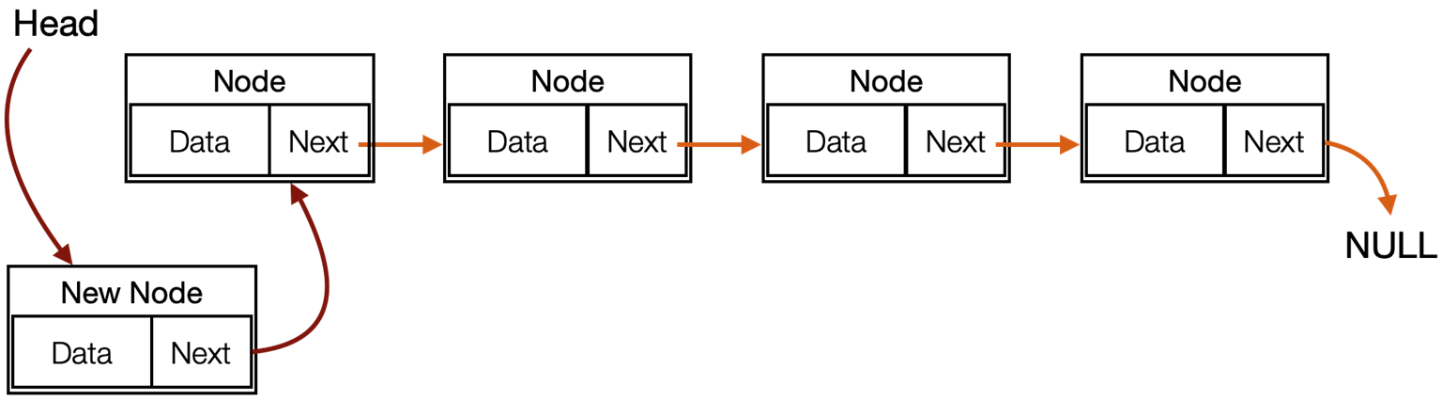
Insert – Step 3

- Adds an element at the beginning of the list

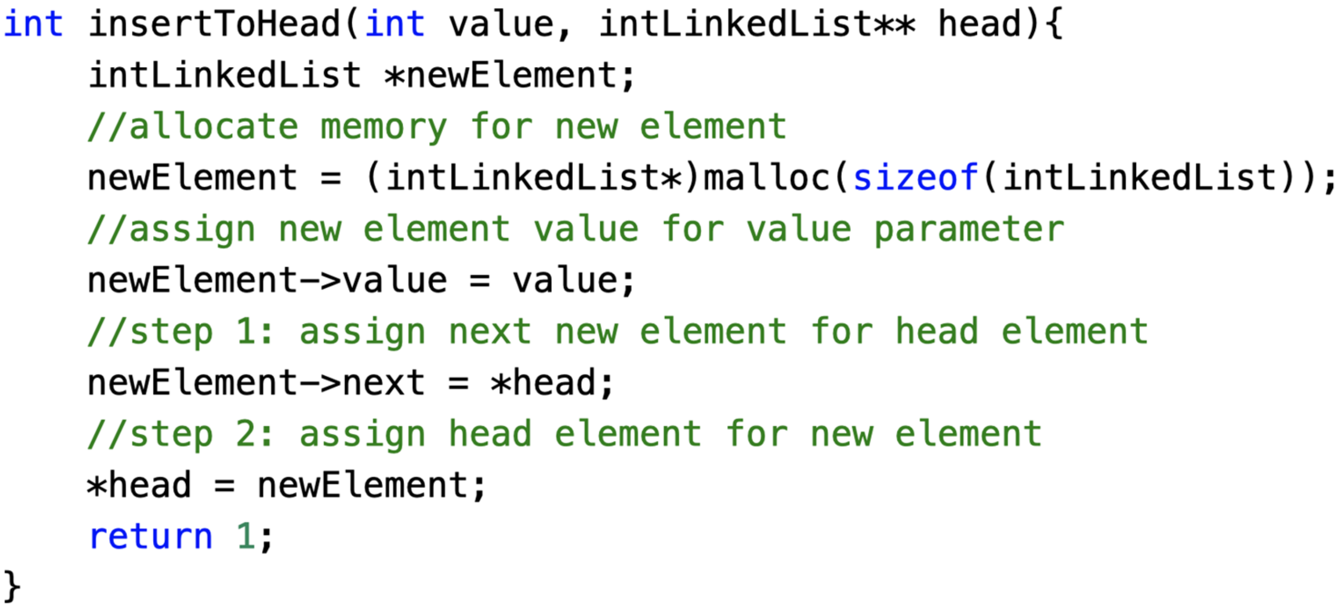


Insert – Step 4

- Adds an element at the beginning of the list

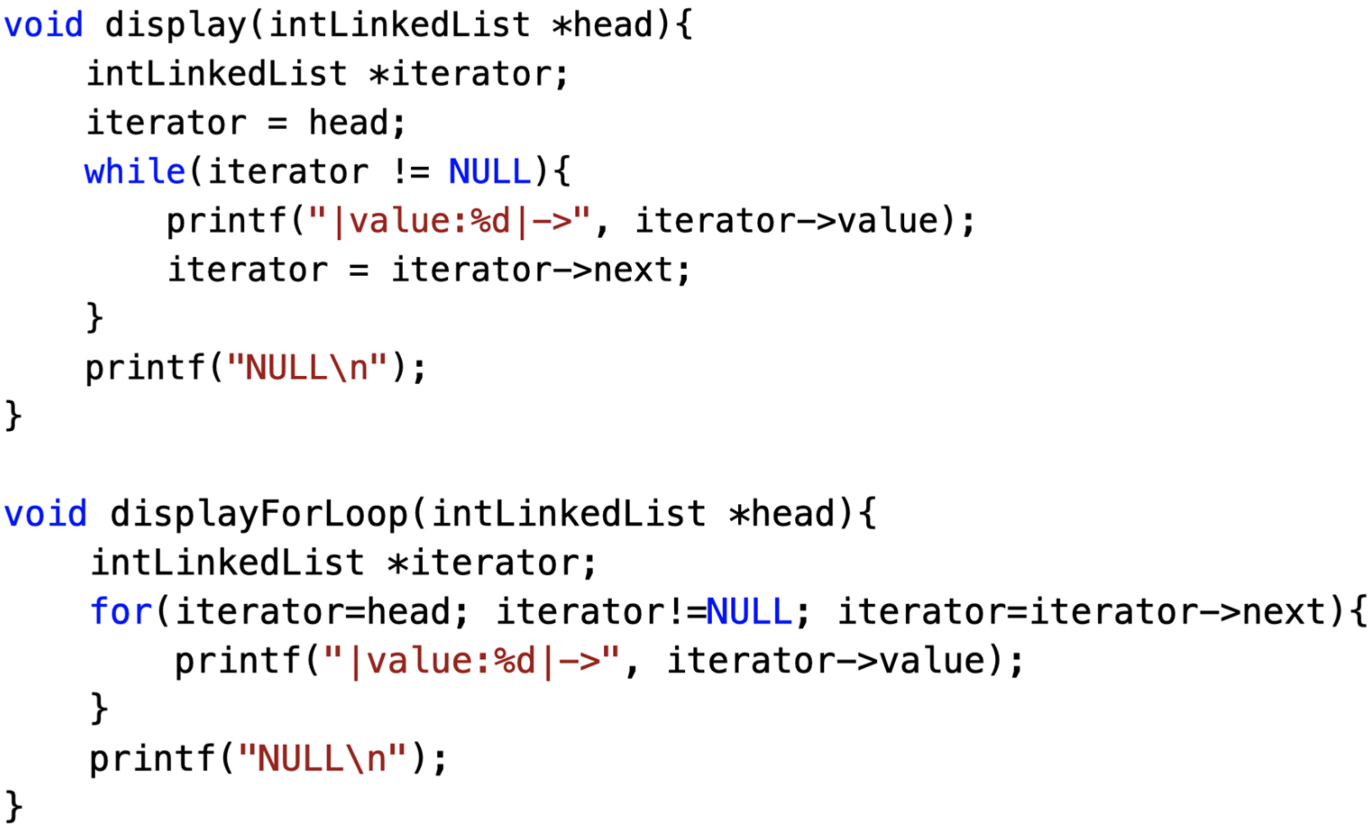


Insert Example



```c
int insertToHead(int value, intLinkedList** head){
    intLinkedList *newElement;
    //allocate memory for new element
    newElement = (intLinkedList*)malloc(sizeof(intLinkedList));
    //assign new element value for value parameter
    newElement->value = value;
    //step 1: assign next new element for head element
    newElement->next = *head;
    //step 2: assign head element for new element
    *head = newElement;
    return 1;
}
```

Display Linked List

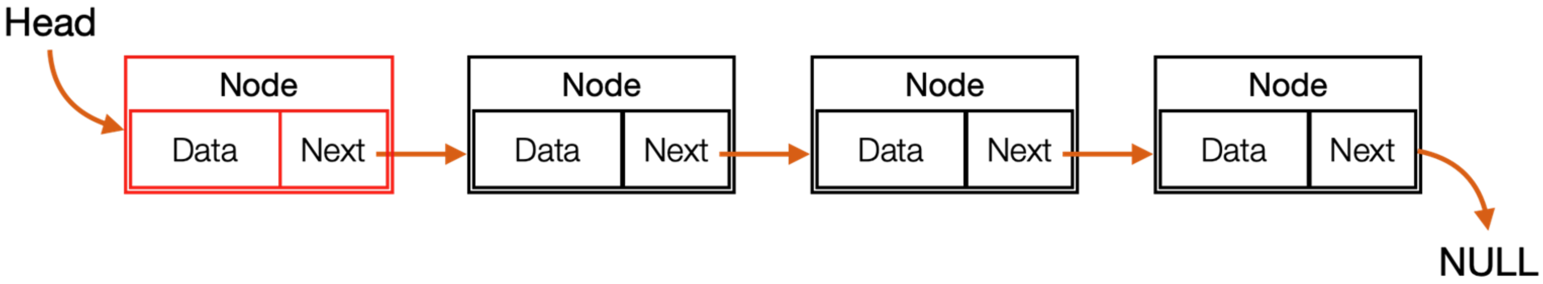


```c
void display(intLinkedList *head){
    intLinkedList *iterator;
    iterator = head;
    while(iterator != NULL){
        printf("|value:%d|->", iterator->value);
        iterator = iterator->next;
    }
    printf("NULL\n");
}

void displayForLoop(intLinkedList *head){
    intLinkedList *iterator;
    for(iterator=head; iterator!=NULL; iterator=iterator->next){
        printf("|value:%d|->", iterator->value);
    }
    printf("NULL\n");
}
```

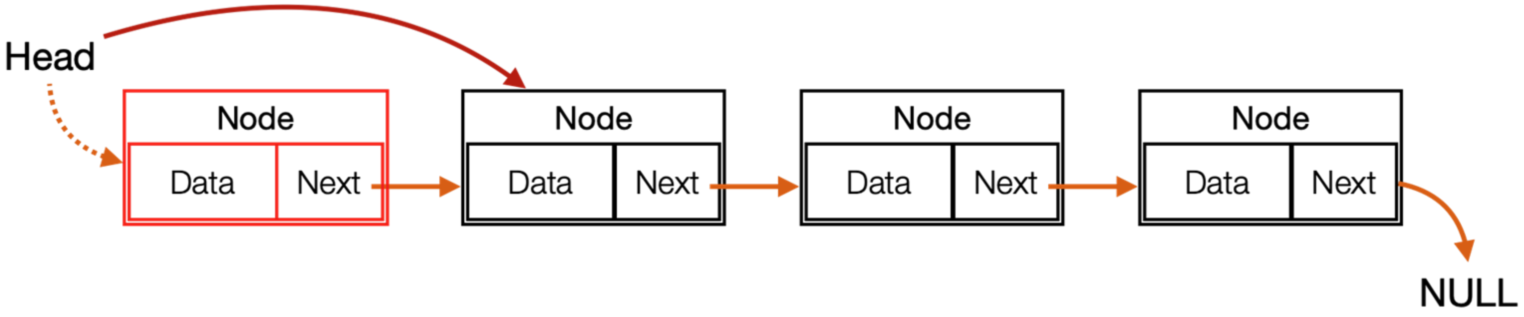
Delete First Element – Step 1

- Delete an element at the beginning of the list



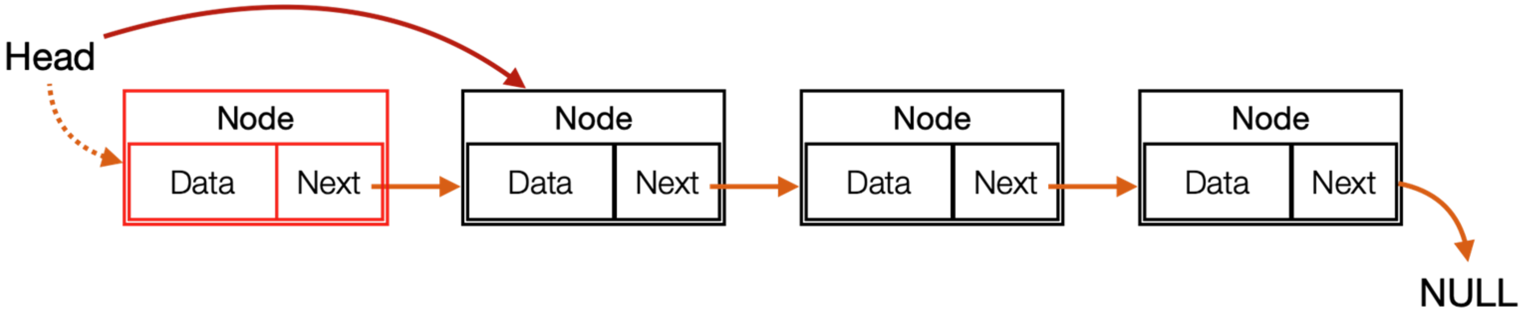
Delete First Element – Step 2

- Delete an element at the beginning of the list



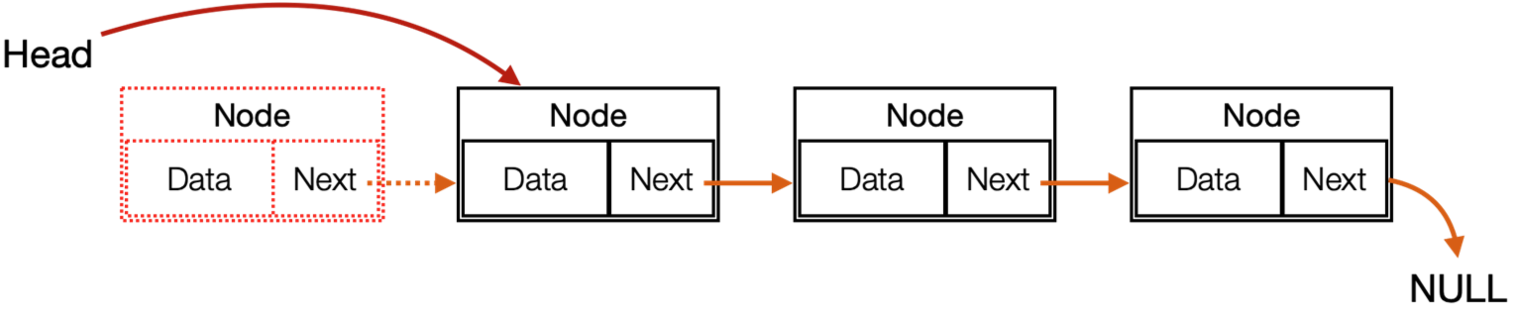
Delete First Element – Step 3

- Delete an element at the beginning of the list

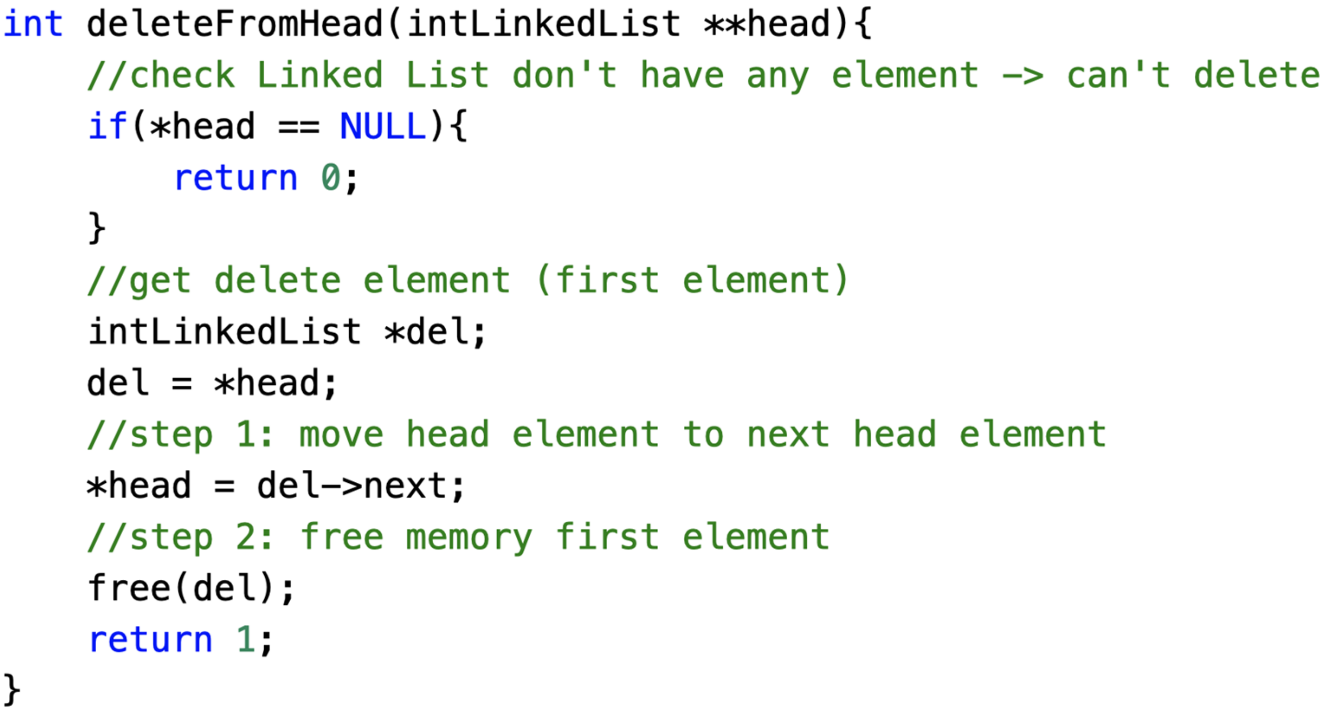


Delete First Element – Step 4

- Delete an element at the beginning of the list



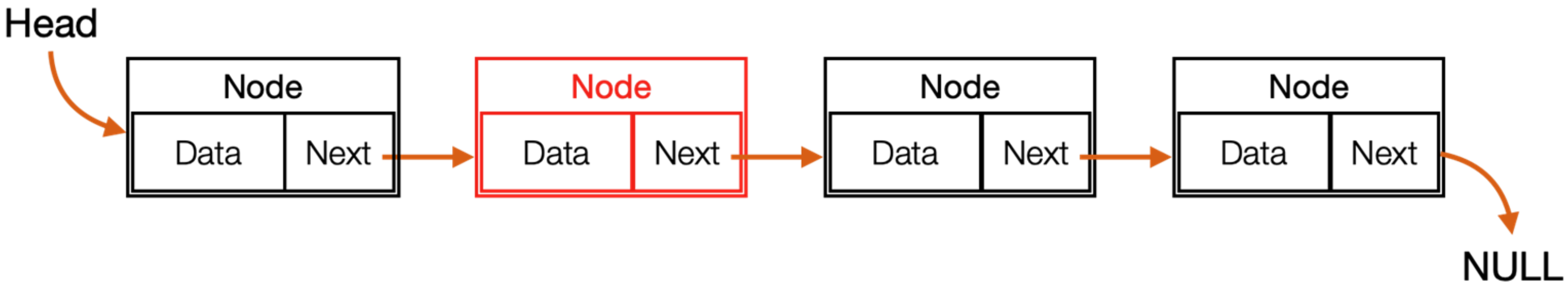
Delete First Element Example



```
int deleteFromHead(intLinkedList **head){
    //check Linked List don't have any element -> can't delete
    if(*head == NULL){
        return 0;
    }
    //get delete element (first element)
    intLinkedList *del;
    del = *head;
    //step 1: move head element to next head element
    *head = del->next;
    //step 2: free memory first element
    free(del);
    return 1;
}
```

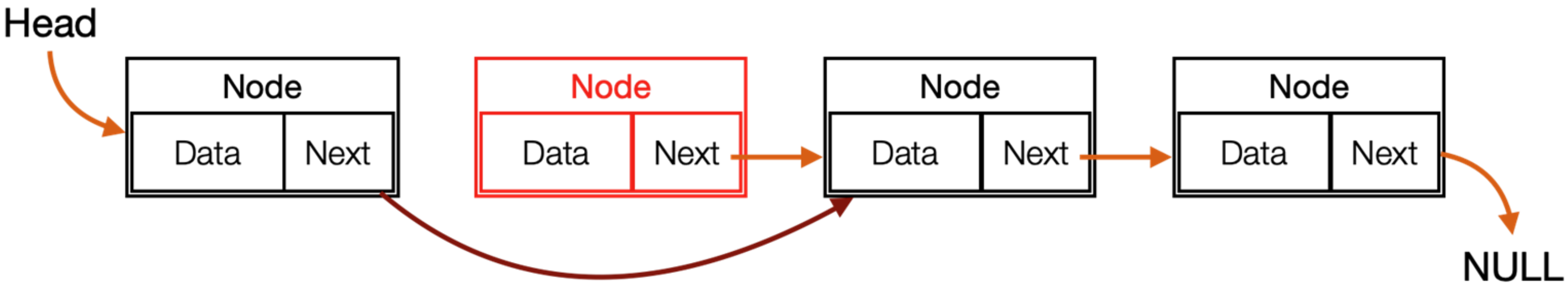
Delete Specific Element – Step 1

- Delete an element at the specific position.
- Deletion is also a more than one step process. We shall learn with pictorial representation. First, locate the target node to be removed, by using searching algorithms.



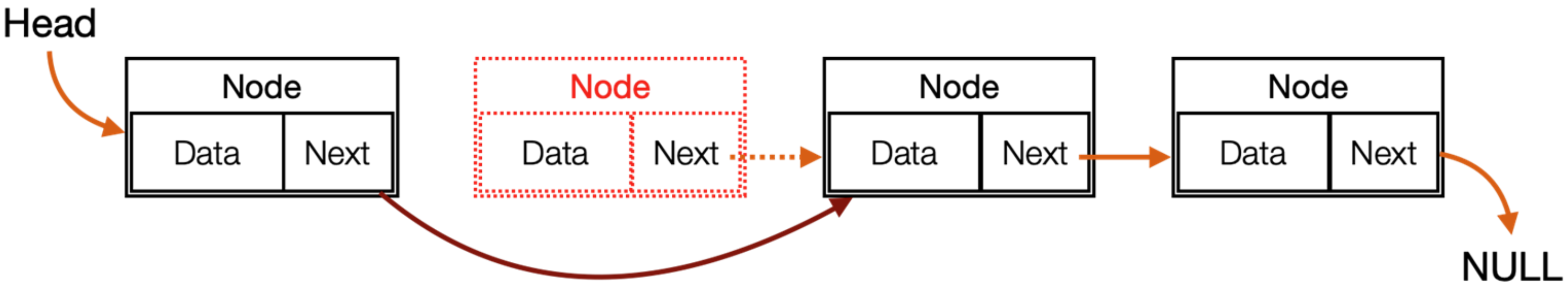
Delete Specific Element – Step 2

- The left (previous) node of the target node now should point to the next node of the target node –



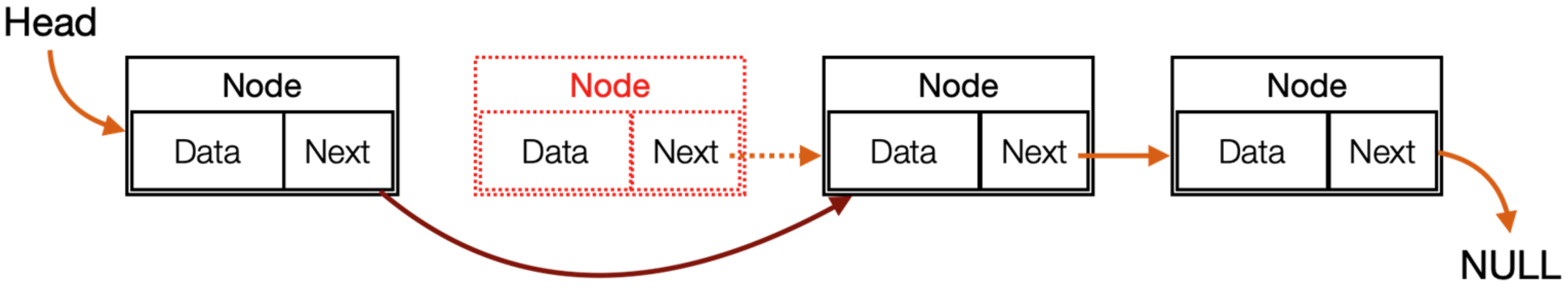
Delete Specific Element – Step 3

- This will remove the link that was pointing to the target node. Now, using the following code, we will remove what the target node is pointing at.

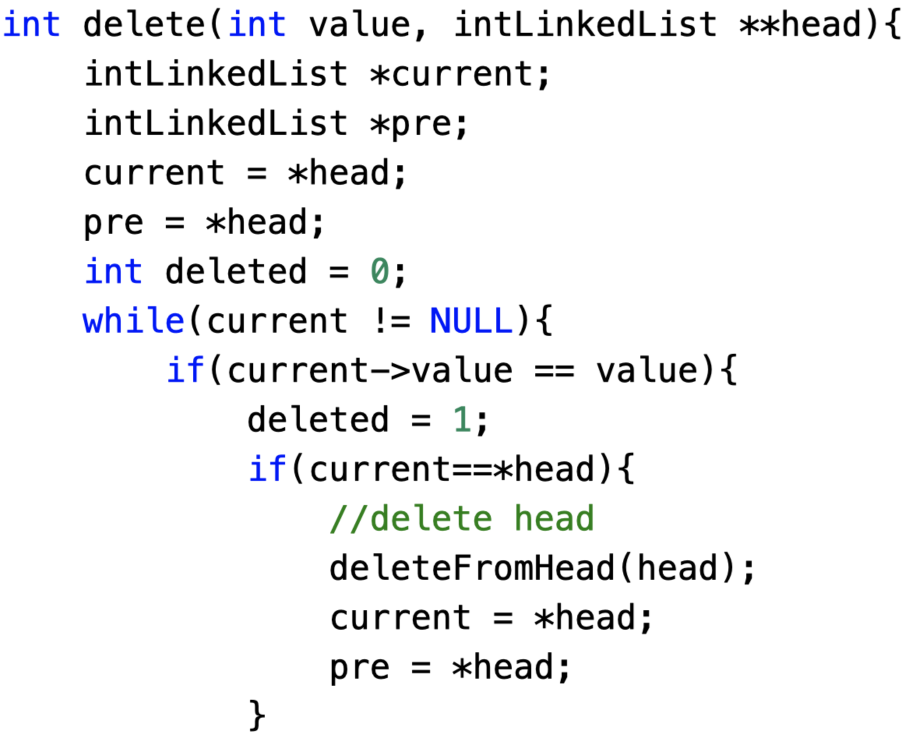


Delete Specific Element – Step 4

- We need to use the deleted node. We can keep that in memory otherwise we can simply deallocate memory and wipe off the target node completely.

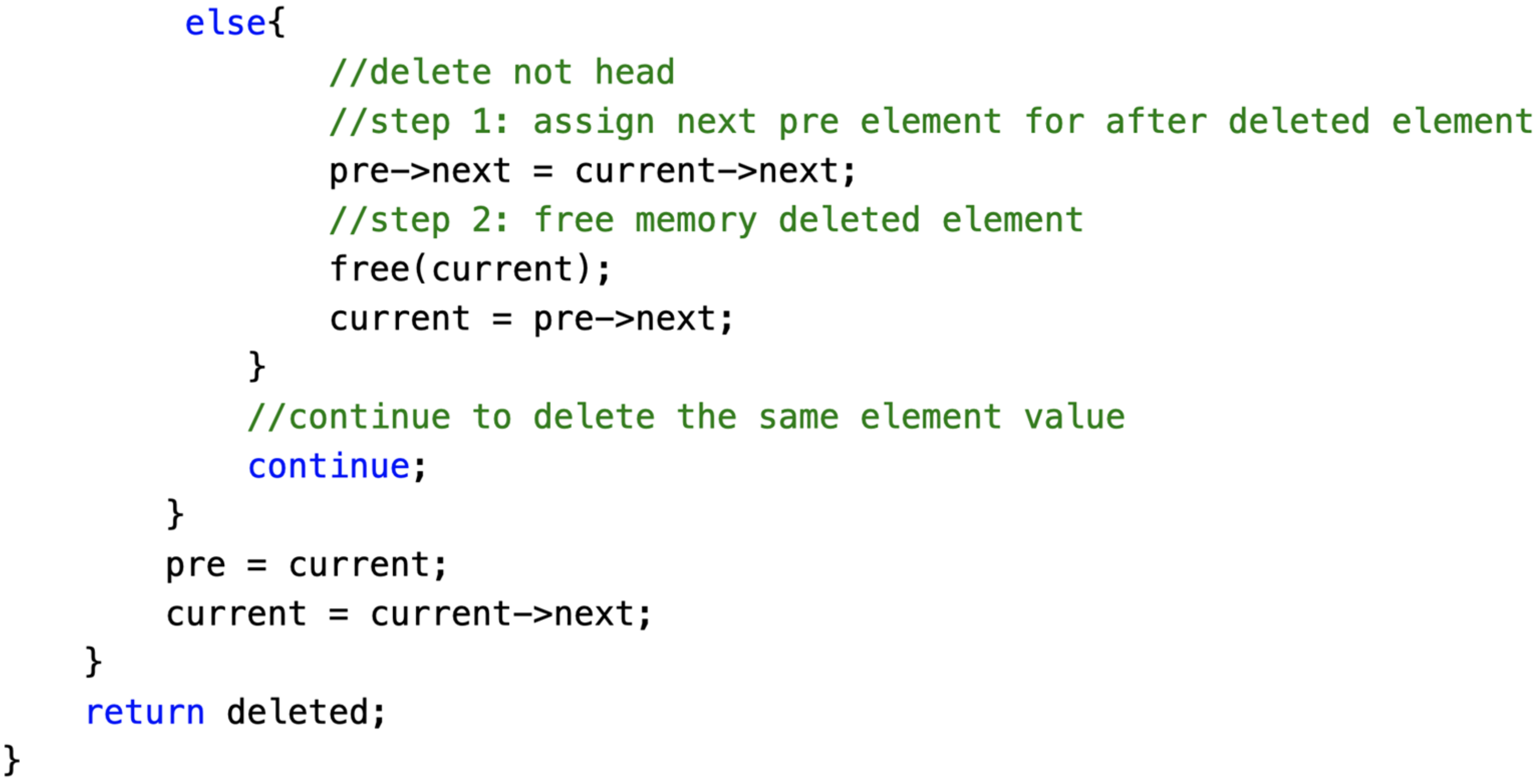


Delete Specific Element – Example



```
int delete(int value, intLinkedList **head){
    intLinkedList *current;
    intLinkedList *pre;
    current = *head;
    pre = *head;
    int deleted = 0;
    while(current != NULL){
        if(current->value == value){
            deleted = 1;
            if(current==*head){
                //delete head
                deleteFromHead(head);
                current = *head;
                pre = *head;
            }
```

Delete Specific Element – Example



```
         else{
                //delete not head
                //step 1: assign next pre element for after deleted element
                pre->next = current->next;
                //step 2: free memory deleted element
                free(current);
                current = pre->next;
            }
            //continue to delete the same element value
            continue;
        }
        pre = current;
        current = current->next;
    }
    return deleted;
}
```

Bookstore Linked List Example

```
// create a book struct
struct book
{
        int isbn;
        char title[100];
};

// create a node in singly linked list
struct node
{
        struct book book;
        struct node *next;
};
```

Summary

- List ADT is a dynamic ordered tuple of homogenous elements.
- The position of Ai is i ; positions range from 0 to N-1 inclusive.
- The size of list is N (a list with no elements is called an “empty list”).
- A linked list is a sequence of data structures, which are connected together via links.
- Linked List is a sequence of links which contains items. Each link contains a connection to another link. Linked list is the second most-used data structure after array.

Thank you!