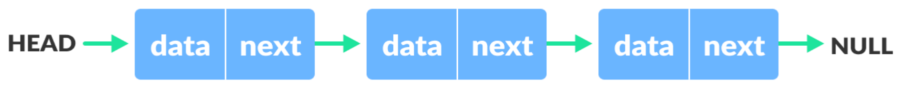
Linked List in Data Structure

A linked list is a linear data structure that includes a series of connected nodes. Here, each node stores the **data** and the **address** of the next node.



Representation of Linked List

Each node consists:

- A data item
- An address of another node

We wrap both the data item and the next node reference in a struct as:

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

Linked List Operations:

Traverse, Insert and Delete

Here's a list of basic linked list operations that we will cover in this article.

- Traversal - access each element of the linked list
- Insertion - adds a new element to the linked list
- Deletion - removes the existing elements
- Search - find a node in the linked list
- Sort - sort the nodes of the linked list

Traverse a Linked List

```
struct node *temp = head;
printf("\n\nList elements are - \n");
while(temp != NULL) {
  printf("%d --->",temp->data);
  temp = temp->next;
}
```

Insert Elements to a Linked List

1. Insert at the beginning

- Allocate memory for new node
- Store data
- Change next of new node to point to head
- Change head to point to recently created node

```
•  struct node *newNode;
•  newNode = malloc(sizeof(struct node));
•  newNode->data = 4;
•  newNode->next = head;
•  head = newNode;
```

2. Insert at the End

- Allocate memory for new node
- Store data
- Traverse to last node
- Change next of last node to recently created node

```
struct node *newNode;
newNode = malloc(sizeof(struct node));
newNode->data = 4;
newNode->next = NULL;

struct node *temp = head;
while(temp->next != NULL){
  temp = temp->next;
}

temp->next = newNode;
```

3. Insert at the Middle

- Allocate memory and store data for new node
- Traverse to node just before the required position of new node
- Change next pointers to include new node in between

```
struct node *newNode;
newNode = malloc(sizeof(struct node));
newNode->data = 4;

struct node *temp = head;

for(int i=2; i < position; i++) {
  if(temp->next != NULL) {
    temp = temp->next;
  }
}
newNode->next = temp->next;
temp->next = newNode;
```

Delete from a Linked List

1. Delete from beginning

- Point head to the second node

```
head = head->next;
```

2. Delete from end

- Traverse to second last element

- Change its next pointer to null

```
struct node* temp = head;
while(temp->next->next!=NULL){
  temp = temp->next;
}
temp->next = NULL;
```

3. Delete from middle

- Traverse to element before the element to be deleted
- Change next pointers to exclude the node from the chain

```
for(int i=2; i< position; i++) {
  if(temp->next!=NULL) {
    temp = temp->next;
  }
}

temp->next = temp->next->next;
```

Search an Element on a Linked List

- Make `head` as the `current` node.
- Run a loop until the `current` node is `NULL` because the last element points to `NULL`.
- In each iteration, check if the key of the node is equal to `item`. If it the key matches the item, return `true` otherwise return `false`.

```
// Search a node
bool searchNode(struct Node** head_ref, int key) {
  struct Node* current = *head_ref;

  while (current != NULL) {
    if (current->data == key) return true;
      current = current->next;
  }
  return false;
}
```

Sort Elements of a Linked List

1. Make the `head` as the `current` node and create another node `index` for later use.
2. If `head` is null, return.
3. Else, run a loop till the last node (i.e. `NULL`).
4. In each iteration, follow the following step 5-6.
5. Store the next node of `current` in `index`.
6. Check if the data of the current node is greater than the next node. If it is greater, swap `current` and `index`.

```
// Sort the linked list
void sortLinkedList(struct Node** head_ref) {
  struct Node *current = *head_ref, *index = NULL;
  int temp;

  if (head_ref == NULL) {
    return;
  } else {
    while (current != NULL) {
      // index points to the node next to current
      index = current->next;

        while (index != NULL) {
        if (current->data > index->data) {
          temp = current->data;
          current->data = index->data;
          index->data = temp;
          }
          index = index->next;
        }
        current = current->next;
    }
  }
}
```

Complete Program

```
// Linked list operations in C++


#include <stdlib.h>

#include <iostream>

using namespace std;

// Create a node

struct Node {

 int data;

 struct Node* next;

};

void insertAtBeginning(struct Node** head_ref, int new_data) {

 // Allocate memory to a node

 struct Node* new_node = (struct Node*)malloc(sizeof(struct Node));
```

```
  // insert the data
  new_node->data = new_data;
  new_node->next = (*head_ref);

  // Move head to new node
  (*head_ref) = new_node;
}

// Insert a node after a node
void insertAfter(struct Node* prev_node, int new_data) {
  if (prev_node == NULL) {
  cout << "the given previous node cannot be NULL";
  return;
  }

  struct Node* new_node = (struct Node*)malloc(sizeof(struct Node));
  new_node->data = new_data;
  new_node->next = prev_node->next;
  prev_node->next = new_node;
}

// Insert at the end
void insertAtEnd(struct Node** head_ref, int new_data) {
  struct Node* new_node = (struct Node*)malloc(sizeof(struct Node));
  struct Node* last = *head_ref; /* used in step 5*/

  new_node->data = new_data;
  new_node->next = NULL;

  if (*head_ref == NULL) {
  *head_ref = new_node;
```

```
 return;
 }

 while (last->next != NULL) last = last->next;

 last->next = new_node;
 return;
}

// Delete a node
void deleteNode(struct Node** head_ref, int key) {
 struct Node *temp = *head_ref, *prev;

 if (temp != NULL && temp->data == key) {
 *head_ref = temp->next;
 free(temp);
 return;
 }
 // Find the key to be deleted
 while (temp != NULL && temp->data != key) {
 prev = temp;
 temp = temp->next;
 }

 // If the key is not present
 if (temp == NULL) return;

 // Remove the node
 prev->next = temp->next;

 free(temp);
```

```
}

// Search a node
bool searchNode(struct Node** head_ref, int key) {
 struct Node* current = *head_ref;

 while (current != NULL) {
 if (current->data == key) return true;
 current = current->next;
 }
 return false;
}

// Sort the linked list
void sortLinkedList(struct Node** head_ref) {
 struct Node *current = *head_ref, *index = NULL;
 int temp;

 if (head_ref == NULL) {
 return;
 } else {
 while (current != NULL) {
  // index points to the node next to current
  index = current->next;

  while (index != NULL) {
  if (current->data > index->data) {
   temp = current->data;
   current->data = index->data;
   index->data = temp;
  }
```

```
    index = index->next;
    }
    current = current->next;
  }
  }
}

// Print the linked list
void printList(struct Node* node) {
  while (node != NULL) {
  cout << node->data << " ";
  node = node->next;
  }
}

// Driver program
int main() {
  struct Node* head = NULL;

  insertAtEnd(&head, 1);
  insertAtBeginning(&head, 2);
  insertAtBeginning(&head, 3);
  insertAtEnd(&head, 4);
  insertAfter(head->next, 5);

  cout << "Linked list: ";
  printList(head);

  cout << "\nAfter deleting an element: ";
  deleteNode(&head, 3);
  printList(head);
  int item_to_find = 3;
  if (searchNode(&head, item_to_find)) {
  cout << endl << item_to_find << " is found";
  } else {
  cout << endl << item_to_find << " is not found";
  }

  sortLinkedList(&head);
  cout << "\nSorted List: ";
  printList(head);
}
```

Types of Linked List

1. Singly Linked List
2. Doubly Linked List
3. Circular Linked List

Singly Linked List

Singly linked list is a type of data structure that is made up of nodes that are created using self-referential structures. Each of these nodes contain two parts, namely the data and the reference to the next list node. Only the reference to the first list node is required to access the whole linked list

Program

```
struct Node {
   int data;
   struct Node *next;
};
******************** Inserting Data **********************
struct Node* head = NULL;
void insert(int new_data) {
   struct Node* new_node = (struct Node*) malloc(sizeof(struct Node));
   new_node->data = new_data;
   new_node->next = head;
   head = new_node;
}
********************* Display Data **********************


void display() {
   struct Node* ptr;
   ptr = head;
   while (ptr != NULL) {
      cout<< ptr->data <<" ";
      ptr = ptr->next;
   }
}
```