Experiment-4

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Subject Name: DAA

1. **Aim:** Apply the concept of Linked list and write code to Insert and Delete an element at the beginning and at end in Doubly and Circular Linked List.

2. **Objective:** To understand and implement insertion and deletion operations at both the beginning and the end of doubly linked lists and circular singly linked lists using C++ classes. The objective is to help students learn pointer manipulation, dynamic memory management, bi-directional traversal in doubly linked lists, and circular node connections in circular linked lists, thereby strengthening their understanding of dynamic data structures and their real-time applications.

3. Procedure:

A. For Doubly Linked List:

1. Start.
2. Define a class DLL with data, prev, and next pointers.
3. Create a DLL class object with head pointer initialized to NULL.
4. Define insertAtBegin():
   - Create a new node.
   - If the list is empty, set both head and tail to the new node.
   - Otherwise, link the new node with the current head and update head.
5. Define insertAtEnd():
   - Create a new node.
   - If the list is empty, set both head and tail to the new node.
   - Otherwise, link the new node with the current tail and update tail.
6. Define deleteAtBegin():
   - If the list is empty, display a message and return.
   - If only one node exists, delete it and set head and tail to NULL.
   - Otherwise, move head to the next node and update pointers.

7. Define deleteAtEnd():
   - If the list is empty, display a message and return.

- If only one node exists, delete it and set head and tail to NULL.
- Otherwise, move tail to the previous node and update pointers.

8. Define display() to traverse from head and print each node's data.

9. End.

B. For Circular Linked List:

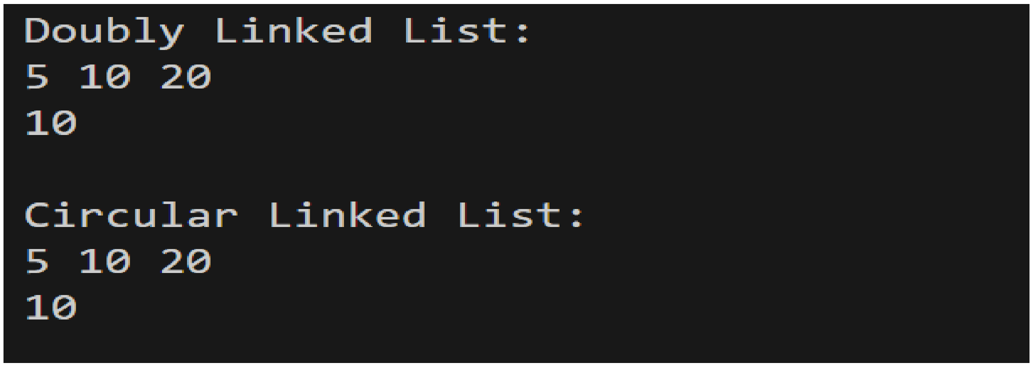
1. Start.
2. Define a class CLL with data and next pointer.
3. Create a CLL class object with tail pointer initialized to NULL.
4. Define insertAtBegin():
    - Create a new node.
    - If the list is empty, point the node to itself and set as tail.
    - Otherwise, link the new node before the head and update tail's next.
5. Define insertAtEnd():
    - Create a new node.
    - If the list is empty, point the node to itself and set as tail.
    - Otherwise, link the new node after tail and update tail.
6. Define deleteAtBegin():
    - If the list is empty, display a message and return.
    - If only one node exists, delete it and set tail to NULL.
    - Otherwise, bypass the head node and update tail's next pointer.
7. Define deleteAtEnd():
    - If the list is empty, display a message and return.
    - If only one node exists, delete it and set tail to NULL.
    - Otherwise, traverse to the node before tail, update it as the new tail, and link it to head.
8. Define display():
    - If the list is empty, display a message.
    - Otherwise, start from tail->next and traverse until the starting node is reached again.
9. End.

4. Code:

```
#include  <iostream>
using namespace std;
class DLL {
public:
    int data;
    DLL* next;
    DLL* prev;
    DLL* head;
    DLL() {
        head = NULL;
        next  = NULL;
        prev = NULL;
    }
    void insertAtBegin(int d) {
        DLL* nn = new DLL;
        nn->data = d;
        nn->next = head;
        nn->prev = NULL;
        if (head != NULL)
            head->prev = nn;
        head = nn;
    }
    void insertAtEnd(int d) {
        DLL* nn = new DLL;
        nn->data = d;
        nn->next   =   NULL;
        if (head == NULL) {
            nn->prev = NULL;
            head = nn;
            return;
        }
        DLL* temp = head;
        while (temp->next != NULL)
            temp = temp->next;
        temp->next = nn;
        nn->prev = temp;
    }
    void deleteAtBegin() {
        if (head == NULL) return;
        DLL* temp = head;
        head = head->next;
        if (head != NULL)
            head->prev = NULL;
        delete temp;
    }
    void deleteAtEnd() {
        if (head == NULL) return;
        DLL* temp = head;
        if (head->next == NULL) {
            delete head;
            head = NULL;
            return;
        }
        while (temp->next != NULL)
            temp = temp->next;
        temp->prev->next = NULL;
        delete temp;
    }
    void display() {
        DLL* temp = head;
        while (temp != NULL) {
            cout << temp->data << " ";
            temp = temp->next;
        }
        cout << endl;
    }
};
class CLL {
public:
    int data;
    CLL* next;
    CLL* tail;
    CLL() {
        tail = NULL;
        next = NULL;
```

```
}
void insertAtBegin(int d) {
    CLL* nn = new CLL;
    nn->data = d;
    if (tail == NULL) {
        tail = nn;
        tail->next = tail;
    } else {
        nn->next = tail->next;
        tail->next = nn;
    }
}
void insertAtEnd(int d) {
    CLL* nn = new CLL;
    nn->data = d;
    if (tail == NULL) {
        tail = nn;
        tail->next = tail;
    } else {
        nn->next = tail->next;
        tail->next = nn;
        tail = nn;
    }
}
void deleteAtBegin() {
    if (tail == NULL) return;
    CLL* head = tail->next;
    if (head == tail) {
        delete   head;
        tail = NULL;
    } else {
        tail->next = head->next;
        delete head;
    }
}
void deleteAtEnd() {
    if (tail == NULL) return;
    CLL* temp = tail->next;
    if (temp == tail) {
            delete tail;
            tail = NULL;
        } else {
            while (temp->next != tail)
                temp = temp->next;
            temp->next = tail->next;
            delete tail;
            tail = temp;
        }
    }
    void display() {
        if (tail == NULL) {
            cout << "List is empty\n";
            return;
        }
        CLL* temp = tail->next;
        do {
            cout << temp->data << " ";
            temp = temp->next;
        } while (temp != tail->next);
        cout << endl;
    }
};
int main() {
    DLL  o1;
    CLL o2;
    cout << "Doubly Linked List:"<<endl;
    o1.insertAtBegin(10);
    o1.insertAtEnd(20);
    o1.insertAtBegin(5);
    o1.display();
    o1.deleteAtBegin();
    o1.deleteAtEnd();
    o1.display();
    cout << "\nCircular Linked List:\n";
    o2.insertAtBegin(10);
    o2.insertAtEnd(20);
    o2.insertAtBegin(5);
    o2.display();
    o2.deleteAtBegin();
    o2.deleteAtEnd();
    o2.display();
    return 0;
}
```

5. Observations:



```
Doubly Linked List:
5 10 20
10

Circular Linked List:
5 10 20
10
```

6. Time Complexity:

Operation	**Doubly Linked List**	**Cicular Linked List**
Insert at Begin	O(1)	O(1)
Insertion at End	O(n)	O(1)
Delete at Begin	O(1)	O(1)
Deletion at End	O(n)	O(n)
Traversal	O(n)	O(n)

7. Learning Outcome:

- Learned how to implement and manipulate doubly and circular linked lists using classes in C++.
- Understood the structural differences between singly, doubly, and circular linked lists.
- Gained practical experience in inserting and deleting nodes at both beginning and end of the list.
- Strengthened understanding of pointer manipulation and dynamic memory allocation in linked list operations.
- Practiced modular programming by encapsulating linked list logic within class functions.