UNIVERSITY OF CALOOCAN CITY
COMPUTER ENGINEERING DEPARTMENT

Data Structure and Algorithm

Laboratory Activity No. 7

Doubly Linked Lists

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08-23-2025

I. Objectives

Introduction

A doubly linked list is a type of linked list data structure where each node contains three components:

Data - The actual value stored in the node
Previous pointer - A reference to the previous node in the sequence
Next pointer - A reference to the next node in the sequence.

This laboratory activity aims to implement the principles and techniques in:

- Writing algorithms using Linked list
- Writing a python program that will perform the common operations in a Doubly linked list
- A doubly linked list is particularly useful when you need frequent bidirectional traversal or easy deletion of nodes from both ends of the list.

II. Methods

- Using Google Colab, type the source codes below:

```
class Node:
    """Node class for doubly linked list"""
    def __init__(self, data):
        self.data = data
        self.prev = None
        self.next = None


class DoublyLinkedList:
    """Doubly Linked List implementation"""


    def __init__(self):
        self.head = None
        self.tail = None
        self.size = 0


    def is_empty(self):
        """Check if the list is empty"""
        return self.head is None


    def get_size(self):
        """Get the size of the list"""
```

```
        return self.size

    def display_forward(self):
        """Display the list from head to tail"""
        if self.is_empty():
            print("List is empty")
            return

        current = self.head
        print("Forward: ", end="")
        while current:
            print(current.data, end="")
            if current.next:
                print(" ↔ ", end="")
            current = current.next
        print()

    def display_backward(self):
        """Display the list from tail to head"""
        if self.is_empty():
            print("List is empty")
            return

        current = self.tail
        print("Backward: ", end="")
        while current:
            print(current.data, end="")
            if current.prev:
                print(" ↔ ", end="")
            current = current.prev
        print()

    def insert_at_beginning(self, data):
        """Insert a new node at the beginning"""
        new_node = Node(data)

        if self.is_empty():
            self.head = self.tail = new_node
```

```
        else:
            new_node.next = self.head
            self.head.prev = new_node
            self.head = new_node

        self.size += 1
        print(f"Inserted {data} at beginning")

    def insert_at_end(self, data):
        """Insert a new node at the end"""
        new_node = Node(data)

        if self.is_empty():
            self.head = self.tail = new_node
        else:
            new_node.prev = self.tail
            self.tail.next = new_node
            self.tail = new_node

        self.size += 1
        print(f"Inserted {data} at end")

    def insert_at_position(self, data, position):
        """Insert a new node at a specific position"""
        if position < 0 or position > self.size:
            print("Invalid position")
            return

        if position == 0:
            self.insert_at_beginning(data)
            return
        elif position == self.size:
            self.insert_at_end(data)
            return

        new_node = Node(data)
        current = self.head
```

```
        # Traverse to the position
        for _ in range(position - 1):
            current = current.next

        # Insert the new node
        new_node.next = current.next
        new_node.prev = current
        current.next.prev = new_node
        current.next = new_node

        self.size += 1
        print(f"Inserted {data} at position {position}")

    def delete_from_beginning(self):
        """Delete the first node"""
        if self.is_empty():
            print("List is empty")
            return None

        deleted_data = self.head.data

        if self.head == self.tail:  # Only one node
            self.head = self.tail = None
        else:
            self.head = self.head.next
            self.head.prev = None

        self.size -= 1
        print(f"Deleted {deleted_data} from beginning")
        return deleted_data

    def delete_from_end(self):
        """Delete the last node"""
        if self.is_empty():
            print("List is empty")
            return None

        deleted_data = self.tail.data
```

```
        if self.head == self.tail:  # Only one node
            self.head = self.tail = None
        else:
            self.tail = self.tail.prev
            self.tail.next = None

        self.size -= 1
        print(f"Deleted {deleted_data} from end")
        return deleted_data

    def delete_from_position(self, position):
        """Delete a node from a specific position"""
        if self.is_empty():
            print("List is empty")
            return None

        if position < 0 or position >= self.size:
            print("Invalid position")
            return None

        if position == 0:
            return self.delete_from_beginning()
        elif position == self.size - 1:
            return self.delete_from_end()

        current = self.head

        # Traverse to the position
        for _ in range(position):
            current = current.next

        # Delete the node
        deleted_data = current.data
        current.prev.next = current.next
        current.next.prev = current.prev

        self.size -= 1
```

```
        print(f"Deleted {deleted_data} from position {position}")
        return deleted_data

    def search(self, data):
        """Search for a node with given data"""
        if self.is_empty():
            return -1

        current = self.head
        position = 0

        while current:
            if current.data == data:
                return position
            current = current.next
            position += 1

        return -1

    def reverse(self):
        """Reverse the doubly linked list"""
        if self.is_empty() or self.head == self.tail:
            return

        current = self.head
        self.tail = self.head

        while current:
            # Swap next and prev pointers
            temp = current.prev
            current.prev = current.next
            current.next = temp

            # Move to the next node (which is now in prev due to swap)
            current = current.prev

        # Update head to the last node we processed
        if temp:
```

```
            self.head = temp.prev

        print("List reversed successfully")

    def clear(self):
        """Clear the entire list"""
        self.head = self.tail = None
        self.size = 0
        print("List cleared")

# Demonstration and testing
def demo_doubly_linked_list():
    """Demonstrate the doubly linked list operations"""
    print("=" * 50)
    print("DOUBLY LINKED LIST DEMONSTRATION")
    print("=" * 50)

    dll = DoublyLinkedList()

    # Insert operations
    dll.insert_at_beginning(10)
    dll.insert_at_end(20)
    dll.insert_at_end(30)
    dll.insert_at_beginning(5)
    dll.insert_at_position(15, 2)

    # Display
    dll.display_forward()
    dll.display_backward()
    print(f"Size: {dll.get_size()}")
    print()

    # Search operation
    search_value = 20
    position = dll.search(search_value)
    if position != -1:
        print(f"Found {search_value} at position {position}")
    else:
```

```
        print(f"{search_value} not found in the list")
    print()

    # Delete operations
    dll.delete_from_beginning()
    dll.delete_from_end()
    dll.delete_from_position(1)

    # Display after deletions
    dll.display_forward()
    print(f"Size: {dll.get_size()}")
    print()

    # Insert more elements
    dll.insert_at_end(40)
    dll.insert_at_end(50)
    dll.insert_at_end(60)

    # Display before reverse
    print("Before reverse:")
    dll.display_forward()

    # Reverse the list
    dll.reverse()

    # Display after reverse
    print("After reverse:")
    dll.display_forward()
    dll.display_backward()
    print()

    # Clear the list
    dll.clear()
    dll.display_forward()

# Interactive menu for user to test
def interactive_menu():
    """Interactive menu for testing the doubly linked list"""
```

```
dll = DoublyLinkedList()

while True:
    print("\n" + "=" * 40)
    print("DOUBLY LINKED LIST MENU")
    print("=" * 40)
    print("1. Insert at beginning")
    print("2. Insert at end")
    print("3. Insert at position")
    print("4. Delete from beginning")
    print("5. Delete from end")
    print("6. Delete from position")
    print("7. Search element")
    print("8. Display forward")
    print("9. Display backward")
    print("10. Reverse list")
    print("11. Get size")
    print("12. Clear list")
    print("13. Exit")
    print("=" * 40)

    choice = input("Enter your choice (1-13): ")

    if choice == '1':
        data = int(input("Enter data to insert: "))
        dll.insert_at_beginning(data)

    elif choice == '2':
        data = int(input("Enter data to insert: "))
        dll.insert_at_end(data)

    elif choice == '3':
        data = int(input("Enter data to insert: "))
        position = int(input("Enter position: "))
        dll.insert_at_position(data, position)

    elif choice == '4':
        dll.delete_from_beginning()
```

```
elif choice == '5':
    dll.delete_from_end()

elif choice == '6':
    position = int(input("Enter position to delete: "))
    dll.delete_from_position(position)

elif choice == '7':
    data = int(input("Enter data to search: "))
    pos = dll.search(data)
    if pos != -1:
        print(f"Element found at position {pos}")
    else:
        print("Element not found")

elif choice == '8':
    dll.display_forward()

elif choice == '9':
    dll.display_backward()

elif choice == '10':
    dll.reverse()

elif choice == '11':
    print(f"Size: {dll.get_size()}")

elif choice == '12':
    dll.clear()

elif choice == '13':
    print("Exiting...")
    break

else:
    print("Invalid choice! Please try again.")
```

```
if __name__ == "__main__":
    # Run the demonstration
    demo_doubly_linked_list()

    # Uncomment the line below to run interactive menu
    # interactive_menu()
```

- Save your source codes to GitHub

Answer the following questions:

1. What are the three main components of a Node in the doubly linked list implementation, and what does the __init__ method of the DoublyLinkedList class initialize?

2. The inser_at_beginning method successfully adds a new node to the start of the list. However, if we were to reverse the order of the two lines of inside the else block, what specific issue would this introduce? Explain the sequence of operations that would lead to this problem:

```
def insert_at_beginning(self, data):

    if self.is_empty():
        self.head = self.tail = new_node
    else:
        new_node.next = self.head
        self.head.prev = new_node
        self.head = new_node

    self.size += 1
```

3. How does the reverse method work? Trace through the reversal process step by step for a list containing [A, B, C], showing the pointer changes at each iteration

```
def reverse(self):
    if self.is_empty() or self.head == self.tail:
        return

    current = self.head
    self.tail = self.head

    while current:
        temp = current.prev
        current.prev = current.next
        current.next = temp
        current = current.prev
```

```
if temp:
    self.head = temp.prev
```

III. Results

```
==================================================
DOUBLY LINKED LIST DEMONSTRATION
==================================================
Inserted 10 at beginning
Inserted 20 at end
Inserted 30 at end
Inserted 5 at beginning
Inserted 15 at position 2
Forward: 5 ↔ 10 ↔ 15 ↔ 20 ↔ 30
Backward: 30 ↔ 20 ↔ 15 ↔ 10 ↔ 5
Size: 5

Found 20 at position 3

Deleted 5 from beginning
Deleted 30 from end
Deleted 15 from position 1
Forward: 10 ↔ 20
Size: 2

Inserted 40 at end
Inserted 50 at end
Inserted 60 at end
Before reverse:
Forward: 10 ↔ 20 ↔ 40 ↔ 50 ↔ 60
List reversed successfully
After reverse:
Forward: 60 ↔ 50 ↔ 40 ↔ 20 ↔ 10
Backward: 10 ↔ 20 ↔ 40 ↔ 50 ↔ 60

List cleared
List is empty
```

Figure 1 Screenshot of output from double linked list refer to this link: [Lab 7 - Colab]

In figure 1, it shows the output of the given source code.

To answer the number 1 questions, the main components of Node in the doubly linked list are: data, prev, and next. The __init__ method of the DoublyLinkedList class initializes the three key attributes which are the head, tail, and size.

```python
def insert_at_beginning(self, data):
    #"""Insert a new node at the beginning"""
    new_node = Node(data)

    if self.is_empty():
        self.head = self.tail = new_node
    else:
        new_node.next = self.head
        self.head.prev = new_node
        self.head = new_node

    self.size += 1
```

Figure 2 Screenshot from the given source code link: [Lab 7 - Colab]()

From the questions of number 2, if you reverse the order of the two lines inside the else block of the insert_at_beginning method—specifically placing self.head = new_node before self.head.prev = new_node—you introduce a subtle but significant issue in the structure of the doubly linked list. Normally, the goal is to insert a new node at the beginning while maintaining proper forward and backward links between nodes. In the correct sequence, the new node's next is set to the current head, then the current head's prev is set to the new node, and finally the head pointer is updated to the new node. This ensures that the original head still exists and can be linked back to the new node. However, if you update self.head to the new node first, then try to set self.head.prev = new_node, you're no longer referencing the original head node. Instead, you're setting the new node's prev pointer to itself, which breaks the backward link. As a result, the original head node is no longer properly connected to the new node, and any reverse traversal from tail to head will fail or behave incorrectly. This misstep compromises the integrity of the doubly linked list and can lead to confusing bugs during list operations.

```python
def reverse(self):
   # """Reverse the doubly linked list"""
    if self.is_empty() or self.head == self.tail:
        return

    current = self.head
    self.tail = self.head

    while current:
        # Swap next and prev pointers
        temp = current.prev
        current.prev = current.next
        current.next = temp

        # Move to the next node (which is now in prev due to swap)
        current = current.prev

    # Update head to the last node we processed
    if temp:
        self.head = temp.prev
```

Figure 3 Screenshot from the given source code link: Lab 7 - Colab

From the question number 3, the `reverse` method works by iterating through each node in the doubly linked list and swapping its `next` and `prev` pointers, effectively reversing the direction of the list. For example, consider a list containing the nodes `[A, B, C]`. Initially, node A is the head and node C is the tail, with each node pointing forward and backward appropriately. The reversal begins by setting `current` to the head (A) and updating the tail to also point to A, since it will become the last node after reversal. In the first iteration, A's `prev` is set to B (its original `next`), and its `next` is set to `None` (its original `prev`), then `current` moves to B. In the second iteration, B's `prev` becomes C and its `next` becomes A, then `current` moves to C. In the final iteration, C's `prev` becomes `None` and its `next` becomes B, then `current` becomes `None`, ending the loop. At this point, all pointers have been flipped, and the list has been successfully reversed to `[C, B, A]`, with C now as the new head and A as the new tail.

VI Conclusion

In this laboratory activity, it discussed the doubly linked link which help to understand their operations. Also, it was implemented the key functions such as insertion, deletion, traversal, searching, and reversal, highlighting the importance of maintaining proper node connections to ensure list integrity.

References

[1] Google. (2024). Google Colaboratory. Retrieved April 18, 2024, from https://colab.research.google.com/