UNIVERSITY OF CALOOCAN CITY
COMPUTER ENGINEERING DEPARTMENT

Data Structure and Algorithm

Laboratory Activity No. 7

Doubly Linked Lists

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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 insert_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 code 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):
    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
```

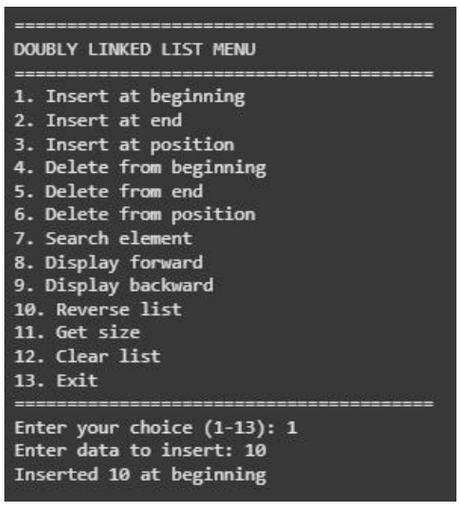
3. How does the reverse method work? Trace through the reversal process step by step for a list containing [A, B, C], showing the pointer changes at each iteration

```
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
```

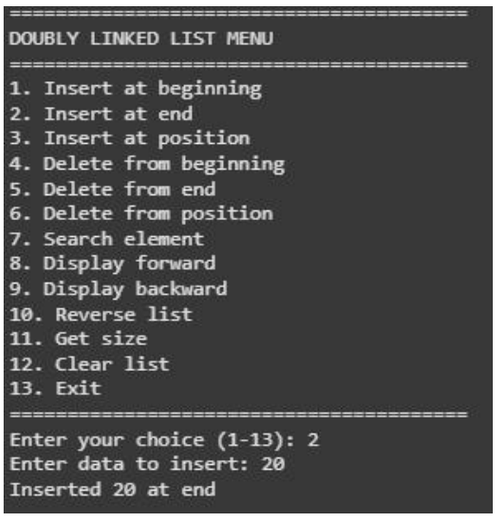
```
            current = current.prev

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

III. Results

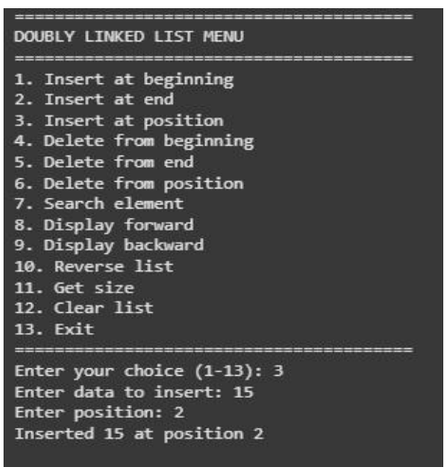
1. INSERT AT BEGINNING



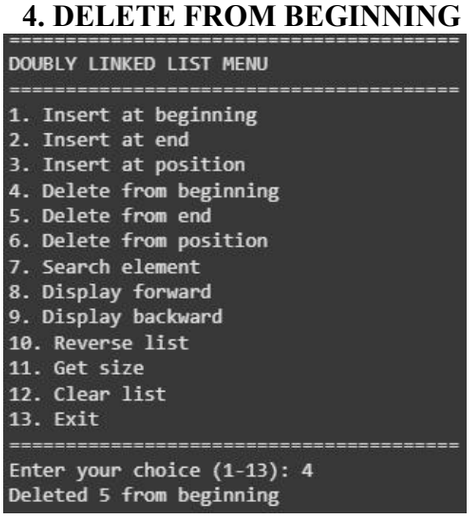
2. INSERTING AT THE END



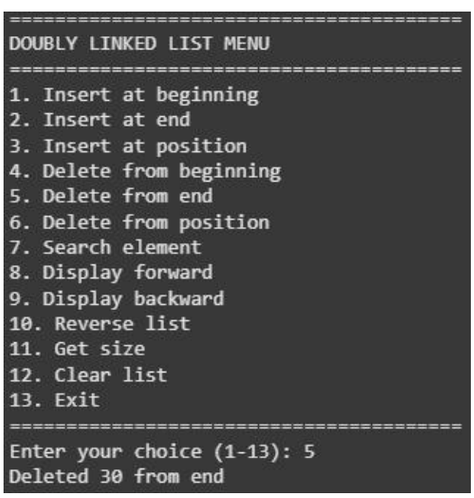
3. INSERT AT POSITION



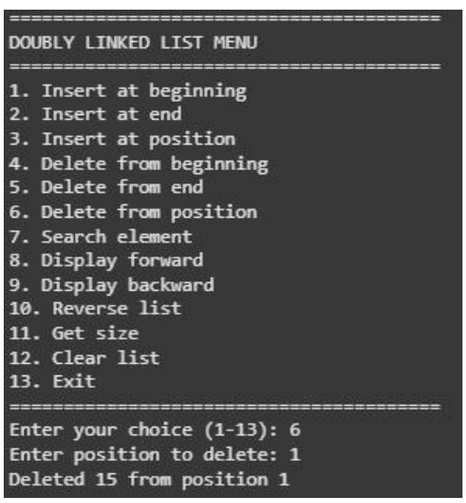
4. DELETE FROM BEGINNING



5. DELETE FROM END



6. DELETE FROM POSITION



7. SEARCH ELEMENT

```
========================================
DOUBLY LINKED LIST MENU
========================================
1. Insert at beginning
2. Insert at end
3. Insert at position
4. Delete from beginning
5. Delete from end
6. Delete from position
7. Search element
8. Display forward
9. Display backward
10. Reverse list
11. Get size
12. Clear list
13. Exit
========================================
Enter your choice (1-13): 7
Enter data to search: 20
Element found at position 3
```

8. DISPLAY FORWARD

```
========================================
DOUBLY LINKED LIST MENU
========================================
1. Insert at beginning
2. Insert at end
3. Insert at position
4. Delete from beginning
5. Delete from end
6. Delete from position
7. Search element
8. Display forward
9. Display backward
10. Reverse list
11. Get size
12. Clear list
13. Exit
========================================
Enter your choice (1-13): 8
Forward: 5 ⇔ 10 ⇔ 15 ⇔ 20 ⇔ 30
```

9. DISPLAY BACKWARD

```
========================================
DOUBLY LINKED LIST MENU
========================================
1. Insert at beginning
2. Insert at end
3. Insert at position
4. Delete from beginning
5. Delete from end
6. Delete from position
7. Search element
8. Display forward
9. Display backward
10. Reverse list
11. Get size
12. Clear list
13. Exit
========================================
Enter your choice (1-13): 9
Backward: 30 ⇔ 20 ⇔ 15 ⇔ 10 ⇔ 5
```

10. REVERSE LIST

```
========================================
DOUBLY LINKED LIST MENU
========================================
1. Insert at beginning
2. Insert at end
3. Insert at position
4. Delete from beginning
5. Delete from end
6. Delete from position
7. Search element
8. Display forward
9. Display backward
10. Reverse list
11. Get size
12. Clear list
13. Exit
========================================
Enter your choice (1-13): 10
List reversed successfully
```

11. GET SIZE

```
========================================
DOUBLY LINKED LIST MENU
========================================
1. Insert at beginning
2. Insert at end
3. Insert at position
4. Delete from beginning
5. Delete from end
6. Delete from position
7. Search element
8. Display forward
9. Display backward
10. Reverse list
11. Get size
12. Clear list
13. Exit
========================================
Enter your choice (1-13): 11
Size: 5
```

12. CLEAR LIST

```
========================================
DOUBLY LINKED LIST MENU
========================================
1. Insert at beginning
2. Insert at end
3. Insert at position
4. Delete from beginning
5. Delete from end
6. Delete from position
7. Search element
8. Display forward
9. Display backward
10. Reverse list
11. Get size
12. Clear list
13. Exit
========================================
Enter your choice (1-13): 12
List cleared
```

13. EXIT

```
========================================
DOUBLY LINKED LIST MENU
========================================
1. Insert at beginning
2. Insert at end
3. Insert at position
4. Delete from beginning
5. Delete from end
6. Delete from position
7. Search element
8. Display forward
9. Display backward
10. Reverse list
11. Get size
12. Clear list
13. Exit
========================================
Enter your choice (1-13): 13
Exiting...
```

1. The three main components of a node in the doubly linked list are the “data” which holds the value or data of the node, “prev” a reference pointer to the previous node and the “next” or the reference pointer for next node. The “__init__” function is used for initializing an empty list of a head, tail, and size.

2. In this case scenario, the issue that will be shown in the program is you made the new node point to itself as a previous node instead of being properly linked to the old head. The sequence operation that would lead to the problem is in the part of code:

new_node.next = self.head (it will link the new node to the old head)
self.head.prev = new_node (it will link the old head back to the new node)
self.head = new_node (this will update the head to new node)

3. The reverse method will flip all the direction of the pointer of the nodes then it will swap the head and tail, In order to reverse the nodes in the list, the reverse method uses the list from the head, swapping the next and previous pointers of each node until all links are reversed. The head is then updated to the last processed node or becoming the tail of the list.

IV. Conclusion

In conclusion, I learned that in the doubly linked list consists of data of nodes, previous node, and next node, and the list’s functions such as head, tail, and size used to initialize the data and used to maintain the correct sequence of pointer of the nodes. Also the reverse method works by swapping each nodes pointers until the linked lists direction is fully reversed.

References

[1] Co Arthur O.. “University of Caloocan City Computer Engineering Department Honor Code,” UCC-CpE Departmental Policies, 2020.