UNIVERSITY OF CALOOCAN CITY
COMPUTER ENGINEERING DEPARTMENT

Data Structure and Algorithm

Laboratory Activity No. 7

Doubly Linked Lists

Submitted by:
Ruperto, April Anne A.

Instructor:
Engr. Maria Rizette H. Sayo

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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

Please follow this link: [CPE-201L-DSA-2-A/Laboratory 7/DSA_Lab7.ipynb at main · Ruperto-April-Anne/CPE-201L-DSA-2-A]

1. The three main components of the node in doubly linked list are data, previous and next pointers. The __init__ initializes the data of the program. The “self.data” is where we store the data of the program. The “self.prev” and “self.next” are the pointer to previous and next node of the program, set up to None by default since the elements have no value yet at the start of the program.

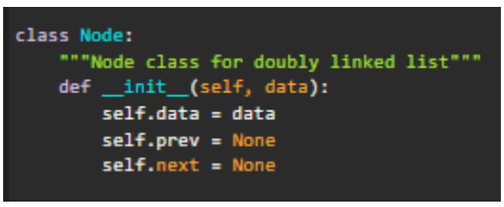


Figure 1: Screenshot of the 1st Program

2. In this program, we will reverse the line “self.head.prev = new_node” and “self.head = new_node”.

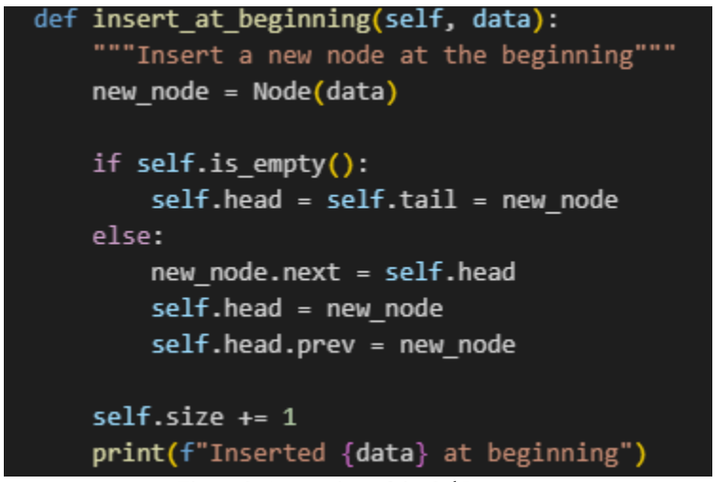
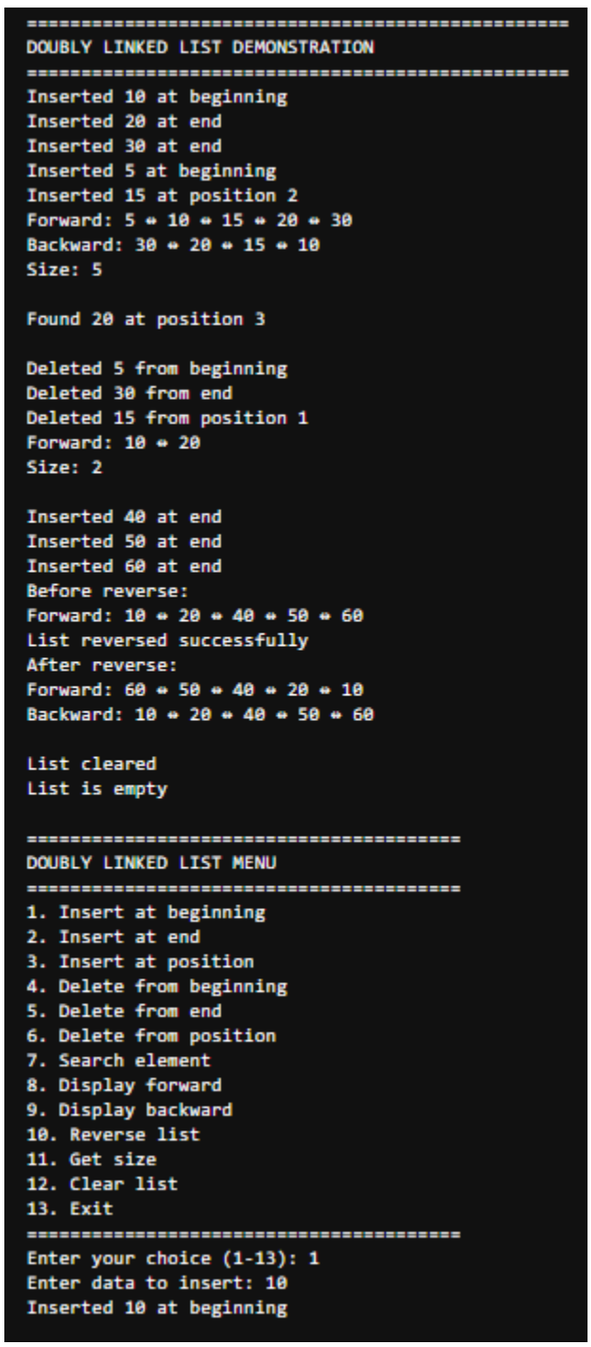
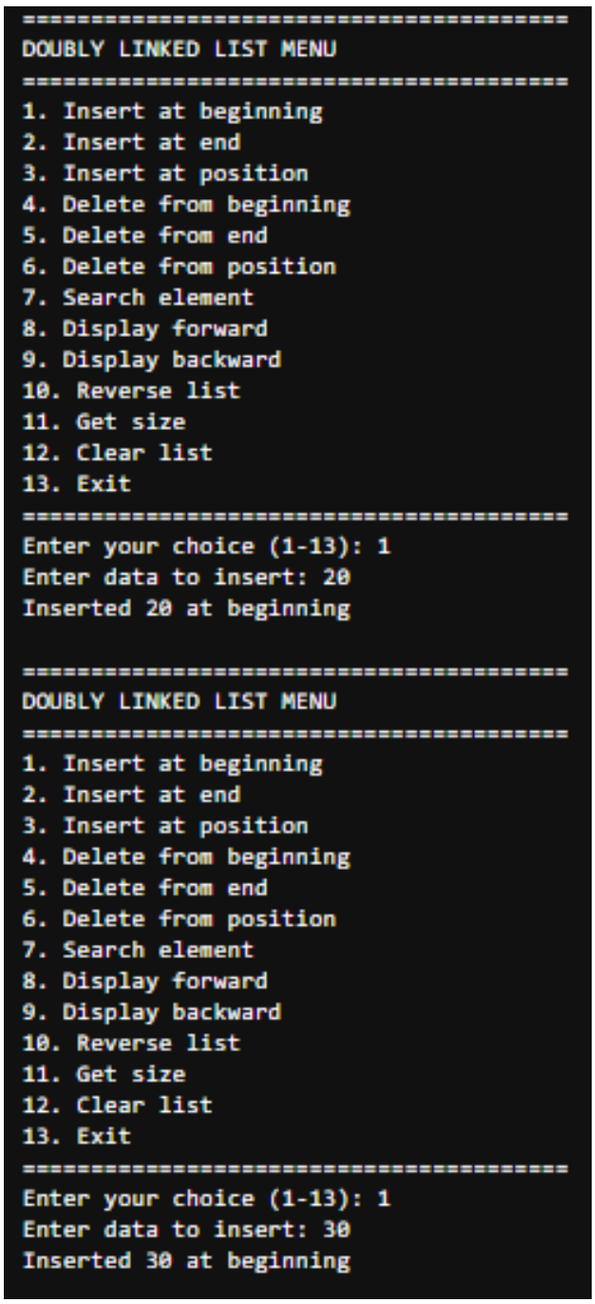


Figure 2: Screenshot of the 2nd Program

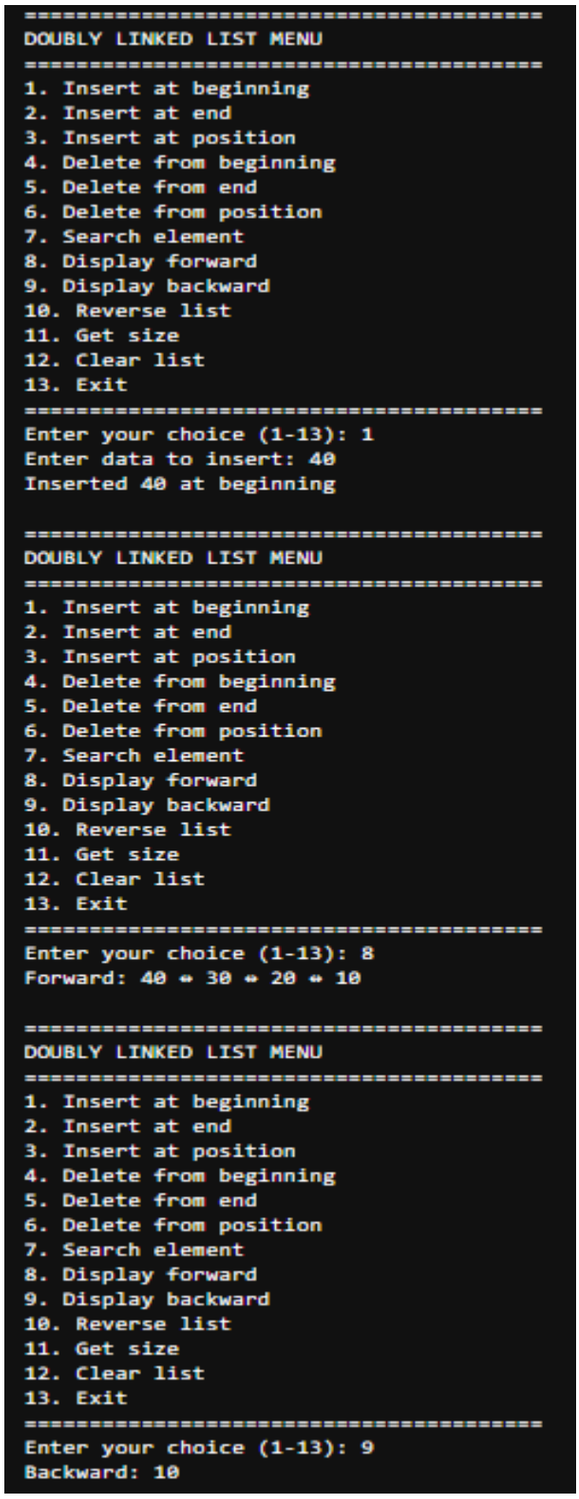
Output/s:


==========
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
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
==========
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): 1
Enter data to insert: 10
Inserted 10 at beginning

1


==========
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): 1
Enter data to insert: 20
Inserted 20 at beginning
==========
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): 1
Enter data to insert: 30
Inserted 30 at beginning

2



2

4

Figure 3: Screenshot of Output of the 2nd Program

Before switching the two lines, the new node's next pointer is set to the current head. This will connect the new node to the existing first node. Then the existing head node's previous pointer is updated to point to the new node, establishing the backward link between the new head and the previous head. Finally, the head pointer of the list is updated to point to the new node, making it the first node in the list. In this program, the head is immediately updated to point to the new node, making it the new first node in the list. At this point, the new node is now the head, but the backward (prev) link of the current head node is still pointing to its original previous node. This

leaves the list in an inconsistent state. The “self.head” now points to the new node, but the previous pointer of the current head node is not updated yet, so it still incorrectly points to None. By the time we reach this line, “self.head” already points to the new node, so now we're trying to set the previous pointer of the new head node. This results in the previous pointer of the new head node (self.head.prev) incorrectly pointing to itself, leading to a broken link. That’s why in the shown output, when we choose to display the list backwards, only the data “10” is shown in the output.

3. The reverse method inverts the order of nodes in the list. In DoublyLinkedList, this class manages the entire linked list including the reverse functionality. In reverse functionality, we used ‘while loop’ and ‘if condition’. The ‘while loop’ is responsible for transversing the entire list and it will keep running until the end of the list is reached (current become None). The ‘if condition’ is used to ensure that the conditions are met. There’s “self.is_empty” or “self.head == self.tail” as the bases since no action has been taken yet. To start reversing the list, we must start from the head of the list (“current = self.head”). Then we will change the ‘previous node’ to ‘next node’, making the “current.prev” to “current.next”. The variable “temp” will serve as temporary placeholder for the previous node while swapping the next and previous pointers of the node. It will help maintain the original reference to the previous node before any changes. After the loop, the head should point to the last node before the reversal, this is achieved by “self.head = temp.prev”.

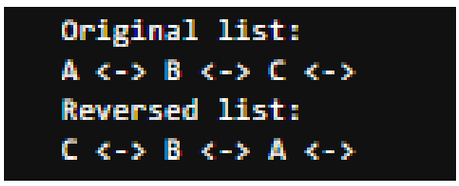


Figure 4: Screenshot of Output of the 3rd Program

```python
class Node:
    def __init__(self, data):
        self.data = data
        self.next = None
        self.prev = None

class DoublyLinkedList:
    def __init__(self):
        self.head = None
        self.tail = None

    def append(self, data):
        new_node = Node(data)
        if not self.head:
            self.head = self.tail = new_node
        else:
            self.tail.next = new_node
            new_node.prev = self.tail
            self.tail = new_node

    def is_empty(self):
        return self.head is None

    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

    def print_list(self):
        current = self.head
        while current:
            print(current.data, end=" <-> ")
            current = current.next
        print()

def main():
    dll = DoublyLinkedList()

    dll.append('A')
    dll.append('B')
    dll.append('C')

    print("Original list:")
    dll.print_list()

    dll.reverse()

    print("Reversed list:")
    dll.print_list()

if __name__ == "__main__":
    main()
```

Figure 5: Screenshot of the 3rd Program

IV. Conclusion

The Doubly Linked List is a type of linked list where each node contains three parts. The data is value stored in the node, next and previous are pointers to transverse the list in both directions, from head to tail and vice versa. This makes them much more flexible compared to singly linked lists, which only allow one-way transversal. This is also more efficient to insert or delete nodes especially if you have a pointer to a specific node. Each node requires extra memory to store the “prev” pointer, which is not needed in a singly linked list.

References

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