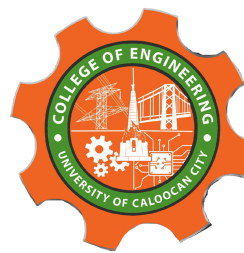




UNIVERSITY OF CALOOCAN CITY
COMPUTER ENGINEERING DEPARTMENT



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)
    w
    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

Question Answer No.1

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

Figure 1 Class Node Initialize

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

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

Figure 2 DoubleLinkedList class initialize

To answer the question no.1, the three main components of a node in a double linked list as shown in the figure 1 is, self.data, self.prev and self.next. The 'DoublyLinkedList' class initialized self.head, self.tails

✓ NO. 2

Correct Order

```
[ ] 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
```

Reversed Order

```
[ ] 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:
        self.head.prev = new_node
        new_node.next = self.head
        self.head = new_node
```

Figure 3 No. 2 Problem

Problem introduced:

When you set `self.head.prev = new_node` *before* assigning `new_node.next = self.head`, the new node is not yet properly linked. At this moment, `new_node.next` is still `None`, so the connection is inconsistent.

- The old head’s **prev** will point to the new node.
- But the new node still has no **next** set.
- This causes a **broken forward link** in the list

Sequence of errors:

1. Old head’s **prev** points to the new node.
2. The new node has no link to the old head.
3. List traversal from **head** breaks (since forward traversal can’t reach the old head).

Question Answer No.3

```
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")
```

Figure 4 No. 3 Problem Function

Initial List: A <=> B <=> C

head = A, tail = C

Step-by-step reversal process:

1. Start with node A

- Swap its prev and next.
- A now points prev → B, next → None.
- Move to node B.

2. At node B

- Swap its prev and next.
- B now points prev → C, next → A.
- Move to node C.

3. At node C

- Swap its prev and next.
- C now points prev → None, next → B.
- Move to None → stop.

4. Update head

- The head is set to the last processed node (C).
- Final list: C <=> B <=> A
- head = C, tail = A

IV. Conclusion

With this laboratory activity, I've better understood the structure of a double linked list and its complexities. I have better understood the concept of Data Structures and Algorithm by understanding this significant topic.

References

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- [4] G. H. Gonnet and R. Baeza-Yates, *Handbook of Algorithms and Data Structures: In Pascal and C*, 2nd ed. Reading, MA, USA: Addison-Wesley, 1991. (For general algorithms including doubly linked lists).