Data Structure and Algorithm Practicum
Double Linked Lists

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1.1 Learning Objective

After learning this lab activity, students will be able to:

1. Understand Double Linked List algorithm
2. Create and declare double linked list algorithm
3. Implement double linked list algorithm in various case studies

1.2 Lab Activities 1

In this lab activity, we will create Node class and DoubleLinkedList class that has operations to insert data in multiple way. (from the beginning or the tail of the list)

1.2.1 Steps

1. Take this class diagram as your reference for creating the **DoubleLinkedList class**

Node
data: int prev: Node next: Node
Node(prev: Node, data:int, next:Node)

DoubleLinkedLists
head: Node size: int
DoubleLinkedLists() isEmpty(): boolean addFirst (): void addLast(): void add(item: int, index:int): void size(): int clear(): void print(): void

2. Create a new package named **DoubleLinkedList**
3. Create a new class in that package named **Node**

4. In that class, declare the attributes as described in the class diagram

```
int data;
Node prev, next;
```

5. Next, add the default constructor in Node class

```
public Node(Node prev, int data, Node next) {
    this.data = data;
    this.prev = prev;
    this.next = next;
}
```

6. Create a new class named **DoubleLinkedList** in the same package with the node as following image:

```
package LabActivities;

public class DoubleLinkedList {

}
```

7. Next, we add the attributes

```
Node head;
int size;
```

8. Then, add the constructor in class **DoubleLinkedList**

```
public DoubleLinkedList() {
    head = null;
    size = 0;
}
```

9. Create method isEmpty(), this method will be used to check whether the linked list is empty or not

```
public boolean isEmpty() {
    return head == null;
}
```

10. Then add method **addFirst()**. This method will be executed when we want to add data in the beginning of the list

```
public void addFirst(int item) {
    if (isEmpty()) {
        head = new Node(null, item, null);
    } else {
        Node newNode = new Node(null, item, head);
        head.prev = newNode;
        head = newNode;
    }
    size++;
}
```

11. Let's not forget about adding the data in the end of the list. We can do it after adding these lines of code in **addLast()** method

```
public void addLast(int item) {
    if (isEmpty()) {
        addFirst(item);
    } else {
        Node current = head;
        while (current.next != null) {
            current = current.next;
        }
        Node newNode = new Node(current, item, null);
        current.next = newNode;
        size++;
    }
}
```

12. If we want to add a data that specified by a certain index, we will need to provide additional method to do so. It can be done by creating the **add()** method

```
public void add(int item, int index) throws Exception{
    if (isEmpty()) {
        addFirst(item);
    } else if (index < 0 || index > size) {
        throw new Exception("Index out of bound");
    } else {
        Node current = head;
        int i = 0;
        while (i < index) {
            current = current.next;
            i++;
        }
```

```
            if (current.next == null) {
                Node newNode = new Node(null, item, current);
                current.prev = newNode;
                head = newNode;
            } else {
                Node newNode = new Node(current.prev, item, current);
                newNode.prev = current.prev;
                newNode.next = current;
                current.prev.next = newNode;
                current.prev = newNode;
            }
        }
        size++;
    }
```

13. We want to make our list has an easy access to retrieve the length of the list. That's why we create method **size()**

```
public int size() {
    return size;
}
```

14. We create a method **clear()** to remove all the data that are exist in linked lists

```
public void clear() {
    head = null;
    size = 0;
}
```

15. Next up, to print the whole data in the list, we need to create a method print().

```
public void print() {
    if (!isEmpty()) {
        Node temp = head;
        while (temp != null) {
            System.out.print(temp.data + "\t");
            temp = temp.next;
        }
        System.out.println("\n successfully added");
    } else {
        System.out.println("Linked list is empty");
    }
}
```

16. After creating the blueprint classes, we will need one main class so that all of that can be included in the program. Create **DoubleLinkedListMain** class to do so

```
package LabActivities;

public class DoubleLinkedListMain {
    public static void main(String[] args) throws Exception {

    }
}
```

17. Instantiate an object from **DoubleLinkedList** class in the main method. Then apply these program code

```
DoubleLinkedList dll = new DoubleLinkedList();
dll.print();
System.out.println("Size: " + dll.size);
System.out.println("================================================");
dll.addFirst(3);
dll.addLast(4);
dll.addFirst(7);
dll.print();
System.out.println("Size: " + dll.size);
System.out.println("================================================");
dll.add(40, 1);
dll.print();
System.out.println("Size: " + dll.size);
System.out.println("================================================");
dll.clear();
dll.print();
System.out.println("Size: " + dll.size);
```

1.2.2 Result

Compile the program and see if the result matches with following image

```
PS D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists>  d:; cd 'd:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists'; & 'C:\Program Files\Java\jdk-18.0.2.1\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists\bin' 'LabActivities.DoubleLinkedListMain'
Linked list is empty
Size: 0
================================================
7       3       4
successfully added
Size: 3
================================================
7       40      3       4
successfully added
Size: 4
================================================
Linked list is empty
Size: 0
```

1.2.3 Questions

1. What's the difference between single linked list and double linked list?
   Answer:
   single linked list has tail and doesn't have prev in the node.

2. In **Node class**, what is the usage of attribute next and prev ?
   Answer:
   to access prev and next node so that the node can go both way in the linked list.

3. In constructor of **DoubleLinkedList** class. What's the purpose of head and size attribute in this following code?
   Answer:
   head is use as a point of start of the linked list. and size is used to identify the linked list size to be able to insert data with index.

4. In method **addFirst()**, why do we initialize the value of Node object to be null at first?

   ```
   Node newNode = new Node(null, item, head);
   ```

   Answer:

because the newNode will be placed at the head of the linked list. thus the Node prev is going to be null because it will be potition at head.

5. In method **addLast()**, what's the purpose of creating a node object by passing the **prev** parameter with **current** and **next** with **null** ?

```
Node newNode = new Node(current, item, null);
```

Answer:
because if the newNode is going to be placed at the last potition, the node current at the last potition is going to be need to be linked with the newNode prev Node. and because it is going to be placed in the last potition, the node next is going to be null.

1.3 Lab Activities 2

In this lab activity, we have added some methods from our 1st lab activity. Now, we added some ways for the users to remove a data in the beginning of the list, the tail, or with specified index. For more details, pay attention to this class diagram:

DoubleLinkedLists
head: Node size: int
DoubleLinkedLists() isEmpty(): boolean addFirst (): void addLast(): void add(item: int, index:int): void size(): int clear(): void print(): void **removeFirst(): void** **removeLast(): void** **remove(index:int):void**

1.3.1 Steps

1. Create method **removeFirst()** in class **DoubleLinkedList**

```
public void removeFirst() throws Exception{
    if (isEmpty()) {
```

```
            throw new Exception("Linked list is still empty, cannot
            ↪ remove data");
        } else if (size == 1) {
            removeLast();
        } else {
            head = head.next;
            head.prev = null;
            size--;
        }
    }
```

2. Create method **removeLast()** in class **DoubleLinkedList**

```
public void removeLast() throws Exception{
    if (isEmpty()) {
        throw new Exception("Linked list is still empty, cannot
        ↪ remove data");
    } else if (head.next == null) {
        head = null;
        size--;
        return;
    }
    Node current = head;
    while (current.next.next != null) {
        current = current.next;
    }
    current.next = null;
    size--;
}
```

3. Create method **remove()** in class **DoubleLinkedList**, alongside with its parameter

```
public void remove(int index) throws Exception{
    if (isEmpty() || index >= size) {
        throw new Exception("Index value is out of bound");
    } else if (size == 0) {
        removeFirst();
    } else {
        Node current = head;
        int i = 0;
        while (i < index) {
            current = current.next;
            i++;
```

```
            }
            if (current.next == null) {
                current.prev.next = null;
            } else if (current.prev == null) {
                current = current.next;
                current.prev = null;
                head = current;
            } else {
                current.prev.next = current.next;
                current.next.prev = current.prev;
            }
            size--;
        }
    }
```

4. To execute additional codes we've just added, also make addition in the main class as well

```
dll.addLast(50);
dll.addLast(40);
dll.addLast(10);
dll.addLast(20);
dll.print();
System.out.println("Size: " + dll.size);
System.out.println("================================================");
dll.removeFirst();
dll.print();
System.out.println("Size: " + dll.size);
System.out.println("================================================");
dll.removeLast();
dll.print();
System.out.println("Size: " + dll.size);
System.out.println("================================================");
dll.remove(1);
dll.print();
System.out.println("Size: " + dll.size);
```

1.3.2 Result

Compile the program and see if the result matches with following image

```
PS D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists>  d:; cd 'd:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists'; & 'C:\Program Files\Java\jdk-18.0.2.1\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists\bin' 'LabActivities.DoubleLinkedListMain'
50      40      10      20
successfully added
Size: 4
================================================
40      10      20
successfully added
Size: 3
================================================
40      10
successfully added
Size: 2
================================================
40
successfully added
Size: 1
```

1.3.3 Questions

1. What's the meaning of these statements in **removeFirst()** method?
   Answer:
   it remove node it the head potition.

2. How do we detect the position of the data that are in the last index in method **removeLast()**?
   Answer:
   loop through the linked list until the node next is null.

3. Explain why this program code is not suitable if we include it in **remove** command!

   ```
   Node tmp = head.next;

   head.next = tmp.next;
   tmp.next.prev = head;
   ```

   Answer:

because even if it can readjust the linked list connection. it isn't dynamic as in can't do specific index.

4. Explain what's the function of this program code in method **remove**!

```
current.prev.next = current.next;
current.next.prev = current.prev;
```

Answer:
to adjust the next and prev acording to the current next and prev perspective.

1.4 Lab Activities 3

In this 3rd lab activity, we will test if we can retrieve a data in linked list in various needs. The first is we can get a data in the beginning of the list, at the end of the list, or in specified index of the list. We will create 3 methods to realize the idea. For more details, feel free to check this class diagram

DoubleLinkedLists
head: Node size: int
DoubleLinkedLists() isEmpty(): boolean addFirst (): void addLast(): void add(item: int, index:int): void size(): int clear(): void print(): void removeFirst(): void removeLast(): void remove(index:int):void **getFirst(): int** **getLast() : int** **get(index:int): int**

1.4.1 Steps

1. Create a method **getFirst()** in class **DoubleLinkedList** to retrieve the first data in the list

```
public int getFirst() throws Exception{
    if (isEmpty()) {
        throw new Exception("Linked list still empty");
    }
    return head.data;
}
```

2. Create a method **getLast()** in class **DoubleLinkedList** to retrieve the data in the list

```
public int getLast() throws Exception{
    if (isEmpty()) {
        throw new Exception("Linked list still empty");
    }
    Node temp = head;
    while (temp.next != null) {
        temp = temp.next;
    }
    return temp.data;
}
```

3. Create a method **get(int index)** in class **DoubleLinkedList** to retrieve the data in specified index of the list

```
public int get(int index) throws Exception{
    if (isEmpty()) {
        throw new Exception("Linked list still empty");
    }
    Node temp = head;
    for (int i = 0; i < index; i++) {
        temp = temp.next;
    }
    return temp.data;
}
```

4. In the main class, add the program code as follows and see the result

```
dll.print();
System.out.println("Size: " + dll.size);
System.out.println("================================================");
dll.addFirst(3);
dll.addLast(4);
dll.addFirst(7);
dll.print();
```

```
        System.out.println("Size: " + dll.size);
        System.out.println("=============================================");

        dll.add(40,1);
        dll.print();

        System.out.println("Size: " + dll.size);
        System.out.println("=============================================");
        System.out.println("Data in the head of the linked list is : " +
        ↪  dll.getFirst());
        System.out.println("Data in the tail of the linked list is : " +
        ↪  dll.getLast());
        System.out.println("Data in the 1st index of the linked list is :
        ↪  " + dll.get(1));
```

1.4.2 Result

Compile the program and see if the result matches with following image

```
PS D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week
↪  12\Double Linked Lists>  d:; cd 'd:\Kuliah\Smt 2\Algoritma dan
↪  Struktur Data\Praktikum\Week 12\Double Linked Lists'; &
↪  'C:\Program Files\Java\jdk-18.0.2.1\bin\java.exe'
↪  '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'D:\Kuliah\Smt
↪  2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked
↪  Lists\bin' 'LabActivities.DoubleLinkedListMain'
Linked list is empty
Size: 0
=============================================
7       3       4
successfully added
Size: 3
=============================================
7       40      3       4
successfully added
Size: 4
=============================================
Data in the head of the linked list is : 7
Data in the tail of the linked list is : 4
Data in the 1st index of the linked list is : 40
```

1.4.3 Questions

1. What is the function of method **size()** in **DoubleLinkedList** class ?
   `Answer:`
   return the size/length of the linked list

2. How do we set the index in double linked list so that it starts from 1st index instead of 0th index?
   `Answer:`
   set the linked list size starting value to 1

3. Please explain the difference between method **Add()** in double linked list and single linked list !
   `Answer:`
   the SLL only need to readjust next and tail while DLL need to change head, next, prev, and next, prev of prev, and next.

4. What's the logic difference of these 2 following codes?

   (a) -

   ```
   public boolean isEmpty() {
       if (size == 0) {
           return true;
       } else {
           return false;
       }
   }
   ```

   (b) -

   ```
   public boolean isEmpty() {
       return head == null;
   }
   ```

   `Answer:`
   the former check the size which in any case can be set at any size, while the later check the head of the linked list being sure it has the value of null. the later having better assurance over the former because if head is null its guarantee that the linked list is empty;

1.5 Assignment

1. Create a program with double linked list implementation that allows user to choose a menu as following image! The searching uses sequential search approach and the program should be able to sort the data in descending order.

You may any choose sorting approach you prefer (bubble sort, selection sort, insertion sort, or merge sort)

Adding a data

Add data in specified index and display the result

Search Data

Sorting Data

Node.java

```
package Assignment;

public class Node {
    int data;
    Node prev, next;

    public Node(Node prev, int data, Node next) {
        this.data = data;
        this.prev = prev;
        this.next = next;
    }
}
```

DoubleLinkedList.java

```
package Assignment;

public class DoubleLinkedList {
    Node head;
    int size;

    public DoubleLinkedList() {
        head = null;
        size = 0;
    }

    public boolean isEmpty() {
        return head == null;
    }

    public void addFirst(int item) {
        if (isEmpty()) {
            head = new Node(null, item, null);
        } else {
            Node newNode = new Node(null, item, head);
```

```
            head.prev = newNode;
            head = newNode;
        }
        size++;
    }

    public void addLast(int item) {
        if (isEmpty()) {
            addFirst(item);
        } else {
            Node current = head;
            while (current.next != null) {
                current = current.next;
            }
            Node newNode = new Node(current, item, null);
            current.next = newNode;
            size++;
        }
    }

    public void add(int item, int index) throws Exception {
        if (isEmpty()) {
            addFirst(item);
        } else if (index < 0 || index > size) {
            throw new Exception("Index out of bound");
        } else {
            Node current = head;
            int i = 0;
            while (i < index) {
                current = current.next;
                i++;
            }
            if (current.next == null) {
                Node newNode = new Node(null, item, current);
                current.prev = newNode;
                head = newNode;
            } else {
                Node newNode = new Node(current.prev, item,
                ↪  current);
                newNode.prev = current.prev;
                newNode.next = current;
                current.prev.next = newNode;
```

```
                current.prev = newNode;
            }
        }
        size++;
    }

    public int size() {
        return size;
    }

    public void clear() {
        head = null;
        size = 0;
    }

    public void print() {
        if (!isEmpty()) {
            Node temp = head;
            while (temp != null) {
                System.out.print(temp.data + "\n");
                temp = temp.next;
            }
            System.out.println("\n successfully added");
        } else {
            System.out.println("Linked list is empty");
        }
    }

    public void removeFirst() throws Exception {
        if (isEmpty()) {
            throw new Exception("Linked list is still empty,
             ↪  cannot remove data");
        } else if (size == 1) {
            removeLast();
        } else {
            head = head.next;
            head.prev = null;
            size--;
        }
    }

    public void removeLast() throws Exception {
```

```
        if (isEmpty()) {
            throw new Exception("Linked list is still empty,
            ↪  cannot remove data");
        } else if (head.next == null) {
            head = null;
            size--;
            return;
        }
        Node current = head;
        while (current.next.next != null) {
            current = current.next;
        }
        current.next = null;
        size--;
    }

    public void remove(int index) throws Exception {
        if (isEmpty() || index >= size) {
            throw new Exception("Index value is out of bound");
        } else if (size == 0) {
            removeFirst();
        } else {
            Node current = head;
            int i = 0;
            while (i < index) {
                current = current.next;
                i++;
            }
            if (current.next == null) {
                current.prev.next = null;
            } else if (current.prev == null) {
                current = current.next;
                current.prev = null;
                head = current;
            } else {
                current.prev.next = current.next;
                current.next.prev = current.prev;
            }
            size--;
        }
    }
```

```
public int getFirst() throws Exception {
    if (isEmpty()) {
        throw new Exception("Linked list still empty");
    }
    return head.data;
}

public int getLast() throws Exception {
    if (isEmpty()) {
        throw new Exception("Linked list still empty");
    }
    Node temp = head;
    while (temp.next != null) {
        temp = temp.next;
    }
    return temp.data;
}

public int get(int index) throws Exception {
    if (isEmpty()) {
        throw new Exception("Linked list still empty");
    }
    Node temp = head;
    for (int i = 0; i < index; i++) {
        temp = temp.next;
    }
    return temp.data;
}

public int search(int key) throws Exception {
    Node temp = head;
    int i = 0;
    while (i < size) {
        if (temp.data == key) {
            return i;
        }
        i++;
        temp = temp.next;
    }
    throw new Exception("Key value doesn't exist");
}
```

```
    public void sort() throws Exception {
        if (head == null || head.next == null) {
            return;
        }
        boolean swapped;
        Node current;
        Node last = null;
        do {
            swapped = false;
            current = head;
            while (current.next != last) {
                if (current.data > current.next.data) {
                    int temp = current.data;
                    current.data = current.next.data;
                    current.next.data = temp;
                    swapped = true;
                }
                current = current.next;
            }
            last = current;
        } while (swapped);
    }
}
```

DoubleLinkedListMain.java

```
package Assignment;

import java.util.Scanner;

public class DoubleLinkedListMain {
    public static void displayMenu() {

        ↪  System.out.println("========================================");
        System.out.println("Data manipulation with Double Linked
        ↪  List");

        ↪  System.out.println("========================================");
        System.out.println("1. Add First");
        System.out.println("2. Add Tail");
        System.out.println("3. Add Data in the nth index");
        System.out.println("4. Remove First");
```

```
        System.out.println("5. Remove Tail");
        System.out.println("6. Remove Data in the nth index");
        System.out.println("7. Print");
        System.out.println("8. Search Data");
        System.out.println("9. Sort Data");
        System.out.println("10. Exit");

        ↪  System.out.println("========================================");
    }

    public static void main(String[] args) throws Exception {
        Scanner sc = new Scanner(System.in);
        DoubleLinkedList dll = new DoubleLinkedList();

        boolean exit = false;
        while (!exit) {
            int option;
            displayMenu();
            option = sc.nextInt();
            int dataAdd;
            int posAdd;
            int posDel;
            int search;

            switch (option) {
                case 1:
                    System.out.println("Insert data in head
                    ↪  position");
                    dataAdd = sc.nextInt();
                    dll.addFirst(dataAdd);
                    break;
                case 2:
                    System.out.println("Insert data in last
                    ↪  position");
                    dataAdd = sc.nextInt();
                    dll.addLast(dataAdd);
                    break;
                case 3:
                    System.out.println("Insert Data");
                    System.out.print("Data node: ");
                    dataAdd = sc.nextInt();
                    System.out.print("In index: ");
```

```
                posAdd = sc.nextInt();
                dll.add(dataAdd, posAdd);
                break;
            case 4:
                System.out.println("First Data deleted");
                System.out.println(dll.getFirst());
                dll.removeFirst();
                break;
            case 5:
                System.out.println("Last Data deleted");
                System.out.println(dll.getLast());
                dll.removeLast();
                break;
            case 6:
                System.out.println("Remove Data");
                System.out.println("In index: ");
                posDel = sc.nextInt();
                System.out.println("Data " + posDel + "
                ↪  deleted");
                System.out.println(dll.get(posDel));
                dll.remove(posDel);
                break;
            case 7:
                System.out.println("Print Data :");
                dll.print();
                break;
            case 8:
                System.out.print("Search Data :");
                search = sc.nextInt();
                System.out.printf("Data %d is in index-%d\n",
                ↪  search, dll.search(search));
                break;
            case 9:
                dll.sort();
                break;
            case 10:
                exit = true;
                break;
        }
    }

    sc.close();
```

```
        }
    }
```

```
PS D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists>  d:; cd 'd:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists'; & 'C:\Program Files\Java\jdk-18.0.2.1\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists\bin' 'Assignment.DoubleLinkedListMain'
========================================
Data manipulation with Double Linked List
========================================
1. Add First
2. Add Tail
3. Add Data in the nth index
4. Remove First
5. Remove Tail
6. Remove Data in the nth index
7. Print
8. Search Data
9. Sort Data
10. Exit
========================================
1
Insert data in head position
34
========================================
Data manipulation with Double Linked List
========================================
1. Add First
2. Add Tail
3. Add Data in the nth index
4. Remove First
5. Remove Tail
6. Remove Data in the nth index
7. Print
8. Search Data
9. Sort Data
10. Exit
========================================
```

```
2
Insert data in last position
10
========================================
Data manipulation with Double Linked List
========================================
1. Add First
2. Add Tail
3. Add Data in the nth index
4. Remove First
5. Remove Tail
6. Remove Data in the nth index
7. Print
8. Search Data
9. Sort Data
10. Exit
========================================
3
Insert Data
Data node: 66
In index: 1
========================================
Data manipulation with Double Linked List
========================================
1. Add First
2. Add Tail
3. Add Data in the nth index
4. Remove First
5. Remove Tail
6. Remove Data in the nth index
7. Print
8. Search Data
9. Sort Data
10. Exit
========================================
8
Search Data :66
Data 66 is in index-0
========================================
Data manipulation with Double Linked List
========================================
1. Add First
```

```
2. Add Tail
3. Add Data in the nth index
4. Remove First
5. Remove Tail
6. Remove Data in the nth index
7. Print
8. Search Data
9. Sort Data
10. Exit
========================================
9
========================================
Data manipulation with Double Linked List
========================================
1. Add First
2. Add Tail
3. Add Data in the nth index
4. Remove First
5. Remove Tail
6. Remove Data in the nth index
7. Print
8. Search Data
9. Sort Data
10. Exit
========================================
7
Print Data :
10
66

successfully added
========================================
Data manipulation with Double Linked List
========================================
1. Add First
2. Add Tail
3. Add Data in the nth index
4. Remove First
5. Remove Tail
6. Remove Data in the nth index
7. Print
8. Search Data
```

```
9. Sort Data
10. Exit
========================================
7
Print Data :
10
66

successfully added
========================================
Data manipulation with Double Linked List
========================================
1. Add First
2. Add Tail
3. Add Data in the nth index
4. Remove First
5. Remove Tail
6. Remove Data in the nth index
7. Print
8. Search Data
9. Sort Data
10. Exit
========================================
10
PS D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week
 ↪  12\Double Linked Lists>
```

2. We are required to create a program which Implement Stack using double linked list. The features are described in following illustrations:
Initial menu and add Data (push)

```
PS D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week
 ↪  12\Double Linked Lists>  & 'C:\Program
 ↪  Files\Java\jdk-18.0.2.1\bin\java.exe'
 ↪  '-XX:+ShowCodeDetailsInExceptionMessages' '-cp'
 ↪  'D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week
 ↪  12\Double Linked Lists\bin' 'Assignment2.Main'
**********
Library Data Book
**********
1. Add new book
2. Get book from top
3. Peek book title from top
```

```
4. Info all books
5. Exit
****************
1
------------------------
Insert new book title
------------------------
How to cuan
```

Print All Data

```
****************
Library Data Book
****************
1. Add new book
2. Get book from top
3. Peek book title from top
4. Info all books
5. Exit
****************
4
------------------------
info all books
------------------------
How to cuan
```

See the data on top of the stack

```
****************
Library Data Book
****************
1. Add new book
2. Get book from top
3. Peek book title from top
4. Info all books
5. Exit
****************
3
------------------------
Peek book title from top
------------------------
How to cuan
```

Pop the data from the top of the stack

```
1  ****************
2  Library Data Book
3  ****************
4  1. Add new book
5  2. Get book from top
6  3. Peek book title from top
7  4. Info all books
8  5. Exit
9  ****************
10 2
11 ------------------------
12 Book on top has been removed
13 ------------------------
14 ****************
15 Library Data Book
16 ****************
17 1. Add new book
18 2. Get book from top
19 3. Peek book title from top
20 4. Info all books
21 5. Exit
22 ****************
23 4
24 ------------------------
25 info all books
26 ------------------------
27 Linked list is empty
28 ****************
29 Library Data Book
30 ****************
31 1. Add new book
32 2. Get book from top
33 3. Peek book title from top
34 4. Info all books
35 5. Exit
36 ****************
37 5
```

Node.java

```
package Assignment2;

public class Node {
```

```
    String data;
    Node prev, next;

    public Node(Node prev, String data, Node next) {
        this.data = data;
        this.prev = prev;
        this.next = next;
    }
}
```

DoubleLinkedList.java

```
package Assignment2;

public class DoubleLinkedList {
    Node head;
    int size;

    public DoubleLinkedList() {
        head = null;
        size = 0;
    }

    public boolean isEmpty() {
        return head == null;
    }

    public void addFirst(String item) {
        if (isEmpty()) {
            head = new Node(null, item, null);
        } else {
            Node newNode = new Node(null, item, head);
            head.prev = newNode;
            head = newNode;
        }
        size++;
    }

    public int size() {
        return size;
    }

    public void clear() {
```

```
        head = null;
        size = 0;
    }

    public void print() {
        if (!isEmpty()) {
            Node temp = head;
            while (temp != null) {
                System.out.print(temp.data + "\n");
                temp = temp.next;
            }
        } else {
            System.out.println("Linked list is empty");
        }
    }

    public void removeFirst() throws Exception {
        if (isEmpty()) {
            throw new Exception("Linked list is still empty,
             ↪  cannot remove data");
        } else if (size == 1) {
            removeLast();
        } else {
            head = head.next;
            head.prev = null;
            size--;
        }
    }

    public void removeLast() throws Exception {
        if (isEmpty()) {
            throw new Exception("Linked list is still empty,
             ↪  cannot remove data");
        } else if (head.next == null) {
            head = null;
            size--;
            return;
        }
        Node current = head;
        while (current.next.next != null) {
            current = current.next;
        }
```

```
            current.next = null;
            size--;
        }

        public String getFirst() throws Exception {
            if (isEmpty()) {
                throw new Exception("Linked list still empty");
            }
            return head.data;
        }
    }
```

Main.java

```
    package Assignment2;

    import java.util.Scanner;

    public class Main {
        static Scanner sc = new Scanner(System.in);
        static DoubleLinkedList dll = new DoubleLinkedList();
        public static void displayMenu() {
            System.out.println("****************");
            System.out.println("Library Data Book");
            System.out.println("****************");
            System.out.println("1. Add new book");
            System.out.println("2. Get book from top");
            System.out.println("3. Peek book title from top");
            System.out.println("4. Info all books");
            System.out.println("5. Exit");
            System.out.println("****************");
        }

        public static void add() throws Exception {
            System.out.println("------------------------");
            System.out.println("Insert new book title");
            System.out.println("------------------------");
            sc.nextLine();
            String data = sc.nextLine();
            dll.addFirst(data);
            pivot();
        }
```

```
    public static void pop() throws Exception {
        System.out.println("------------------------");
        System.out.println("Book on top has been removed");
        System.out.println("------------------------");
        dll.removeFirst();
        pivot();
    }

    public static void peek() throws Exception {
        System.out.println("------------------------");
        System.out.println("Peek book title from top");
        System.out.println("------------------------");
        System.out.println(dll.getFirst());
        pivot();
    }

    public static void print() throws Exception {
        System.out.println("------------------------");
        System.out.println("info all books");
        System.out.println("------------------------");
        dll.print();
        pivot();
    }

    public static void exit() {
        sc.close();
    }

    public static void pivot() throws Exception {
        displayMenu();
        int option = sc.nextInt();
        switch (option) {
            case 1 -> add();
            case 2 -> pop();
            case 3 -> peek();
            case 4 -> print();
            case 5 -> exit();
        }
    }

    public static void main(String[] args) throws Exception {
        pivot();
```

```
            sc.close();
        }
    }
```

3. Create a program that helps vaccination process by having a queue algorithm alongside with double linked list as follows **(the amount left of queue length in menu print(3) and recent vaccinated person in menu Remove data (2) should be displayed)**
   Initial menu and adding a data

```
PS D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists>  d:; cd 'd:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists'; & 'C:\Program Files\Java\jdk-18.0.2.1\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists\bin' 'Assignment3.Main'
++++++++++++++++++++++++++
Extravaganza Vaccine Queue
++++++++++++++++++++++++++
1. Add vaccine queue
2. Remove vaccine queue
3. Display vaccine queue
4. Exit
++++++++++++++++++++++++++
1
Add vaccine queue
Queue number : 123
Name : joko
```

   Print data (notice the highlighted red in the result)

```
++++++++++++++++++++++++++
Extravaganza Vaccine Queue
++++++++++++++++++++++++++
1. Add vaccine queue
2. Remove vaccine queue
3. Display vaccine queue
4. Exit
++++++++++++++++++++++++++
3
current vaccine queue :
|No.   |Name    |
```

```
|123   |joko    |
Queue left : 1
```

Remove Data (the highlighted red must displayed in the console too)

```
++++++++++++++++++++++++++
Extravaganza Vaccine Queue
++++++++++++++++++++++++++
1. Add vaccine queue
2. Remove vaccine queue
3. Display vaccine queue
4. Exit
++++++++++++++++++++++++++
2
joko has been vaccinated !
++++++++++++++++++++++++++
Extravaganza Vaccine Queue
++++++++++++++++++++++++++
1. Add vaccine queue
2. Remove vaccine queue
3. Display vaccine queue
4. Exit
++++++++++++++++++++++++++
4
```

Person.java

```
package Assignment3;

public class Person {
    String name;
    int queue;

    public Person(String name, int queue) {
        this.name = name;
        this.queue = queue;
    }
}
```

Node.java

```
package Assignment3;

public class Node {
```

```
    Person data;
    Node prev, next;

    public Node(Node prev, Person data, Node next) {
        this.data = data;
        this.prev = prev;
        this.next = next;
    }
}
```

DoubleLinkedList.java

```
package Assignment3;

public class DoubleLinkedList {
    Node head;
    int size;

    public DoubleLinkedList() {
        head = null;
        size = 0;
    }

    public boolean isEmpty() {
        return head == null;
    }

    public void addFirst(Person item) {
        if (isEmpty()) {
            head = new Node(null, item, null);
        } else {
            Node newNode = new Node(null, item, head);
            head.prev = newNode;
            head = newNode;
        }
        size++;
    }

    public void addLast(Person item) {
        if (isEmpty()) {
            addFirst(item);
        } else {
            Node current = head;
```

```
            while (current.next != null) {
                current = current.next;
            }
            Node newNode = new Node(current, item, null);
            current.next = newNode;
            size++;
        }
    }

    public int size() {
        return size;
    }

    public void clear() {
        head = null;
        size = 0;
    }

    public void print() {
        if (!isEmpty()) {
            Node temp = head;
            int count = 0;
            System.out.println("|No.   |Name    |");
            while (temp != null) {
                System.out.printf("|%-6d|%-8s|\n",
                ↪  temp.data.queue, temp.data.name);
                count++;
                temp = temp.next;
            }
            System.out.printf("Queue left : %d\n", count);
        } else {
            System.out.println("Linked list is empty");
        }
    }

    public void removeFirst() throws Exception {
        if (isEmpty()) {
            throw new Exception("Linked list is still empty,
            ↪  cannot remove data");
        } else if (size == 1) {
            removeLast();
        } else {
```

```
            head = head.next;
            head.prev = null;
            size--;
        }
    }

    public void removeLast() throws Exception {
        if (isEmpty()) {
            throw new Exception("Linked list is still empty,
            ↪  cannot remove data");
        } else if (head.next == null) {
            head = null;
            size--;
            return;
        }
        Node current = head;
        while (current.next.next != null) {
            current = current.next;
        }
        current.next = null;
        size--;
    }

    public String getFirst() throws Exception {
        if (isEmpty()) {
            throw new Exception("Linked list still empty");
        }
        return head.data.name;
    }
}
```

Main.java

```
package Assignment3;

import java.util.Scanner;

public class Main {
    static Scanner sc = new Scanner(System.in);
    static DoubleLinkedList dll = new DoubleLinkedList();
    public static void displayMenu() {
        System.out.println("++++++++++++++++++++++++++");
```

```
        System.out.println("Extravaganza Vaccine Queue");
        System.out.println("++++++++++++++++++++++++++");
        System.out.println("1. Add vaccine queue");
        System.out.println("2. Remove vaccine queue");
        System.out.println("3. Display vaccine queue");
        System.out.println("4. Exit");
        System.out.println("++++++++++++++++++++++++++");
    }

    public static void add() throws Exception {
        System.out.println("Add vaccine queue");
        System.out.print("Queue number : ");
        int queueNumber = sc.nextInt();
        System.out.print("Name : ");
        sc.nextLine();
        String name = sc.nextLine();
        Person data = new Person(name, queueNumber);
        dll.addFirst(data);
        pivot();
    }

    public static void pop() throws Exception {
        System.out.printf("%s has been vaccinated !\n",
        ↪  dll.getFirst());
        dll.removeLast();
        pivot();
    }

    public static void print() throws Exception {
        System.out.println("current vaccine queue : ");
        dll.print();
        pivot();
    }

    public static void exit() {
        sc.close();
    }

    public static void pivot() throws Exception {
        displayMenu();
        int option = sc.nextInt();
        switch (option) {
```

```
                case 1 -> add();
                case 2 -> pop();
                case 3 -> print();
                case 4 -> exit();
            }
        }

        public static void main(String[] args) throws Exception {
            pivot();
            sc.close();
        }
    }
```

4. Create a program implementation that list students score. Each student's data consist of their nim, name, and gpa. The program should implement double linked list and should be able to search based on NIM and sort the GPA in descending order. **Students class must be implemented in this program**

   Initial menu and adding data

```
PS D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists>  d:; cd 'd:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists'; & 'C:\Program Files\Java\jdk-18.0.2.1\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'D:\Kuliah\Smt 2\Algoritma dan Struktur Data\Praktikum\Week 12\Double Linked Lists\bin' 'Assignment4.Main'
================================
Student Data Management System
================================
1. Add data from head
2. Add data from Tail
3. Add data in specific index
4. Remove data from head
5. Remove data from Tail
6. Remove data in specific index
7. Print
8. Search by NIM
9. Sort by GPA - Desc
10. Exit
================================
1
Insert NIM in head position
```

```
NIM  : 123
Name : Anang
GPA  : 2.77
================================
Student Data Management System
================================
1. Add data from head
2. Add data from Tail
3. Add data in specific index
4. Remove data from head
5. Remove data from Tail
6. Remove data in specific index
7. Print
8. Search by NIM
9. Sort by GPA - Desc
10. Exit
================================
2
Insert NIM in tail position
NIM  : 233
Name : Suparjo
GPA  : 3.67
================================
Student Data Management System
================================
1. Add data from head
2. Add data from Tail
3. Add data in specific index
4. Remove data from head
5. Remove data from Tail
6. Remove data in specific index
7. Print
8. Search by NIM
9. Sort by GPA - Desc
10. Exit
================================
3
Insert student's data node
NIM  : 743
Name : Freddy
GPA  : 2.90
In index : 2
```

Printing data

```
==============================
Student Data Management System
==============================
1. Add data from head
2. Add data from Tail
3. Add data in specific index
4. Remove data from head
5. Remove data from Tail
6. Remove data in specific index
7. Print
8. Search by NIM
9. Sort by GPA - Desc
10. Exit
==============================
7
================================
NIM  : 123
Name : Anang
GPA  : 2.77
================================
NIM  : 233
Name : Suparjo
GPA  : 3.67
================================
NIM  : 743
Name : Freddy
GPA  : 2.90

All data printed successfully
```

Searching data

```
==============================
Student Data Management System
==============================
1. Add data from head
2. Add data from Tail
3. Add data in specific index
4. Remove data from head
5. Remove data from Tail
6. Remove data in specific index
```

```
7. Print
8. Search by NIM
9. Sort by GPA - Desc
10. Exit
================================
8
Insert NIM to be searched : 233
Data 233 is in node - 1
Identity :
================================
NIM  : 233
Name : Suparjo
GPA  : 3.67
```

Sorting data

```
================================
Student Data Management System
================================
1. Add data from head
2. Add data from Tail
3. Add data in specific index
4. Remove data from head
5. Remove data from Tail
6. Remove data in specific index
7. Print
8. Search by NIM
9. Sort by GPA - Desc
10. Exit
================================
9
================================
Student Data Management System
================================
1. Add data from head
2. Add data from Tail
3. Add data in specific index
4. Remove data from head
5. Remove data from Tail
6. Remove data in specific index
7. Print
8. Search by NIM
9. Sort by GPA - Desc
```

```
10. Exit
================================
7
================================
NIM  : 233
Name : Suparjo
GPA  : 3.67
================================
NIM  : 743
Name : Freddy
GPA  : 2.90
================================
NIM  : 123
Name : Anang
GPA  : 2.77

All data printed successfully
================================
Student Data Management System
================================
1. Add data from head
2. Add data from Tail
3. Add data in specific index
4. Remove data from head
5. Remove data from Tail
6. Remove data in specific index
7. Print
8. Search by NIM
9. Sort by GPA - Desc
10. Exit
================================
10
```

Student.java

```java
package Assignment4;

public class Student {
    String name;
    int nim;
    double gpa;

    public Student(String name, int NIM, double GPA) {
```

```
        this.name = name;
        this.nim = NIM;
        this.gpa = GPA;
    }

    public void print() {
        System.out.println("================================");
        System.out.printf("NIM  : %d\n", nim);
        System.out.printf("Name : %s\n", name);
        System.out.printf("GPA  : %.2f\n", gpa);
    }
}
```

Node.java

```
package Assignment4;

public class Node {
    Student data;
    Node prev, next;

    public Node(Node prev, Student data, Node next) {
        this.data = data;
        this.prev = prev;
        this.next = next;
    }
}
```

DoubleLinkedList.java

```
package Assignment4;

public class DoubleLinkedList {
    Node head;
    int size;

    public DoubleLinkedList() {
        head = null;
        size = 0;
    }

    public boolean isEmpty() {
        return head == null;
    }
```

```
public void addFirst(Student item) {
    if (isEmpty()) {
        head = new Node(null, item, null);
    } else {
        Node newNode = new Node(null, item, head);
        head.prev = newNode;
        head = newNode;
    }
    size++;
}

public void addLast(Student item) {
    if (isEmpty()) {
        addFirst(item);
    } else {
        Node current = head;
        while (current.next != null) {
            current = current.next;
        }
        Node newNode = new Node(current, item, null);
        current.next = newNode;
        size++;
    }
}

public void add(Student item, int index) throws Exception {
    if (isEmpty()) {
        addFirst(item);
    } else if (index < 0 || index > size) {
        throw new Exception("Index out of bound");
    } else if (index == size) {
        addLast(item);
    } else {
        Node current = head;
        int i = 0;
        while (i < index) {
            current = current.next;
            i++;
        }
        if (current.next == null) {
            Node newNode = new Node(null, item, current);
```

```
                current.prev = newNode;
                head = newNode;
            } else {
                Node newNode = new Node(current.prev, item,
                ↪  current);
                newNode.prev = current.prev;
                newNode.next = current;
                current.prev.next = newNode;
                current.prev = newNode;
            }
        }
        size++;
    }

    public int size() {
        return size;
    }

    public void clear() {
        head = null;
        size = 0;
    }

    public void print() {
        if (!isEmpty()) {
            Node temp = head;
            while (temp != null) {
                temp.data.print();
                temp = temp.next;
            }
            System.out.println("\nAll data printed
            ↪  successfully");
        } else {
            System.out.println("Linked list is empty");
        }
    }

    public void removeFirst() throws Exception {
        if (isEmpty()) {
            throw new Exception("Linked list is still empty,
            ↪  cannot remove data");
        } else if (size == 1) {
```

```
            removeLast();
        } else {
            head = head.next;
            head.prev = null;
            size--;
        }
    }

    public void removeLast() throws Exception {
        if (isEmpty()) {
            throw new Exception("Linked list is still empty,
            ↪  cannot remove data");
        } else if (head.next == null) {
            head = null;
            size--;
            return;
        }
        Node current = head;
        while (current.next.next != null) {
            current = current.next;
        }
        current.next = null;
        size--;
    }

    public void remove(int index) throws Exception {
        if (isEmpty() || index >= size) {
            throw new Exception("Index value is out of bound");
        } else if (size == 0) {
            removeFirst();
        } else {
            Node current = head;
            int i = 0;
            while (i < index) {
                current = current.next;
                i++;
            }
            if (current.next == null) {
                current.prev.next = null;
            } else if (current.prev == null) {
                current = current.next;
                current.prev = null;
```

```
            head = current;
        } else {
            current.prev.next = current.next;
            current.next.prev = current.prev;
        }
        size--;
    }
}

public Student getFirst() throws Exception {
    if (isEmpty()) {
        throw new Exception("Linked list still empty");
    }
    return head.data;
}

public Student getLast() throws Exception {
    if (isEmpty()) {
        throw new Exception("Linked list still empty");
    }
    Node temp = head;
    while (temp.next != null) {
        temp = temp.next;
    }
    return temp.data;
}

public Student get(int index) throws Exception {
    if (isEmpty()) {
        throw new Exception("Linked list still empty");
    }
    Node temp = head;
    for (int i = 0; i < index; i++) {
        temp = temp.next;
    }
    return temp.data;
}
public int search(int key) throws Exception {
    Node temp = head;
    int i = 0;
    while (i < size) {
        if (temp.data.nim == key) {
```

```
                return i;
            }
            i++;
            temp = temp.next;
        }
        throw new Exception("Key value doesn't exist");
    }

    public void sort() throws Exception {
        if (head == null || head.next == null) {
            return;
        }
        boolean swapped;
        Node current;
        Node last = null;
        do {
            swapped = false;
            current = head;
            while (current.next != last) {
                if (current.data.gpa < current.next.data.gpa) {
                    Student temp = current.data;
                    current.data = current.next.data;
                    current.next.data = temp;
                    swapped = true;
                }
                current = current.next;
            }
            last = current;
        } while (swapped);
    }
}
```

Main.java

```
package Assignment4;

import java.util.Scanner;

public class Main {
    static Scanner sc = new Scanner(System.in);
    static DoubleLinkedList dll = new DoubleLinkedList();

    public static void displayMenu() {
```

```
        System.out.println("============================== ");
        System.out.println("Student Data Management System  ");
        System.out.println("============================== ");
        System.out.println("1. Add data from head          ");
        System.out.println("2. Add data from Tail          ");
        System.out.println("3. Add data in specific index  ");
        System.out.println("4. Remove data from head       ");
        System.out.println("5. Remove data from Tail       ");
        System.out.println("6. Remove data in specific index");
        System.out.println("7. Print                       ");
        System.out.println("8. Search by NIM               ");
        System.out.println("9. Sort by GPA - Desc          ");
        System.out.println("10. Exit                       ");
        System.out.println("============================== ");
    }

    public static Student newStudent() {
        System.out.print("NIM  : ");
        int NIM = sc.nextInt();
        System.out.print("Name : ");
        sc.nextLine();
        String name = sc.nextLine();
        System.out.print("GPA  : ");
        double GPA = sc.nextDouble();
        Student data = new Student(name, NIM, GPA);
        return data;
    }

    public static void addFirst() throws Exception {
        System.out.println("Insert NIM in head position");
        Student data = newStudent();
        dll.addFirst(data);
        pivot();
    }

    public static void addLast() throws Exception {
        System.out.println("Insert NIM in tail position");
        Student data = newStudent();
        dll.addLast(data);
        pivot();
    }
```

```
public static void add() throws Exception {
    System.out.println("Insert student's data node");
    Student data = newStudent();
    System.out.print("In index : ");
    int index = sc.nextInt();
    dll.add(data, index);
    pivot();
}

public static void removeFirst() throws Exception {
    System.out.println("Insert NIM in head position");
    dll.removeFirst();
    pivot();
}

public static void removeLast() throws Exception {
    System.out.println("Insert NIM in tail position");
    dll.removeLast();
    pivot();
}
public static void remove() throws Exception {
    System.out.println("Insert student's data node");
    System.out.print("In index : ");
    int index = sc.nextInt();
    dll.remove(index);
    pivot();
}

public static void print() throws Exception {
    dll.print();
    pivot();
}

public static void search() throws Exception {
    System.out.print("Insert NIM to be searched : ");
    int key = sc.nextInt();
    System.out.printf("Data %d is in node - %d\n", key,
    ↪  dll.search(key));
    System.out.println("Identity : ");
    dll.get(dll.search(key)).print();
    pivot();
}
```

```
    public static void sort() throws Exception {
        dll.sort();
        pivot();
    }

    public static void exit() {
        sc.close();
    }

    public static void pivot() throws Exception {
        displayMenu();
        int option = sc.nextInt();
        switch (option) {
            case 1  -> addFirst();
            case 2  -> addLast();
            case 3  -> add();
            case 4  -> removeFirst();
            case 5  -> removeLast();
            case 6  -> remove();
            case 7  -> print();
            case 8  -> search();
            case 9  -> sort();
            case 10 -> exit();
        }
    }

    public static void main(String[] args) throws Exception {
        pivot();
        sc.close();
    }
}
```