Week 7 worksheet: Complexity Analysis and Generics

Total points: 10

Out: 2024 October 14 (Monday)

Due: 2024 October 16 (Thursday end of day [2359 CDT according to D2L])

What to submit?

Upload only one Word or PDF file to the designated D2L folder.

Running time assumptions

- Assume that basic arithmetic operations (+, -, *, /, %) run in constant time.
- Assume that the System.out.println(…) statement runs in constant time.

Generic Node <E> assumptions

- Assume that generic class E has an equals method.

Exercise 1: Detailed Runtime Complexity Analysis

[2 pts] In the following code, assume that arithmetic and the println statement run in constant time.

```
int count = 10;
for ( int j = 0; j < 5; j++ ) {
      System.out.println( j * count );
}
```

For each line of this code, how many times is the line executed, and how many operations are executed whenever the line is executed? *[0.7]*

Line of code	Ops per execution	Number of times executed
`int count = 10;`	2	1
`for ( int j = 0; j < 5; j++ )`	3	6
`System.out.println( j * count );`	2	5
TOTAL NUMBER OF STEPS		30 – 2 (int j = 0 only happens once) 28

Now consider the following code snippet:

```
int count = 10;
for ( int j = 0; j < n; j++ ) {
      System.out.println( j * count );
}
```

For each line of this code, how many times is the line executed, and how many operations are executed whenever the line is executed? *[0.7]*

Line of code	Ops per execution	Number of times executed
`int count = 10;`	1	1
`for ( int j = 0; j < n; j++ )`	3	n + 1
`System.out.println( j * count );`	2	n + 1
TOTAL NUMBER OF STEPS		1 + (5 * (n + 1))

What is the big-O running time of this code snippet? *[0.6]* O(N)

Exercise 2: Another runtime analysis

[3 pts] What are the big-O running times of the following methods as a function of the input parameter(s)?

```
public void method1( int n ) {
      for ( int j = 1; j <= n; j++ ) {
            for ( int k = 1; k < n; k++ ) {
                  System.out.println ( j * k ) ;
            }
      }
}
```

Big-O running time of method1 O(N^2)

```
public void method2( int m, int n ) {
      for ( int j = 1; j <= m; j++ ) {
            for ( int k = 1; k < n; k++ ) {
                  System.out.println ( j * k ) ;
            }
      }
}
```

Big-O running time of method2 O(N^2)

```
public void method3( int n ) {
      for ( int j = 1; j <= n; j *= 2 ) {
            System.out.println ( j * k ) ;
      }
}
```

Big-O running time of method3 O(n log n)

Exercise 3: Implement `removeFirst`

[5 pts] Suppose that you have a linked list of Nodes of generic objects:

```
public class Node<E> {
	E data;
	Node<E> link;

	public E getData() { return data; }

	public Node<E> getLink() { return link; }

	public void setData( E data ) { this.data = data; }

	public void setLink( Node<E> link ) { this.link = link; }
}
```

Suppose further you have a linked list with a head Node<E> named “head”.

Suppose further that class E has an equals method.

Write a method removeFirst that removes the first node of the linked list that contains a value “target” of type E. Of course, your method must then reconnect the list. If there is no such element in the list, return null. *[4 pts]* The signature of this method is **`public E removeFirst( E target, Node<E> head )`**

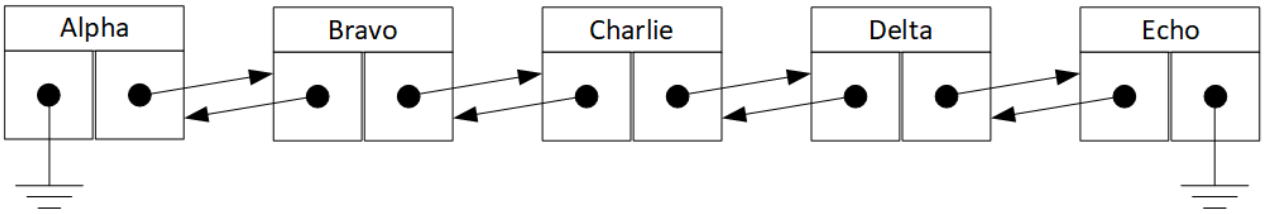
```java
/**
 * Removes the first element found that equals target
 * @param target element to look for
 * @param head linked list
 * @return returns the node if found and removed or null if not found
 */
public E removeFirst(E target, Node<E> head) {
    if (head == null) {
        return null;
    }

    if (head.getData().equals(target)) {
        E rData = head.getData();
        head = head.getLink();
        return rdata;
    }

    Node<E> cursor = head;
    Node<E> prev_cursor = null;

    while (cursor != null) {
        if (cursor.getData().equals(target)) {
            if (prev_cursor != null) {
                prev_cursor.setLink(cursor.getLink());
            }
            return cursor.getData();
        }
        prev_cursor = cursor;
        cursor = cursor.getLink();
    }

    return null;

}
```

If the list has n nodes, what is the big-O running time of this method in terms of n? *[1 pt]* O(N)

Exercise 4: Doubly linked list `removeFirst`

[2 pts] Suppose that you have a doubly linked list of Nodes of generic objects. Each Node<E> has two references, one to the previous element in the list and one to the next element. It has two named nodes, "head" and "tail". "head" has a null "prev" reference, and "tail" has a null "next" reference.

A sample such list with Strings would look like this:




```
public class Node<E> {
	E data;
	Node<E> prev;
	Node<E> next;

	public E getData() { return data; }
	public Node<E> getPrev() { return prev; }
	public Node<E> getNext() { return next; }

	public void setData( E data ) { this.data = data; }
	public void setPrev ( Node<E> prev ) { this.prev = prev; }
	public void setNext ( Node<E> next ) { this.prev = next; }

}
```

Write a method removeLast that removes the last node of the linked list that contains a value "target" of type E, and then reconnects the list. If there is no such element in the list, return null. The signature of this method is **`public E removeLast( E target, Node<E> head, Node<E> tail )`**

```java
/**
 * Removes last instance of element target from the list
 * @param target target we are looking for
 * @param head head of linked list
 * @param tail tail of linked list
 * @return returns the data if found and replaced, else return
 */
public E removeLast(E target, Node<E> head, Node<E> tail) {
    if (tail == null) {
        return null;
    }

    Node<E> cursor = tail;

    while (cursor != null) {
        if (cursor.getData().equals(target)) {
            if (cursor.getPrev() != null) {
                cursor.getPrev().setNext(cursor.getNext());
            }
            else {
                head = cursor.getNext();
            }
            if (cursor.getNext() != null) {
                cursor.getNext().setPrev(cursor.getPrev());
            }
            else {
                tail = cursor.getPrev();
            }
            return rdata;
        }
        cursor = cursor.getPrev();
    }
    return null;
}
```

Exercise 4: reflect on your learning this week

1- What is the most important thing you learned in this week's lecture? Write 2-3 sentences to explain your answer.

Generic classes can be used to handle multiple different kinds of objects however, they all must be the same type per use.

2- What is the muddiest (most-unclear) point(s) in this week's lecture? Explain why?

Doubly linked lists, kind of as expected. I just don't have enough practice working through it yet.