The University of Saskatchewan

Saskatoon, Canada
Department of Computer Science

CMPT 280 – Intermediate Data Structures and Algoirthms

Assignment 1

Date Due: July 7, 2016, 11:45pm

Total Marks: 45

1 Submission Instructions

Assignments must be submitted using Moodle.

Programs must be written in Java.
No late assignments will be accepted. See the course syllabus for the full late assignment policy for this class.

2 Background

For this assignment you'll be working with linked list classes from the data structure library lib280. lib280 is a library of data structures that we will build up over the duration of the course. We will start with a version that has very few data structures in it and add more with each assignment. Each assignment will come with a new version of lib280 which contains the correct implementations of ADTs that were the subject of the previous assignment.

Obtaining and Setting Up lib280

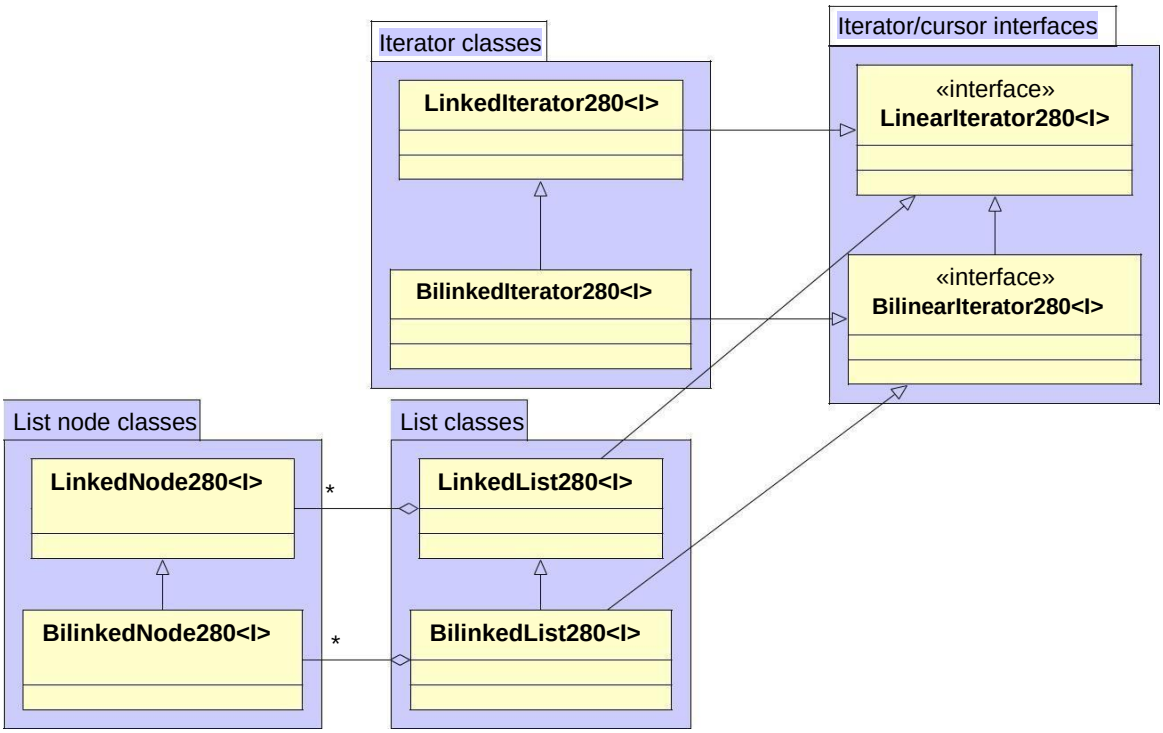
For this assignment the first thing you'll need to do is to obtain a copy of lib280-asn1. It is provided along with this assignment description on the class webpage. Download the lib280-asn1.zip file and expand its contents somewhere in your filesystem.

The class website provides a self-guided tutorial that explains how to import lib280 into an eclipse workspace once you have downloaded it; it is located under the "Laboratory/Tutorial Resources" heading. You'll need to follow these instructions for questions 1 and 2. For Question 1 complete all of the steps in the self-guided tutorial. If you've done this for question 1, then for question 2 you only need to follow Step 2 of the tutorial since you already will have imported lib280 into your Eclipse workspace, and since we won't be using a separate project that needs access to the lib280-asn1 project; instead you'll be working on the files within lib280-asn1 itself. For question 3, you won't have to do any of the tutorial steps if you've already done them for qustions 1 and 2 because you'll just be making more modifications to the files within lib280-asn1.

If you are using NetBeans, first create an Assignment 1 project folder using NetBeans. Then copy all the source files into it. Be sure to ajust the package name to that of your "main" class.

Singly- and Doubly- Linked List Classes in lib280

The UML diagram below shows the class hierarchy you'll be working with in this assignment. It may look a bit daunting at first, but you'll soon see it's not that complicated. In essence, there are four pairs of classes/interfaces (denoted by light blue boxes[1]). And in each pair, one is for a singly-linked list and one for a doubly-linked list. The class/interface of each pair that pertains to doubly linked lists extends the class/interface related to singly linked lists.



LinkedNode280<I>**:** The node class used for a singly-linked list.

BilinkedNode280<I>**:** An extension of LinkedNode280<I> that adds the "previous node" reference required for nodes in a doubly linked list.

LinearIterator280<I>**:** An interface that defines the methods that must be supported by cursors and iterators that can step forwards over a linear structure, such as goFirst(), goForth(), after(), etc.

BilinearIterator280<I>**:** An interface that extends LinearIterator280<I> by adding methods that allow stepping backwards, such as goBack() and goLast().

LinkedIterator<I>**:** An implementation of LinearIterator280<I> which is an iterator object for a singly-linked list. It is used by the LinkedList280<I> class to provide iterators.

[1]The light blue boxes in the UML diagram are only to show the pairs of classes that serve the same roles for singly-/doublylinked lists and do not represent any actual grouping within lib280. All of the pictured classes are in the same package within lib280.

BiinkedIterator<I>**:** An implementation of BilinearIterator280<I>, and an extension of LinkedIterator280<I>, which is an iterator object for a doubly-linked list. It is used by the BilinkedList280<I> class to provide iterators.

LinkedList280<I>**:** A singly-linked list class. It provides a cursor by implementing the LinearItera-tor280<I> interface. The Nodes of the list are LinkedNode280<I> objects, and it can provide iterators of of type LinkedIterator<I>.

BiLinkedList280<I>**:** A doubly-linked list class. It provides a cursor that can move both forwards and backwards by implementing the BilinearIterator280<I> interface. The nodes of the list are BilinkedNode280<I> objects, and it can provide iterators of of type BilinkedIterator<I>.

Take a moment to familiarize yourself with these classes and their methods, particularly the LinkedList280<I> and LinkedIterator280<I> classes as you will be working on coding extensions of these classes.

Iterators

This section describes a bit more about how iterators work. Iterators provide the same functionality as a container ADT that has a cursor, but they are separate objects from the container. This allows us to record a cursor position that is different and independent from the position recorded by the container's internal cursor.

The list objects, LinkedList280<I> and BilinkedList280<I> both have methods called iterator. The iterator method in the LinkedList280<I> class returns a new cursor position encapsulated in an instance of the LinkedIterator280<I> class. This instance will have references directly to the nodes of the LinkedList280<I> instance that created it. In essence, the LinkedIterator280<I> contains its own copies of the position and prevPosition fields that appear in LinkedList280<I> – i.e. another cursor that is external to the list! This cursor can be manipulated in exactly the same was as the internal cursor of the list. If you compare the methods in LinkedIterator280<I> to the methods of the same name in LinkedList280<I>, you'll see that they are almost identical.

Thus, each time we want a new cursor that is independent of the list's internal cursor, we can call the iterator method and get a new one. This adds additional flexibility. If we can get away with just using the lists internal cursor for our purposes, then we can do so, but we have the option to create more cursors in the form of iterators should we so desire.

3 Your Tasks

Question 1 (8 points):

Tractor Jack is a notorious pirate captain who sails the Saskatchewan River plundering farms for wheat, barley, and all the other grains. At the end of each day, Jack enters into his computer a log of each sack of grain he has plundered, what kind of grain it is, and how much it weighs. You will help Jack write a program to organize this data, and calculate much of each type of grain he plundered.

Enumerations

In this question we're going to use a data type in Java called an enumeration. Enumerations define a fixed set of named constant values. The grains Jack most commonly plunders are wheat, barley, oats and rye so he wants to count the amount of those four grains separately. Any other types of grain he wants to count together. We can use an enumeration to define five constants to denote what type of grain is in a sack:

```
enum Grain {
    WHEAT , BARLEY , OATS , RYE , OTHER
}
```

This declaration defines a data type called Grain and five values which we can assign to variables of type Grain. You can find it at the top of Sack.java. Now we can then write in Java:

```
Grain g = Grain . WHEAT ; // Assign value WHEAT to the variable g
```

Here are some other thing we can do with enumerations that you will need:

Enumeration types have a static method called values() which returns an array of the values it defines. For example:

```
// This returns the array: {WHEAT, BARLEY, OATS, RYE, OTHER}
Grain.values ();
```

Each value defined by the enumeration is associated with an integer value between 0 and N (where N is the number of values in the enumeration). These ordinals are a convenient way to map values in an enumeration to offsets of an N-element array.

```
Grain g = Grain . OATS ;
g . ordinal (); // returns the integer 2 ,
                // because OATS is the 3rd value in the enum .
g = Grain . WHEAT ; g . ordinal ();
// returns the integer 0 ,
                // because WHEAT is the 1st value in the enum .
```

You can find out how many values are in an enumeration asking for the length of the array returned by the values() method:

```
Grain . values (). length // this is 5 because there are five values
```

```
                                    // in the      Grain    e n u m e r a t i o n .
```

Because enumerations have toString() methods, we can print enumerated types, and concatenate them with strings. For example:

```
Grain  g  =  Grain . RYE ;
System . out . println ( g )   //  prints :  RYE
System . out . println (" The  grain  is :  "+ g )  //  prints :   The  grain  is  RYE
```

The Problem

Your task is to write a program to sort the sacks of grain that Jack plundered by the type of grain in each sack, and calculate how much of each type of grain he has. This will be done by adding all the sacks of grain containing one kind of grain to its own list.

Create a new project that references lib280-asn1 as described in the self-guided tutorial on the class website. Add to it a class called A1Q1. Add the generatePlunder method (given below) to this class. Add the provided Sack.java to your project.

Add a main() method to your A1Q1 class. Inside it, write a program that does the following:

1. Call the following function to generate some data that represents Captain Jack's plunder for the day:

```
public static Sack [] g e n e r a t e P l u n d e r ( int howMany ) {
    Random g ene ra to r = new Random (); Sack
    grain []  =  new Sack [ howMany ];

    for ( int i =0; i < howMany ; i ++) { grain [ i ] = new
        Sack (
        Grain . values ()[ g en er at or . nextInt ( Grain . values (). length )] , ge ne ra to r
        . n e x t D o u b l e () * 100 );
    }

    return     grain ;
}
```

   This will return array of randomly generated Sack objects with howMany elements. Sack is a simple class that stores the type of grain in a sack (as the enumerated type Grain), and how much it weighs.

   The Sack class is provided for you to use. You'll that see its quite straightforward.

2. Create an array of linked lists of Sack objects; there should be one list for each type of grain, including OTHER. This should be an array of LinkedList280<Sack> objects. Each list in the array will store Sack objects for one and only one type of grain. All of the sacks containing OTHER grain should go on the same list. Remember to create not only the array, but also instantiate a list for each element of the array.

3. Put each Sack object in the array you created in step 1 onto one of the lists you created in step 2. Use the ordinal of the grain type of the sack object to index the array of linked lists to find the correct list for the type of grain, and add the sack object to that list.

4. Go through each list and compute the total weight of each type of grain that Jack plundered. Remember that since the data is randomly generated, it is possible for a list to be empty!

5. Print a report of Jack's plundering to the console. Below is a sample of what that should look like.[1]

```
Jack plundered   0.0  pounds  of  WHEAT
Jack plundered 7 5 . 8 4 2 2 9 8 4 9 4 3 7 3 5 pounds of BARLEY
Jack plundered   7 4 . 0 1 7 2 1 5 7 4 4 9 6 4 8 4 pounds of OATS
Jack plundered    4 8 . 8 2 3 8 9 4 9 3 3 6 9 3 5 1 pounds of RYE
Jack plundered    4 4 . 9 6 2 9 5 1 7 5 4 6 2 0 0 6 5 pounds of OTHER
```

This question was inspired by this song (click to link). Arrrr!

Question 2 (23 points):

The BilinkedList280<I> and BilinkedIterator280<I> classes in lib280-asn1 are incomplete. There are missing method bodies in each class. Each missing method body is tagged with a // TODO com-ment.

The javadoc headers for each method explain what each method is supposed to do[2]. Many of the methods you must implement override methods of the LinkedList280<I> superclass. Add your code right into the existing files within the lib280-asn1 project.

Marks for this question are earned by implementing the methods correctly.

You are not permitted to modify any existing code in the .java files given. You may only fill in the missing method bodies.

Question 3 (14 points):

Write a regression tests for the BilinkedList280<I> class. You only need to test the methods that you had to write. You may generate test cases using white-box, black-box, or a combination of both methods. Again, write this code in the existing BiLinkedList280.java within the lib280-asn1 project. A function header for the regression test (main() function) has already been provided.

Marks for this question will be earned for generating and coding good tests, not whether or not the methods being tested actually work. This means that you can still get full marks on this question even if the methods you were supposed to code in Question 2 don't work.

4 Files Provided

lib280-asn1: A copy of lib280.

Sack.java: A copy of Captain Jack's Sack class.

[1] Jack seems to have a very precise scale for weighing his sacks of grain!

[2] The javadoc comments in these files are also good examples of how we will expect you to document methods that you write yourself in future assignments.

5 What to Hand In

You must submit the following files:

A1Q1.java: Your program for question 1. (You do not need to submit Sack.java).

A1Q1output.txt: The output from the program you wrote for question 1 cut and paste from the Eclipse console.

BilinkedList280.java: Your completed doubly linked list class from question 2 and its regression test that you wrote for question 3.

BilinkedIterator280.java: Your completed iterator class from question 2.
