Lab 6 - Evaluating Algorithm Performance  
Due (via Bitbucket and hard copy) Wednesday, 21 October 2015  
50 points

Lab Goals

• Practice timing the performance speed of algorithms on a variety of input sizes
• Evaluate the Big-O performance of said algorithms
• Answer a few questions to test your knowledge about the class content to-date

Assignment Details

In the past few classes, we have been discussing the performance of algorithms. We saw that there are two different ways to evaluate the performance of an algorithm: measuring the running time of a section of code, and counting the number of primitive operations with respect to input size. In this lab, we will write a few short functions and measure the performance of the code by each of these methods.

String vs StringBuilder (15 points)

Java supports a few different methods for storing strings of characters. The first is the String class, which is the one we have most commonly used so far. One downside to Strings is that they are immutable objects – once created, they cannot be changed. That means that when concatenating two Strings, we are in fact creating a brand new String. In other words, the following code segment:

```java
String str1 = "My String";
str1 = str1 + " is awesome!";
```

actually replaces the original str1 reference with a new String that is declared and initialized implicitly to the phrase “My String is awesome!”. Concatenating and modifying Strings is thus an expensive process in Java. For strings that will be modified frequently, StringBuilder is a better choice. StringBuilders are mutable objects. By calling the append() method of a StringBuilder object, the internal character array will be altered, which is a much more efficient process than creating a whole new object.

In this section of the lab, we will test just how much faster we can append strings with both String and StringBuilder objects. You should create a class (the name is up to you) to compare the running time of these classes. You should use System.nanoTime() to measure this performance.
In your code, you will be running a loop of various lengths, appending a single character onto one object from each class. Your `String` loop should look something like:

```java
String myString = new String();
for (int i = 0; i < N; i++) {
    myString = myString + "a";
} //for
```

and your `StringBuilder` loop should look something like:

```java
StringBuilder mySB = new StringBuilder();
for (int i = 0; i < N; i++) {
    mySB.append("a");
} //for
```

You should add your timing code around these loops, to measure how long it takes to run through the loops. You should time runs with loop sizes of 1,000, 10,000, 50,000, and 100,000. For each of these loop sizes, you should measure 5 running times, to ensure that one outlying datapoint isn’t confusing your analysis.

You should then take the average of these timings for each loop size, and then plot them on a chart. The x-axis of your chart should measure loop size, and the y-axis of your chart should note the running time.

When complete, you should see average timing results sort of similar to what is reported in the textbook on pages 152-153.

**Arrays vs ListedList vs SinglyLinkedList (25 points)**

Since we spent some time earlier in the class discussing both arrays and linked lists, it would also be interesting to evaluate their performance with respect to each other. Since we also created our own `SinglyLinkedList` class, we can include this in the analysis as well.

For this section of the lab, you should test both insertion and retrieval from arrays, Java’s `LinkedList`, and our `SinglyLinkedList` class. For the insertion component, you can add 1,000, 10,000, 50,000, and 100,000 items to an integer array, `LinkedList`, and `SinglyLinkedList`. For retrieval, you can do something similar, using the `get()` function on the created lists, and using the index in the array. See the code on the next page.

As with the last section, you should measure 5 running times for each of the array and list sizes, to ensure that one outlying datapoint isn’t confusing your analysis. Additionally, you should take the average of these timings for each array/list size and plot them on a chart. The x-axis of the chart should measure the array/list size, and the y-axis of the chart should note the running time.
int[] myArray = new int[N];
for (int i = 0; i < N; i++) {
    myArray[i] = i;
} //for

LinkedList<Integer> myList = new LinkedList<Integer>();
for (int i = 0; i < N; i++) {
    myList.add(i);
} //for

SinglyLinkedList mySList = new SinglyLinkedList();
for (int i = 0; i < N; i++) {
    mySList.add(i);
} //for

for (int i = 0; i < N; i++) {
    int something = myArray[i];
} //for

for (int i = 0; i < N; i++) {
    int variable = myList.get(i);
} //for

for (int i = 0; i < N; i++) {
    int somethingElse = mySList.get(i);
} //for

Additional Questions (10 points)

Please answer the following questions thoroughly:

1. Evaluate the Big-O order of growth of the following loops:

   ```java
   for (int j = 0; j < N; j++) {
       for (int k = 0; k <= j; k++) {
           total += arr[j];
       } //for
   } //for
   ```

2. Evaluate the Big-O order of growth of the following loop:

   ```java
   for (int j = 0; j < N; j+=2) {
       total += arr[j];
   } //for
   ```
3. Evaluate the Big-O order of growth of the following loops:

```java
for (int i = 0; i < N; i++) {
    for (int j = 0; j < N; j++) {
        for (int k = 0; k <= j; k++) {
            total += arr[k];
        } //for
    } //for
} //for
```

4. Evaluate the Big-O order of growth of the following loops:

```java
for (int j = 0; j < N; j++) {
    for (int k = 1; k < N; k = k * 2) {
        total += arr[j];
    } //for
} //for
```

Submission Details

For this assignment, your submission (to both your BitBucket repository and by hardcopy) should include the following:

1. Upload: Your commented source code for the timing algorithms that you wrote
2. Print and Upload: Tables and charts showing the runtimes for the first two sections of the lab
3. Print and Upload: The answers to the questions from the “Additional Questions” section
4. Print and Upload: An Assignment Information Sheet for your code submission

Please note that each student in the class is responsible for completing and submitting their own version of this assignment. However, you also will be assigned to work to a team that is tasked with ensuring that all of its members are able to complete each step of the assignment. Team members should make themselves available to each other to answer questions and resolve any problems that develop during the laboratory session. While it is acceptable for members of a team to have high-level conversations, you should not share source code or full command lines with your team members. To ensure that you can communicate effectively, members of each team should sit next to each other in the room. Please see the instructor if you have questions about this policy.