CS 134 Midterm
Spring 2013

This is a closed book exam. You have 75 minutes to complete the exam. There are 5 questions on this examination. The point values for the questions are shown in the table below. Your answers should fit in the space provided in the exam booklet. Paper for scrap work will be made available during the examination.

NAME: __________________________________________

LECTURE SECTION:      __ 09.00     __ 10.00

<table>
<thead>
<tr>
<th>Question</th>
<th>Points</th>
<th>Score</th>
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<tr>
<td>1</td>
<td>20</td>
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<td>TOTAL</td>
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I have neither given nor received aid on this examination.

Signature: ____________________________
Write Java code to implement the two methods described below. Your solutions should not use any built-in `String` methods that do substring replacement (i.e., `replace` and `replaceAll`). You may use other `String` methods including `indexOf`, `substring`, etc.

a) Define a method `removeLetter` that takes two parameters, `word` and `letter`, and returns the `String` obtained by removing one copy of `letter` from `word`. You may assume that `letter` is a `String` of length one. For example, `removeLetter("mississippi", "p")` would return "mississipi".

```java
private String removeLetter( String word, String letter ) {

}
b) Define a method `removeAllLetter` that takes two parameters, `word` and `letter`, and returns a `String` obtained by removing all copies of `letter` from `word`. You may assume that `letter` is a `String` of length 1. For example, `removeAllLetter("mississippi","s")` would return "miiippi". You may use the `removeLetter` method from part (a) in your definition of `removeAllLetter` even if you are not confident your `removeLetter` implementation is correct.

```java
private String removeAllLetter( String word, String letter ) {
```

**Question 2**

Consider the code shown below. Much of it should look quite a bit like code you wrote as part of this week’s lab.

```java
public class StringList {

    private boolean empty = true;

    private String first;
    private StringList others;

    public StringList() {
    }

    public StringList( String text, StringList existing ) {
        empty = false;
        first = text;
        others = existing;
    }

    public String toString() {
        if ( empty ) {
            return "";
        } else {
            return others.toString() + first + " ";
        }
    }

    public int R() {
        if ( empty ) {
            return 0;
        } else {
            return first.length() + others.R();
        }
    }

    public StringList T( String target ) {
        if ( empty ) {
            return new StringList();
        } else if ( first.startsWith( target ) ) {
            return others;
        } else {
            return new StringList( first, others.T( target ) );
        }
    }

    public StringList V() {
        if ( empty ) {
            return new StringList();
        } else {
            return new StringList( first, others );
        }
    }
}
```
Suppose that we have executed the assignment:

```java
StringList words = new StringList(  "greater", 
     new StringList( "than" , 
         new StringList( "all" , 
             new StringList( "the" , 
                 new StringList( "parts" , 
                     new StringList() 
                 ) 
             ) 
         ) 
     ) 
);
```

Indicate the String or int value that would be produced by each of the following expressions. If possible, also provide a brief description of what the first method invoked in each expression does in general to a StringList.

a) `words.toString()`

b) `words.R()`

c) `words.V().toString()`

d) `words.T( "all" ).toString()`
Question 3

Imagine that you would like to efficiently transmit the titles of songs and albums by the Irish folk rock band Clannad, such as

*Anam*

*An Gleann*

*Macalla*

(meaning *Soul, The Valley, and Echo*, respectively).

The table below shows the counts of the letters A, C, G, L, M, and N in the small sample of Clannad’s songs listed above.

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>G</th>
<th>M</th>
<th>L</th>
<th>N</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

One possible Huffman tree that can be derived from the table above is:

![Huffman Tree](image)

a. Show the binary sequence that would be used to encode the title “Macalla” using the tree above. (i.e. In the table below, fill in the correct binary code for each letter in the word.)

<table>
<thead>
<tr>
<th>M</th>
<th>A</th>
<th>C</th>
<th>A</th>
<th>L</th>
<th>L</th>
<th>A</th>
</tr>
</thead>
</table>

b. How many bits are needed to encode “Macalla”?
c. Note that the length of the longest codeword given by the tree on the previous page is 4. Derive another Huffman tree from the table of letter occurrences above, where the length of the longest codeword represented by the tree is 5.

d. Since there are 6 symbols in the alphabet we’re considering (A, C, G, L, M, and N), a fixed-length code would require that each symbol be represented by three bits. Is there a Huffman tree for the letters and occurrence counts above for which the longest codeword would be 3? If so, show the tree. If not, briefly explain why not.
**Question 4**

Suppose that computers A, B, C, and D are all connected to an Ethernet as shown below so that the length of the cables between any pair of computers is equal to \( L/2 \), where \( L \) is the maximum allowed length between any pair of computers on an Ethernet. Note that with this configuration, the distance between any pair of computers in the group A, B, and C is \( L \).

![Diagram of network connections](image)

a) Suppose that A becomes ready to send a packet while D is already transmitting. Approximately how much time will elapse between the point when C hears the last bit of D’s packet and the first bit of A’s?

b) Suppose that D becomes ready to send a packet while A is already transmitting. Approximately how much time will elapse between the point when C hears the last bit of A’s packet and the first bit of D’s?

c) Suppose that A, B and C all try to send packets containing 640 bytes (i.e., 5120 bits or 10 times the minimum packet size) at exactly the same time. All three computers will detect the collision simultaneously and then choose random delays according to the binary exponential backoff algorithm. Assume that after it delays, A is the first computer to successfully transmit and that no additional collisions have occurred. What random delay must each of the three computers involved have chosen given that A transmits successfully? Briefly explain your answer.
d) Now, assume that A actually had two packets to send, so that A, along with B and C, will try to transmit again as soon as A’s first transmission completes. This will lead to a second collision which all three computers will detect simultaneously. Again, all three computers will choose random delays. From what range of backoff values will each of the three computers choose? What is the probability that B is the first to transmit successfully during this second round of competition without further collisions? Explain briefly.

e) Suppose that A, B, and C each have many 640 byte packets to send so that the collision resolution process repeats many, many times. Assume that the network transmission rate is 10 megabits per second and that network monitoring shows that the network is operating at 90% efficiency and that the three computers are each able to send roughly equal numbers of packets. How many packets per second is A able to send? Don’t bother getting out your calculator for this question. A clear formula will be a better answer than an actual value.

f) Consider a network identical to that considered in (d) except that A, B, and C each have many 64 byte (i.e. 512 bit) packets to send. What value would you predict for the efficiency of this network based on the measured efficiency of the network described in part (e) and the formula from the paper by Metcalfe and Boggs shown below?

\[
\text{efficiency} = \frac{P/R}{WT + P/R} = \frac{1}{WT/(P/R) + 1}
\]

As usual, justify your answer.
Question 5

The program on the next page draws five buttons in a window. These buttons -- button1, button2, button3, button4, and button5 -- are labeled “CIRCUMFERENCE”, “EQUALS”, “PI”, “TIMES”, “DIAMETER”, respectively, as shown below. Pressing the buttons changes the labels of various buttons.

Suppose that the buttons named button1, button2, button3, button4, and button5 are clicked in sequence. Indicate the labels on each of the buttons after the buttonClicked method is invoked in response to each of the five clicks in this sequence.

i) After clicking button1

ii) After clicking button2

iii) After clicking button3

iv) After clicking button4
v) After clicking button5

```java
public class ExamButtons extends GUIManager {

    private JButton button1, button2, button3, button4, button5;

    public ExamButtons() {
        this.createWindow(600, 150);
        button1 = new JButton("CIRCUMFERENCE");
        button2 = new JButton("EQUALS");
        button3 = new JButton("PI");
        button4 = new JButton("TIMES");
        button5 = new JButton("DIAMETER");
        contentPane.add(button1);
        contentPane.add(button2);
        contentPane.add(button3);
        contentPane.add(button4);
        contentPane.add(button5);
    }

    public void buttonClicked( JButton which ) {
        button4.setText("PLUS");

        if (which == button1) {
            button3.setText("CAKE");
            button2.setText("EATS");
        }

        if (which == button2) {
            button1.setText("VOLUME");
        }

        if (which == button3) {
            button1.setText("AREA");
            if (button3.getText().equals("PI")) {
                button3.setText("ICE CREAM");
            }
        }

        if (which == button4) {
            if (button3.getText().equals("ICE CREAM")) {
                button2.setText("SLURPS");
            } else {
                button2.setText("EQUALS");
            }
        }

        if (which == button5) {
            button4.setText("TIMES");
        }
    }
}
```
if (button3.getText().equals("CAKE")) {
    button3.setText("PI");
}
} else if ( which == button2 ) {
    button5.setText("RADIUS^2");
}
}