CS61B, Fall 2013 **HW #7** **P. N. Hilfinger**

Due: Wed., 30 October 2013

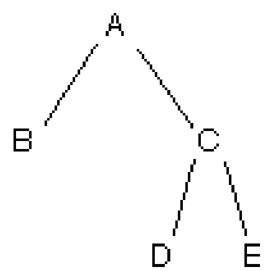
Homework Exercises. You'll find a skeleton for your answers in the `hw7` staff directory.

1. Consider an implementation of binary trees using a `BinaryTree` class with an inner `TreeNode` class, as shown below. The framework is available online in the skeleton file `hw7/BinaryTree.java`.

Fill in the blanks in the following code (part of `BinaryTree` to print a tree so as to see its structure. Empty trees (such as the children of leaf nodes) should print nothing.

```
/** Dump THIS, with indentation showing structure. */
public void print() {
  if (myRoot != null) {
    print (myRoot, 0);
  }
}

/** Dump ROOT indented by INDENT indentation units. */
void print(TreeNode<?> root, int indent) {

  // REPLACE THIS

  println(root.myItem, indent);

  // REPLACE THIS

}

/** Number of spaces in one indentation unit. */
static int INDENTATION = 4;

/** Print OBJ, indented by INDENT indentation units, followed by a
 *  newline. */
static private void println(Object obj, int indent) {
  for (int k = 0; k < indent * INDENTATION; k += 1)
    System.out.print(" ");
  System.out.println(obj);
}
```

The `print` method should print the tree in such a way that if you turned it 90 degrees clockwise, you see the tree. Here's an example:

<table><tr><th>Tree</th><th>Printed version</th></tr><tr><td>
</td><td><pre>
        E
    C
        D
A
    B
</pre></td></tr></table>

2. Compilers and interpreters convert string representations of structured data into tree data structures. For instance, they would contain a method that, given a `String` representation of an expression, returns a tree representing that expression:

```
/** The expression tree corresponding to S.  S is a legal, fully
 *  parenthesized expressions, contains no blanks, and involves
 *  only the operations + and *, and leaf labels (which can be
 *  any string of characters other than *, + and parentheses). */
public static BinaryTree<String> exprTree(String s) {
    BinaryTree<String> result = new BinaryTree<String>( );
    result.myRoot = result.exprTreeHelper(s);
    return result;
}
```

See the example on the next page.

Complete and test the following helper method for `exprTree`. You will find this in skeleton file `hw7/BinaryTree.java`.

```
private TreeNode<String> exprTreeHelper(String expr) {
    if (expr.charAt(0) != '(') {
        return null; // REPLACE WITH MISSING CODE
    } else {
        // expr is a parenthesized expression.
        // Strip off the beginning and ending parentheses,
        // find the main operator (an occurrence of + or * not nested
        // in parentheses), and construct the two subtrees.
        int nesting = 0;
        int opPos = 0;
        for (int k=1; k<expr.length()-1; k += 1) {
            // REPLACE WITH MISSING CODE
        }
        String opnd1 = expr.substring(1, opPos);
        String opnd2 = expr.substring(opPos+1, expr.length()-1);
        String op = expr.substring(opPos, opPos+1);
        return null; // REPLACE WITH MISSING CODE.
    }
}
```

Given the expression `((a+(5*(a+b)))+(6*5))`, your method should produce a tree that, when printed using the `print` method you just designed, would look like

```
        5
    *
        6
+
                b
            +
                a
        *
            5
    +
        a
```

3. Given a tree returned by the `exprTree` method, write and test a method named `optimize` that replaces all occurrences of an expression involving only integers with the computed value. Here's the header.

```
public static void optimize(BinaryTree<String> expr)
```

It will call a helper method as did `BinaryTree` methods in earlier exercises.

For example, given the tree produced for

```
((a+(5*(9+1)))+(6*5))
```

your `optimize` method should produce the tree corresponding to the expression

```
((a+50)+30)
```

Don't create any new `TreeNodes`; merely relink those already in the tree.

4. Assume that we have a heap that is stored with the largest element at the root. To print all elements of this heap that are greater than or equal to some key X, we *could* perform the `removeFirst` operation repeatedly until we get something less than X, but this would presumably take worst-case time Theta(k lg N), where N is the number of items in the heap and k is the number of items greater than or equal to X. Furthermore, of course, it changes the heap. Show how to perform this operation in $\Theta(k)$ time *without* modifying the heap. See the skeleton file `hw7/HeapStuff.java`.