

**Programming Assignment 2**  
Due Friday February 6, 10:00 pm

The goal of this project is to implement a *Dictionary* ADT based on a linked list data structure. The elements of the Dictionary will be pairs of Strings called *key* and *value* respectively. Keys will be distinct, whereas values may be repeated. Thus any two (*key*, *value*) pairs will have different keys, but may possibly have the same value. You can think of a key as being an account number, and a value as say an account balance, both represented by Strings.

Recall that an ADT consists of two things: (1) a collection of states, and (2) a collection of operations which act on states. In the Dictionary ADT a state is simply a set of (*key*, *value*) pairs. There are seven ADT operations which are to be implemented by the methods below.

```
public boolean isEmpty()
```

Returns true if the Dictionary contains no pairs and returns false otherwise.

```
public int size()
```

Returns the number of (*key*, *value*) pairs in the Dictionary.

```
public String lookup(String key)
```

If the Dictionary contains a pair whose key field matches the argument key, lookup returns the associated value field. If no such pair exists in the Dictionary a null reference is returned.

```
public void insert(String key, String value)
```

If the Dictionary does not currently contain a pair whose key matches the argument key, then the pair (*key*, *value*) is added to the Dictionary. If such a pair does exist, a `KeyCollisionException` will be thrown with the message: "cannot insert duplicate keys". Thus `insert()` has the precondition that the Dictionary does not currently contain the argument key. This precondition can be tested by the client module by doing `lookup(key)==null`.

```
public void delete(String key)
```

If the Dictionary currently contains a pair whose key field matches the argument key, then that pair is removed from the Dictionary. If no such pair exists, then a `KeyNotFoundException` is thrown with the message: "cannot delete non-existent key". Thus `delete()` has the precondition that the Dictionary currently contains the argument key. This precondition can be tested by the client module by doing `lookup(key)!=null`.

```
public void makeEmpty()
```

Resets the Dictionary to the empty state.

```
public String toString()
```

Returns a String representation of the current state of the Dictionary. Keys will be separated from values by a single space, and consecutive pairs will be separated by newline characters. The return String will be terminated by a newline character. Pairs will occur in the return String in the same order in which they were added to the Dictionary.

## Implementation of the Dictionary ADT

An interface file for the Dictionary ADT (`DictionaryInterface.java`) with prototypes for the above methods will be provided on the class webpage. The implementation file for the Dictionary ADT, which you will write, will be called `Dictionary.java`. In it you will define the Dictionary class and explicitly implement the interface, i.e. the class heading will be:

```
public class Dictionary implements DictionaryInterface
```

You will turn in the interface file with your project, but you are not to alter the contents of that file in any way (don't even put in the customary comment block with your name). In addition to the implementation file you will also write files `KeyCollisionException.java` and `KeyNotFoundException.java` which define the two types of exception classes to be thrown. Make both of these exceptions to be subclasses of `RuntimeException`, and follow the examples given in lecture and on the webpage.

Your implementation of the Dictionary ADT will utilize a linked list data structure. The linked list may be any of the variations discussed in class (e.g. singly linked with head reference, singly linked with both head and tail reference, circular, doubly linked, with or without dummy node(s), or any combination of the preceding types.) It is recommended that you take the linked list representation of the `IntegerList` ADT as a starting point for this project. Just rename that file (which can be copied from the website) and start making changes to it. In particular your `Node` class must be a private inner class to the `Dictionary` class. However, your `Node` class will no longer contain an `int` field since the data stored at each node will be a pair of `Strings`. You have two options on how to store pairs. You may let the `Dictionary` class contain another private inner class called `Pair` which encapsulates the two `Strings` with fields called `key` and `value` respectively. The second option is to define your `Node` class to contain two `String` fields in addition to its `Node` reference field(s). It is also recommended that your `Dictionary` class contain a private method with the following heading.

```
private Node findKey(String key)
```

This method should return a reference to the `Node` containing its argument `key`, or return `null` if no such `Node` exists. Such a method will be helpful in implementing the methods `insert()`, `delete()` and `lookup()`.

## Testing

Create another file called `DictionaryTest.java` whose purpose is to serve as a test client for the Dictionary ADT while it is under construction. This file will define the class `DictionaryTest`, which need not contain any more than a `main()` method (although you may add other static methods at your discretion.) The design philosophy here is that an ADT should be thoroughly tested in isolation before it is used in any application. Build your Dictionary ADT one method at a time, calling each operation from within `DictionaryTest.java` to wring out any bugs before going on to the next method. The idea is to add functionality to the Dictionary in small bits, compiling and testing as you go. This way you are never very far from having something which compiles, and errors that arise are likely to be confined to recently written code. You will submit the file `DictionaryTest.java` with this project. It is expected that it will change significantly during the testing phases of your project, but you need not include every bit of test code in the final version. Include enough to convince the grader that you did in fact test your ADT in isolation before proceeding.

Once you believe all ADT operations are working properly, copy the files `DictionaryClient.java` and `makefile` to your working directory (both provided on the webpage). At this point `%make` will create an

executable jar file in your working directory called `DictionaryClient`. This program will have the following output. (Recall that `%` here represents the Unix prompt.)

```
%DictionaryClient
1 a
2 b
3 c
4 d
5 e
6 f
7 g

key=1 value=a
key=3 value=c
key=7 value=g
key=8 not found

2 b
4 d
5 e
6 f

false
4
true

%
```

If your Dictionary ADT behaves according to specs, your output should look exactly as above. You can check this by doing `% DictionaryClient > out`, copy the file `model-out` from the webpage to your working directory, then do `% diff out model-out`. If `diff` gives no output, then the files are exactly the same, which is good. Note the unix operator `>` redirects program output to a file. In other words it associates the data stream `stdout` with the file on its right hand side, instead of the screen. Similarly the unix operator `<` associates the file on its right hand side with the data stream `stdin`, instead of the keyboard. See the man pages for a description of the `diff` command.

### What to turn in

You may alter the provided Makefile to include submit and test utilities, or alter it in any other way you see fit, as long as it creates an executable jar file called `DictionaryClient`, and includes a clean utility. Do not however alter the files `DictionaryInterface.java` or `DictionaryClient.java`. Submit the files:

```
README
Dictionary.java
DictionaryTest.java
KeyCollisionException.java
KeyNotFoundException.java
DictionaryInterface.java
DictionaryClient.java
makefile
```

to `/afs/cats.ucsc.edu/class/cms012b-pt.w09/pa2`. (Remember programming assignments go to `cms012b-pt.w09`, while lab assignments go to `cms012m-pt.w09`). As always, start early and ask plenty of questions.