# Lab 5

## Objectives

- More practice with linked data structures
- Introduction to recursion on a list

## Recursion overview

In this lab you will be completing the implementation of methods according to the documentation in IntegerLinkedList **recursively**.

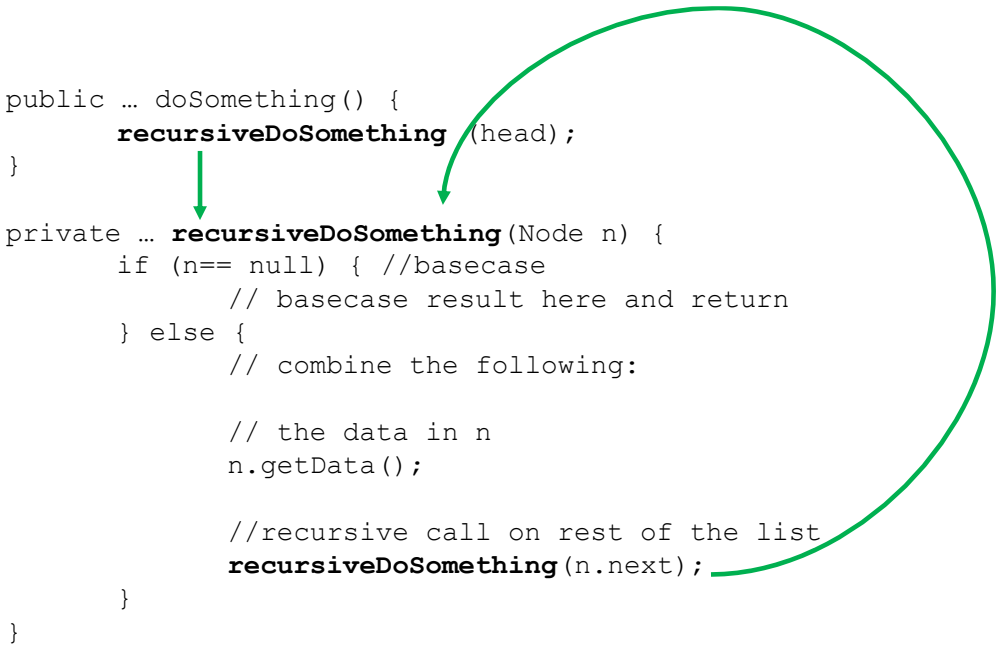
The following image shows a general template for designing a recursive function that traverses a list. The public method doSomething calls the private helper method recursiveDoSomething passing it the head (the first element in the list) as an initial Node.

The method recursiveDoSomething takes a Node as a parameter. This Node can be one of two things:

- null
- a Node with some data and a next pointer

These two case provide the basis for the if/else structure of this recursive function template:

- if (n is null) we are in the base case condition
  - implement the base case answer/result
- otherwise n is not null and we pull apart n into its two pieces
  - n's data (this is current piece of data – the method can do what it needs with it)
  - n's next (this is the REST of the list – we pass it to a call to recursiveDoSomething) This call will deal with the REST of the data in the list (all Nodes after n)



```
public … doSomething() {
        recursiveDoSomething (head);
}

private … recursiveDoSomething(Node n) {
        if (n== null) { //basecase
                // basecase result here and return
        } else {
                // combine the following:

                // the data in n
                n.getData();

                //recursive call on rest of the list
                recursiveDoSomething(n.next);
        }
}
```

*Exercises*

1. Download IntegerLinkedList.java Lab5Tester.java and IntegerNode.java to your Lab5 folder.,
2. Start by opening IntegerLinkedList.java
    a. Notice there a two methods that will add one to every element in the list. One is iterative(addOne) and the other is recursive (addOneRecursive).
    b. Take time to see the structure of the template shown on the previous page in the implementation of addOneRecursive
    c. Notice the tests in Lab5Tester.java test the empty list case and the case of a list at least 3 elements long.
3. In IntegerLinkedList.java test and implement the next two functions (one at a time) marked with //ToDo comments following the given documentation. To help you with the implementation, follow these steps:
    a. Create a public stub for the method
    b. In Lab5Tester.java write tests calling this method on an empty list and on a list that is at least 3 elements long (model after addOneRecursive tests)
    c. Write the template for the private recursive helper function (ie. addOneRecursiveHelper) and place a call to that helper function in the public stub method you created in Step a.
    d. Add code for your basecase answer/result
    e. Add code to deal with the current Node
    f. Run the tests you added to Lab5Tester.java

**CHECKPOINT (Ungraded)** – Now might be a good time to check-in with the TA if you are aren't comfortable in your understanding of how we are expecting you to implement the methods recursively. Remember, please don't hesitate to ask questions if you are unclear about anything.

Look at the implementation of the recursive Sum method. This method also has that general structure of the template shown on page 1, but it is returning a result after it traverses the list unlike the previous functions you just wrote (they made changes to each Node as they traversed the list).

Since the method returns a value of type int, the result of the call to the private helper function must be returned and the two cases of the helper function must return a result of the expected type.
In this example:

- When n is null (the empty list case) – the sum is 0, therefore the base case result statement is: return 0;
- When n is not null – the sum will be the value in the current Node + the result of the recursive call on the rest of the list, therefore the result statement is: return first + sumRest;

4. In IntegerLinkedList.java test and implement the next function marked with //ToDo comments following the given documentation. Use the process from Step 3 above to help.

Look at the implementation of the recursive doubleOddPosition method. This method also has that general structure of the template shown on Page 1, but it has an additional parameter. This additional parameter is called an accumulator which is used to keep track of and pass on context that would otherwise be lost in the recursive call. In this case, the accumulator (position) is keeping track of the position of the current Node within the whole list.
The position of the first element of the list is 0, the next element is at position 1, the next at position 2…

There are 4 steps to adding an accumulator to your recursive function:

- Add it to the parameter list in the private helper function:
  public void doubleOddPositionValues(IntegerNode n, **int position**);

- Give the accumulator an initial value in the call to the private helper method:
  doubleOddPositionValues(head, **0**);

- Exploit (use) the value of the accumulator as needed within the method:
  if (**position** % 2 ! = 0) {

- Pass the (likely updated) value of the accumulator as a parameter to the recursive call:
  doubleOddPositionValues(n.next, **position+1**);

5. In IntegerLinkedList.java test and implement the next two functions (one at a time) marked with //ToDo comments following the given documentation.
   **HINT:** Think about if you need an accumulator or not. Is there context that you need to know about from the previous steps of the recursion. One of these methods will need one!
   Again, use the process from Step 3 above to help and follow the steps given above to systematically add your accumulator.

**SUBMISSION (Graded)** – Submit the **IntegerLinkedList.java** file into the Lab 5 submission page on ConneX.