Recursion (part 1)

October 25, 2006

ComS 207: Programming I (in Java)
Iowa State University, FALL 2006
Instructor: Alexander Stoytchev

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Administrative announcements

- **The Final Exam is on Wednesday Dec 13 @ 2:15 – 4:15pm (room TBD)**
- **No class On Friday November 17 (That's the Friday before Thanksgiving Break)**

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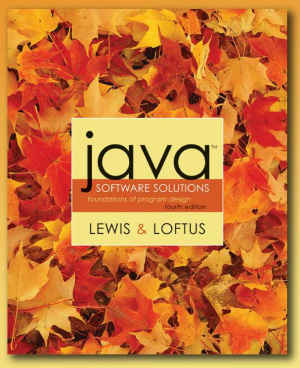
Chapter 11

Recursion



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Recursion

Recursion is a fundamental programming technique that can provide an elegant solution certain kinds of problems.

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Recursive Thinking

- **A *recursive definition* is one which uses the word or concept being defined in the definition itself**
- **When defining an English word, a recursive definition is often not helpful**
- **But in other situations, a recursive definition can be an appropriate way to express a concept**
- **Before applying recursion to programming, it is best to practice thinking recursively**

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Circular Definitions

- **Debugger – a tool that is used for debugging**

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Recursive Definitions

- Consider the following list of numbers:

```
24, 88, 40, 37
```

- Such a list can be defined as follows:

```
A LIST is a:  number
      or a:  number  comma  LIST
```

- That is, a LIST is defined to be a single number, or a number followed by a comma followed by a LIST
- The concept of a LIST is used to define itself

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Recursive Definitions

- The recursive part of the LIST definition is used several times, terminating with the non-recursive part:

```
number comma LIST
  24     ,   88, 40, 37

             number comma LIST
               88     ,   40, 37

                          number comma LIST
                            40     ,   37

                                       number
                                         37
```

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Infinite Recursion

- All recursive definitions have to have a non-recursive part
- If they didn't, there would be no way to terminate the recursive path
- Such a definition would cause *infinite recursion*
- This problem is similar to an infinite loop, but the non-terminating "loop" is part of the definition itself
- The non-recursive part is often called the *base case*

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Recursive Definitions

- N!, for any positive integer N, is defined to be the product of all integers between 1 and N inclusive
- This definition can be expressed recursively as:

```
1!  =  1
N!  =  N * (N-1)!
```

- A factorial is defined in terms of another factorial
- Eventually, the base case of 1! is reached

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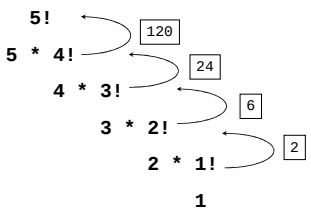
Recursive Definitions



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Example: Factorial_Iterative.java

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Example: Factorial_Recursive.java

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Recursive Programming

- A method in Java can invoke itself; if set up that way, it is called a *recursive method*
- The code of a recursive method must be structured to handle both the base case and the recursive case
- Each call to the method sets up a new execution environment, with new parameters and local variables
- As with any method call, when the method completes, control returns to the method that invoked it (which may be an earlier invocation of itself)

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Recursive Programming

- Consider the problem of computing the sum of all the numbers between 1 and any positive integer N
- This problem can be recursively defined as:

$$\sum_{i=1}^{N} i = N + \sum_{i=1}^{N-1} i$$

$$= N + N-1 + \sum_{i=1}^{N-2} i$$

$$= N + N-1 + N-2 + \sum_{i=1}^{N-3} i$$

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Recursive Programming

```
// This method returns the sum of 1 to num
public int sum (int num)
{
    int result;

    if (num == 1)
        result = 1;
    else
        result = num + sum (n-1);

    return result;
}
```

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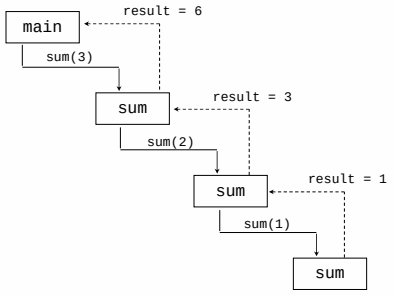
Recursive Programming



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Example: Sum_Iterative.java

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Example: Sum_Recursive.java

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Example: Fibonacci_Iterative.java

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Example: Fibonacci_Recursive.java

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THE END

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