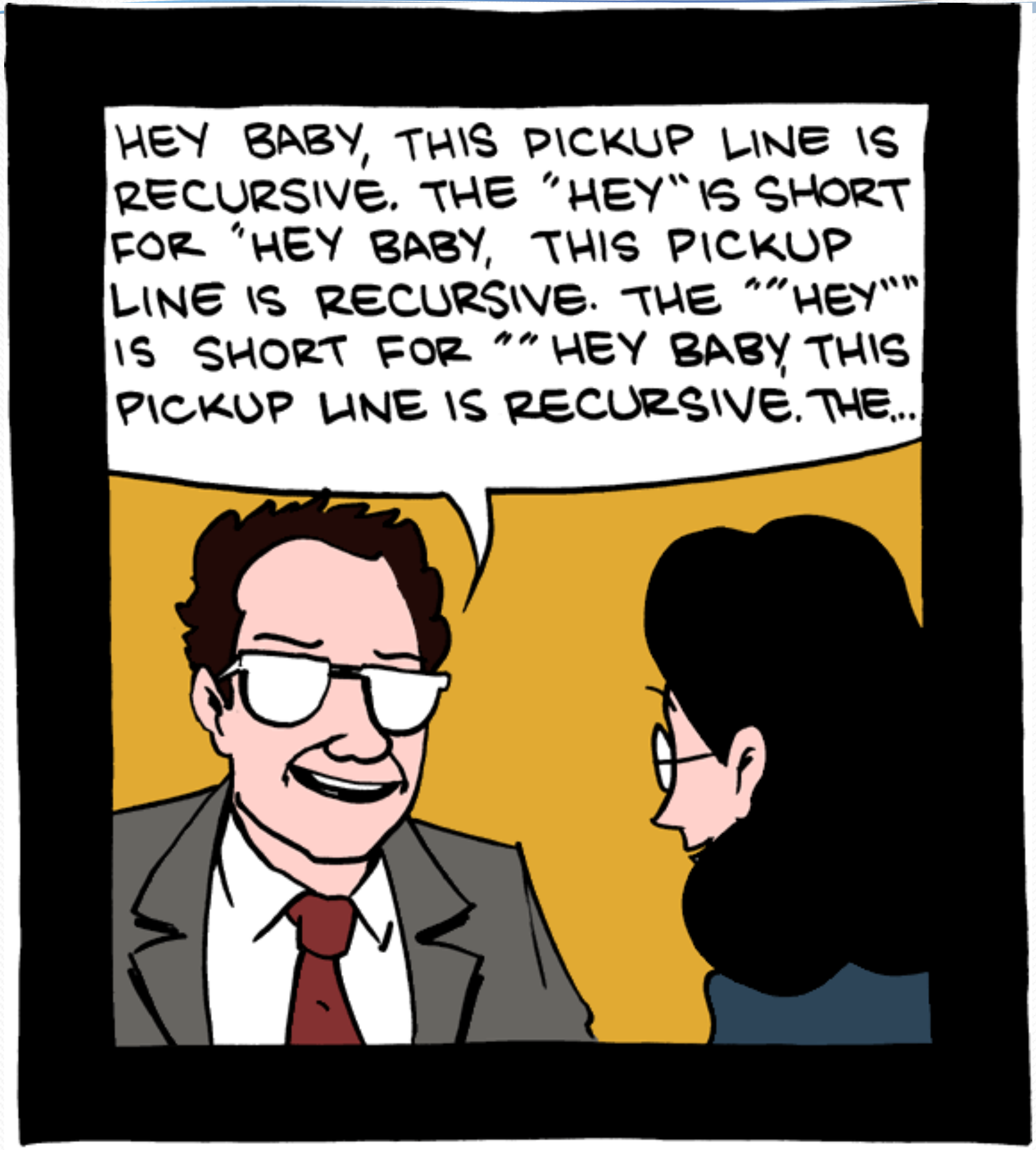
Building Java Programs

Chapter 12

Lecture 12-2: recursive programming

reading: 12.2 - 12.3


HEY BABY, THIS PICKUP LINE IS RECURSIVE. THE "HEY" IS SHORT FOR "HEY BABY, THIS PICKUP LINE IS RECURSIVE. THE ""HEY"" IS SHORT FOR ""HEY BABY, THIS PICKUP LINE IS RECURSIVE. THE...

Benoit Mandelbrot: Master of seduction.

Exercise

- Write a recursive method `pow` accepts an integer base and exponent and returns the base raised to that exponent.
  - Example: `pow(3, 4)` returns 81

  - Solve the problem recursively and without using loops.

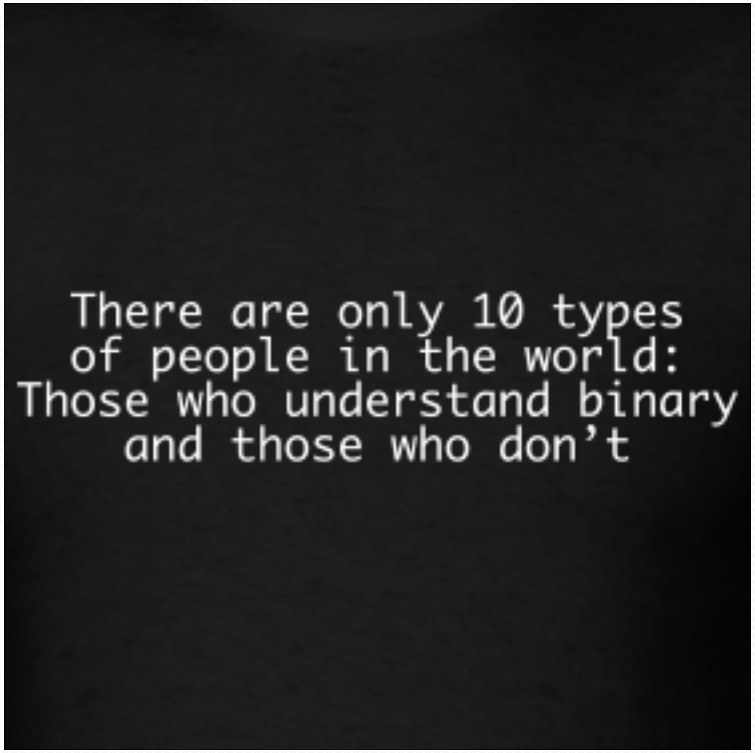
An optimization

- Notice the following mathematical property:

$$3^{12} = 531441 = 9^6$$
$$= (3^2)^6$$

$$531441 = (9^2)^3$$
$$= ((3^2)^2)^3$$

  - When does this "trick" work?
  - How can we incorporate this optimization into our `pow` method?
  - What is the benefit of this trick if the method already works?



There are only 10 types
of people in the world:
Those who understand binary
and those who don't

Exercise

- Write a recursive method `printBinary` that accepts an integer and prints that number's representation in binary (base 2).
  - Example: `printBinary(7)` prints 111
  - Example: `printBinary(12)` prints 1100
  - Example: `printBinary(42)` prints 101010

place	10	1
value	**4**	**2**

32	16	8	4	2	1
1	**0**	**1**	**0**	**1**	**0**

  - Write the method recursively and without using any loops.

Stutter

- How did we break the number apart?

```
public static int stutter(int n) {
    if (n < 10) {
        return (10 * n) + n;
    } else {
        int a = mystery(n / 10);
        int b = mystery(n % 10);
        return (100 * a) + b;
    }
}
```

Case analysis

- Recursion is about solving a small piece of a large problem.
  - What is 69743 in binary?
    - Do we know *anything* about its representation in binary?
  - Case analysis:
    - What is/are easy numbers to print in binary?
    - Can we express a larger number in terms of a smaller number(s)?

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printBinary solution

```
// Prints the given integer's binary representation.
// Precondition: n >= 0
public static void printBinary(int n) {
    if (n < 2) {
        // base case; same as base 10
        System.out.println(n);
    } else {
        // recursive case; break number apart
        printBinary(n / 2);
        printBinary(n % 2);
    }
}
```

- Can we eliminate the precondition and deal with negatives?

Exercise

- Write a recursive method `isPalindrome` accepts a `String` and returns `true` if it reads the same forwards as backwards.
  - `isPalindrome("madam")` → `true`
  - `isPalindrome("racecar")` → `true`
  - `isPalindrome("step on no pets")` → `true`
  - `isPalindrome("able was I ere I saw elba")` → `true`
  - `isPalindrome("Java")` → `false`
  - `isPalindrome("rotater")` → `false`
  - `isPalindrome("byebye")` → `false`
  - `isPalindrome("notion")` → `false`

Exercise solution

```
// Returns true if the given string reads the same
// forwards as backwards.
// Trivially true for empty or 1-letter strings.
public static boolean isPalindrome(String s) {
    if (s.length() < 2) {
        return true;   // base case
    } else {
        char first = s.charAt(0);
        char last  = s.charAt(s.length() - 1);
        if (first != last) {
            return false;
        }              // recursive case
        String middle = s.substring(1, s.length() -
  1);
        return isPalindrome(middle);
    }
}
```

Exercise solution 2

```
// Returns true if the given string reads the same
// forwards as backwards.
// Trivially true for empty or 1-letter strings.
public static boolean isPalindrome(String s) {
    if (s.length() < 2) {
        return true;   // base case
    } else {
        return s.charAt(0) == s.charAt(s.length() - 1)
            && isPalindrome(s.substring(1, s.length() -
  1));
    }
}
```

Exercise

- Write a method `crawl` accepts a `File` parameter and prints information about that file.
  - If the `File` object represents a normal file, just print its name.
  - If the `File` object represents a directory, print its name and information about every file/directory inside it, indented.

```
cse143
    handouts
        syllabus.doc
        lecture_schedule.xls
    homework
        1-sortedintlist
            ArrayIntList.java
            SortedIntList.java
            index.html
            style.css
```

  - **recursive data**: A directory can contain other directories.

File objects

- A File object (from the java.io package) represents a file or directory on the disk.

Constructor/method	**Description**
File(**String**)	creates File object representing file with given name
canRead()	returns whether file is able to be read
delete()	removes file from disk
exists()	whether this file exists on disk
getName()	returns file's name
isDirectory()	returns whether this object represents a directory
length()	returns number of bytes in file
listFiles()	returns a File[] representing files in this directory
renameTo(**File**)	changes name of file

Public/private pairs

- We cannot vary the indentation without an extra parameter:

```
public static void crawl(File f, String indent) {
```

- Often the parameters we need for our recursion do not match those the client will want to pass.

In these cases, we instead write a pair of methods:

1) a public, non-recursive one with the parameters the client wants

2) a private, recursive one with the parameters we really need

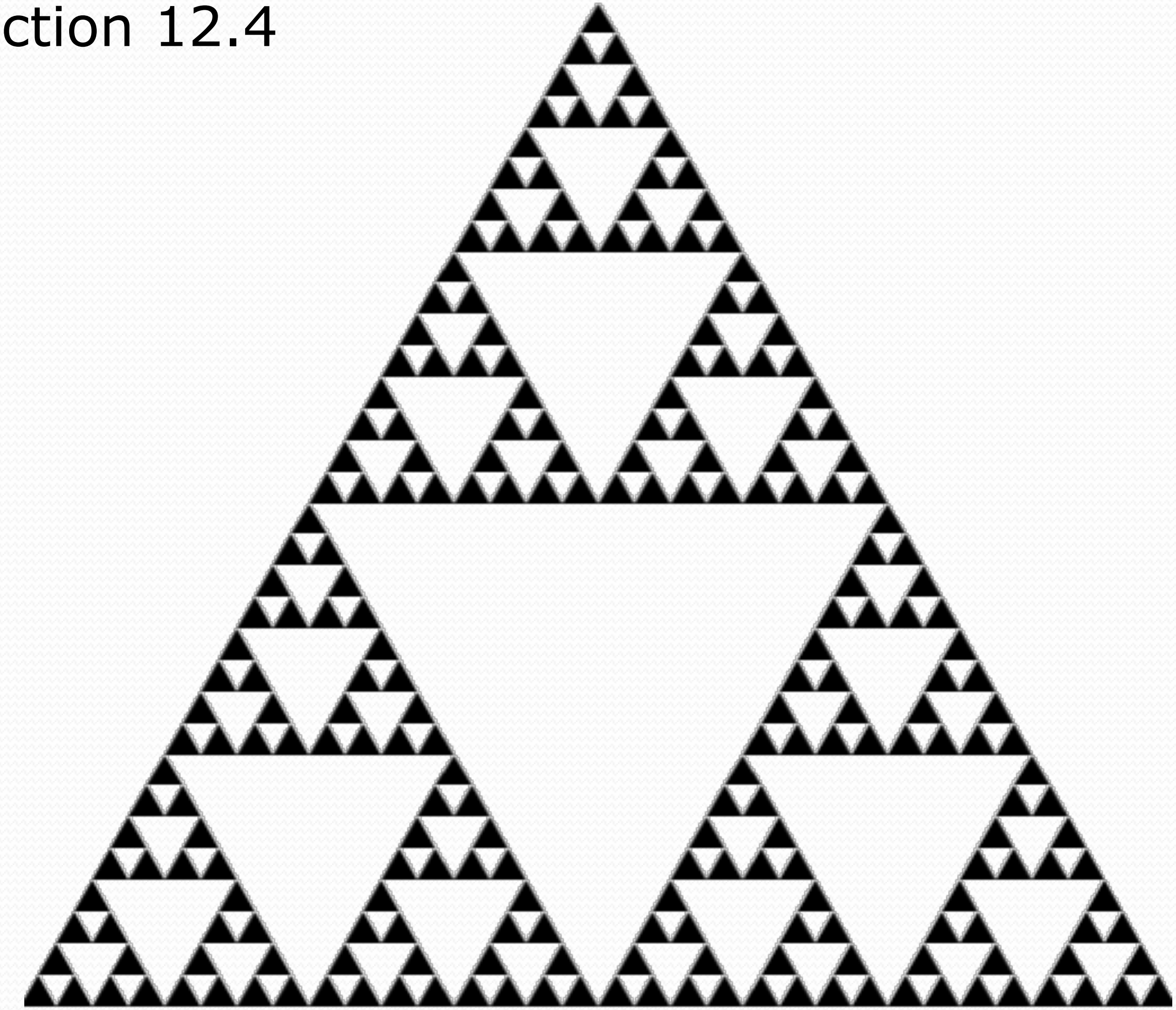
Exercise solution 2

```
// Prints information about this file,
// and (if it is a directory) any files inside it.
public static void crawl(File f) {
    crawl(f, "");   // call private recursive helper
}

// Recursive helper to implement crawl/indent
  behavior.
private static void crawl(File f, String indent) {
    System.out.println(indent + f.getName());
    if (f.isDirectory()) {
        // recursive case; print contained files/dirs
        for (File subFile : f.listFiles()) {
            crawl(subFile, indent + "    ");
        }
    }
}
```

Recursive Graphics

- See section 12.4



Recursion Challenges

- Forgetting a base case
  - Infinite recursion resulting in `StackOverflowError`

- Working away from the base case
  - The recursive case must make progress towards the base case
  - Infinite recursion resulting in `StackOverflowError`

- Running out of memory
  - Even when making progress to the base case, some inputs may require too many recursive calls: `StackOverflowError`

- Recomputing the same subproblem over and over again
  - Refining the algorithm could save significant time