Introduction to Recursion

Colorado State University

Department of Computer Science

Slides Originally Created by Albert Lionelle (Albert.Lionelle@colostate.edu),
updated by Marcia Moraes (marcia.moraes@colostate.edu)

Announcements

TODO Reminders:

Readings are due **before** lecture

- Reading 23 (zybooks) – you should have already done that ☺
- Lab 15
- Reading 24 (zyBooks)
- Lab 16
- Practical Project Lecture
- RPA 11

Keep practicing your RPAs in a spaced and mixed manner ☺

NEXT WEEK – Exam 3 Week
Catch up, if you need!

https://www.facebook.com/corpnet/posts/it-doesnt-matter-what-others-are-doing-it-matters-what-you-are-doing/10161039565148812/

Help Desk

Day	Time : Room
Monday	12 PM - 2 PM : CSB 120
Tuesday	6 PM - 8 PM : Teams
Wednesday	3 PM - 5 PM : CSB 120
Thursday	6 PM - 8 PM : Teams
Friday	3 PM - 5 PM : CSB 120
Saturday	12 PM - 4 PM : Teams
Sunday	12 PM - 4 PM : Teams

Recursion

- Simple recursion is a loop
  - A **method** that calls itself!
- How to write it?
  1. Write a base case! (condition!!)
  2. Write method that calls itself
- Starting with Factorial example
  1. Let's take a look at an interactive solution (loop)

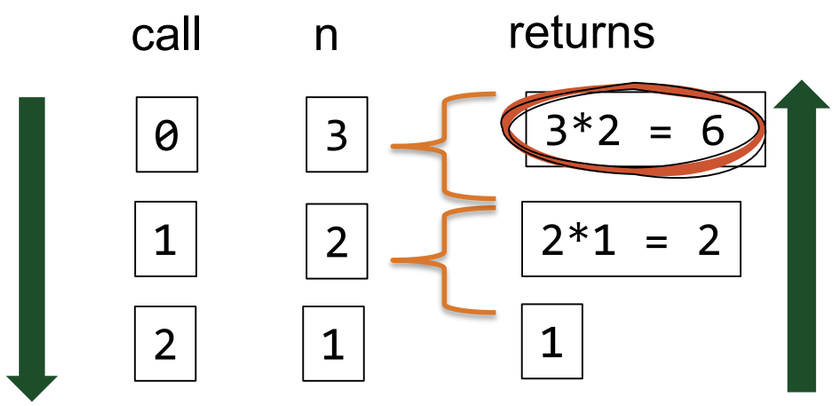
```
public static long factorialLoop (int n){
   long fact = 1;
   for(int i = n; i > 1; i--)
       fact *= i;
   return fact;
}
```

- Building our first recursion method
  - Factorial
  - 0! = 1
  - 1! = 1
  - $n!=n\times(n-1)\times(n-2)\times\ldots\times2\times1$
- How do you go about creating a recursive solution?
  1. What is the base case? `if (n == 1 || n == 0) return 1;`
  2. How we build the recursive call? `return n * factorial(n-1);`

```
public static long factorial (int n){
    if(n == 1 || n == 0) return 1;
    return n * factorial(n-1);
}
```

Recursion Factorial Walk Through

```
public class Recursion {
   public static long factorial(int n){
      if(n == 1 || n == 0 ) return 1;
      return n * factorial(n-1);
   }
   public static void main(String args[]){
      System.out.println("Factorial of 3: " + factorial(3));
   }
}
```



Another way to look at this:

```
factorial(3)
   factorial(2)
      factorial(1)
         return 1
      return 2*1 = 2
   return 3*2 = 6
```

Recursion – String Reverse

- Let's start with a String reverse method that uses a loop solution to return a reversed String

```
public static String reverseLoop (String str){
   String reversed = "";
   for(int i = str.length(); i > -1; i--)
       reversed += str.charAt(i);
   return reversed;
}
```

- How to write a recursive version of it?
  1. Write a base case `if (index < 0) return "";`
  2. Write method that calls itself

```
return str.charAt(index) + reverseString(str, index-1)
```

```
public static String reverseString(String str) {
   return reverseString(str, str.length()-1);
}

public static String reverseString(String str, int index) {
   if(index < 0) return "";        <-- Base Case
   return str.charAt(index) + reverseString(str, index-1);
}                                      ^-- Recursive Call

public static void main(String[] args) {
   System.out.println(reverseString("arepO eht fo motnahP"));
}
```

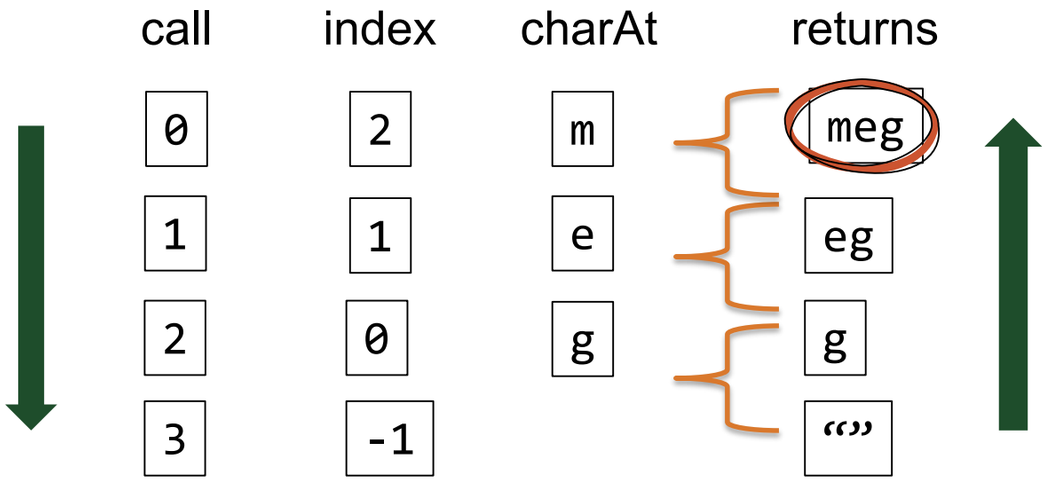
Phantom of the Opera

Reverse String Walk Through

```
public static String reverseString(String str) {
    return reverseString(str, str.length()-1);
}

public static String reverseString(String str, int index) {
    if(index < 0) return "";
    return str.charAt(index) + reverseString(str, index-1);
}

public static void main(String[] args) {
    System.out.println(reverseString("gem"));
}
```



Recursion – Group Practice

- Consider the method presented below:

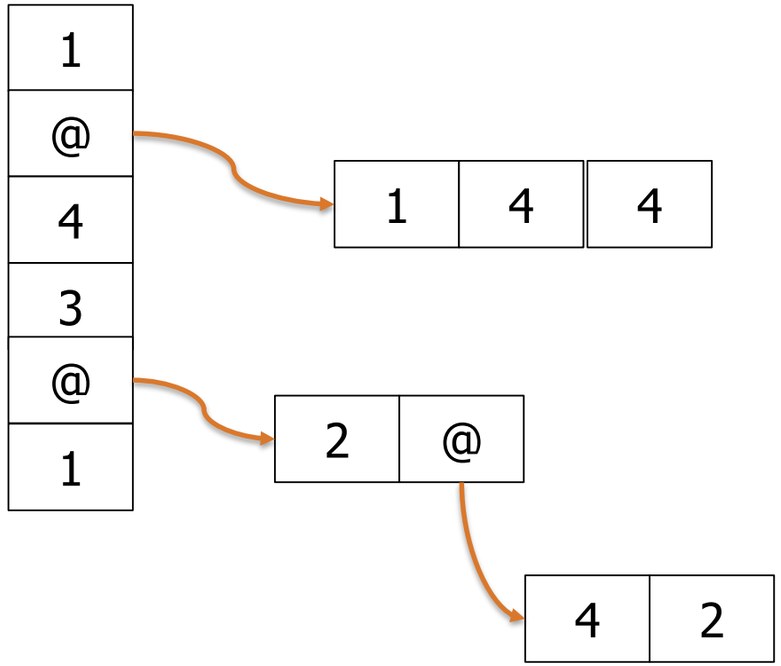
```
public static int sum (int [] array){
   int s = 0;
   for(int i = 0; i < array.length; i++)
       s += array[i];
   return s;
}
```

- How to write a recursive version of it?
  1. Write a base case
  2. Write method that calls itself

  3. Tip – you can change the number of parameters

Real Example and Sneak Peak Into Inheritance

- Assume you have the following data structure
  - An array of values, but some values can be other arrays!
- How do you represent all the different values?
- **Inheritance (and Polymorphism)**
  - All Objects "inherit" from the class Object
    - Gains properties of Object
    - Which means you can store all objects as Objects
    - But you need to 'cast' back to do something useful
- Now – the Real Example
  - How can I sum all the values across the structure to the right?
    - Would a loop work?
      - Why or why not?
- Solution - **Recursion**!



Sneak Peak Solution

```
public class RecursionExample {

    public static int sum(Object[] values) {
        return sum(values, 0); // overload, for easier initial call
    }
    public static int sum(Object[] values, int current) {
        if(current >= values.length) return 0; // past end of array, return 0
        if(values[current] instanceof Object[]) // another array!
            return sum((Object[])values[current], 0) + sum(values, current+1);
        return (Integer)values[current] + sum(values, current+1); // number plus something
    }
    public static void main(String[] args) {
        Object[] values = new Object[]{1, 2, 3,
            new Object[]{4, 5, new Object[]{1,1}},
            10, new Integer[]{2,2}, 1, 10};
        System.out.println(sum(values));
    }
}
```

Add values for the answer…

Worksheet

- Work on your worksheet.

- Turn in to the TAs or myself, this will be your attendance for today's class.