CS112 Lab 01, Jan 21, 24 2010

http://cs-people.bu.edu/deht/cs112_spring11/lab01/

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Preliminaries

- I want to help you.
  - Please put “CS112” in the subject line when you email
- Don’t get stuck!
  - Technical details (development environment, compiler errors) can be as much work as the actual task at hand
- Don’t procrastinate.
  - Even professionals can get stuck on little things. Give yourself enough time to finish.
- Don’t get behind.
  - You will need to understand previous material in order to go forward

Recursion

- Define the solution to a big problem in terms of the solution to a similar, slightly smaller problem

- You know how to functionally decompose a "normal" problem using functions

```
Boolean solveProblem(parameter x){
    int result = Step1(x);
    return Step2(result);
 }
```

A Cartoon Recursive Function

```
int recursiveProblem(int x)
{
    If(x == 1) return 1;
    return recursiveProblem(x-1) + 1;
}
```

A Cartoon Recursive Function

- Recursive solutions have two important parts:
  - Base Case (what to do with trivial inputs)
  - Recursive Call (how to solve the problem)

```
int recursiveProblem(int x)
{
 If(x == 1) return 1;   //base case
 return recursiveProblem(x-1) + 1; //recursive call
}
```

A Classic Recursive Problem

- Fibonacci numbers (you've seen this on the SAT!)
- Each number in the sequence is the sum of the previous two numbers

```
int Fibonacci(int x)
{
 if(x == 0) return 0;
 If(x == 1) return 1;
 return Fibonacci(x-1) + Fibonacci(x-2);
}
```

Recursive functions and Stack frames

- Every time you call any function, the local variables, arguments, etc. are saved, before jumping to the next function.
- When a function returns, the caller's state is restored before continuing execution
- The place where this information is saved is called "the stack" or "the call stack."
- Practical Upshot: Each call to a function has its own copy of its arguments and local variables (a.k.a. a stack frame)

Normal functions and Stack frames

```
Void doWork(int x)
{
        int y=5;
        int z = StepOne(x,y);
}
int StepOne(int x, int y)
{
      int q = StepTwo(x*y, x)
      return q;
}
int StepTwo(int q, in r)
{
      int x = q/r;
      return x;
}
```

What happens when you call doWork(2)?

Normal functions and Stack frames

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Void doWork(int x)
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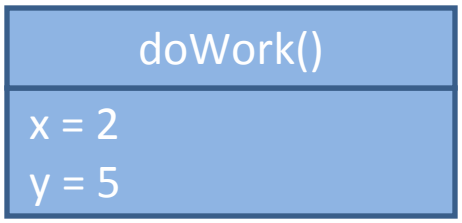

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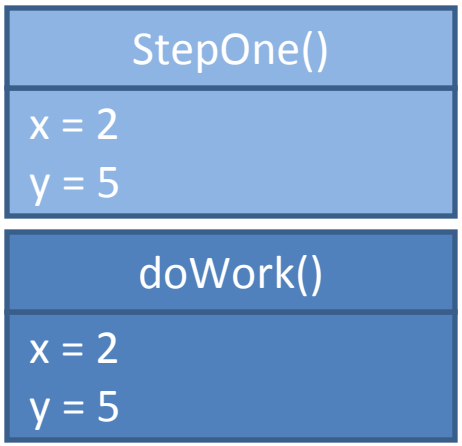

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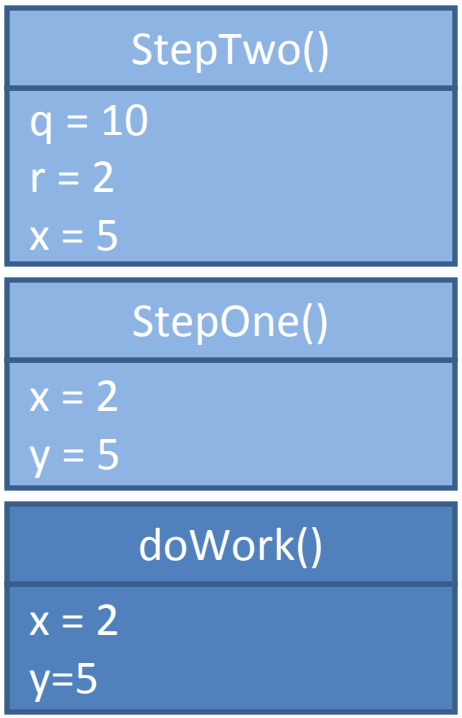

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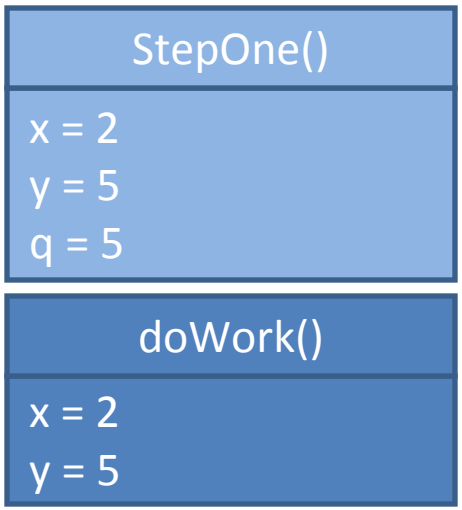

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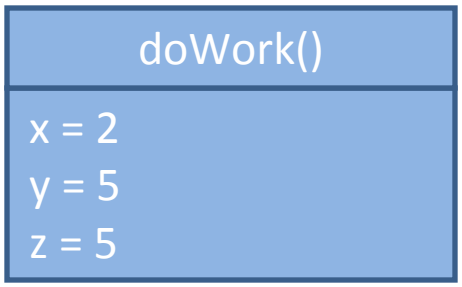

Recursive functions and Stack frames

```
Void doWork(int x)
{
      int z = recursive(x)
}
int recursive(int x)
{
     int y;
     if(x == 1)
       y = 5;
     else
       y = recursive(x-1)+1;
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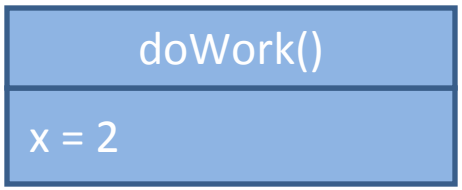

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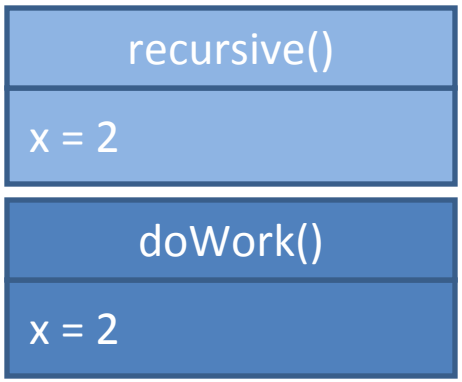

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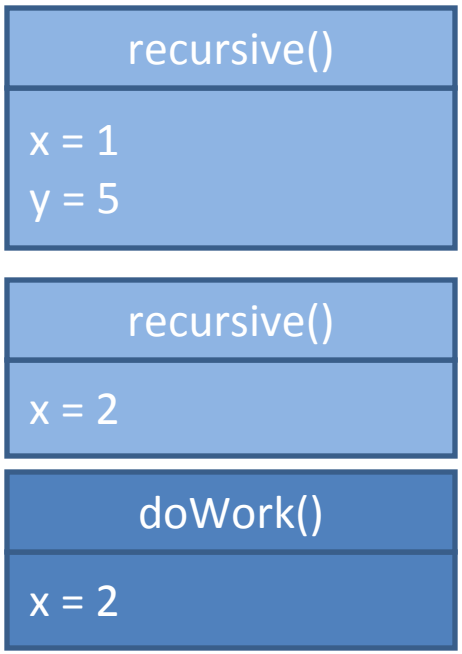

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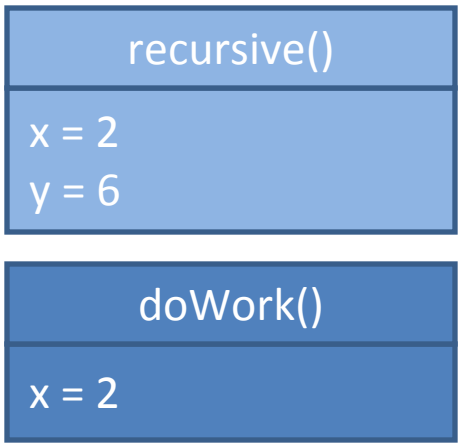

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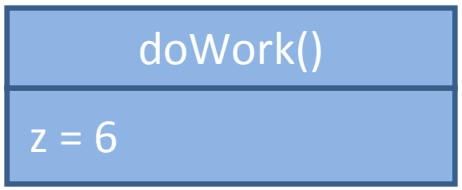

How to Think about Recursive Functions

- Use wishful thinking:

  "If only I knew the answer to _____, solving this problem would be easy."

  - Understand which variables are changing, and which are constant
  - Think about the easiest version(s) of your problem (define your base case)
  - Run your program in your head (or on paper) using some simple, but not trivial inputs

Practical Lab: Implementing Exponentiation

- Write a function to recursively compute the function $f(x,n) = x^n$
- Compare your results with the built-in java function Math.pow(x,n);
- This can be implemented by repeated squaring: $f(x,n) = x^{n/2} * x^{n/2}$
  - Assume that *n* is an integer
  - What do you need to do if *n* is odd?

Practical Lab:
Counting the number of recursive calls

- Add features to your exponentiation function to count the number of recursive calls.
- How can you improve your efficiency by caching your results?
- Count the number of recursive calls with and without your optimization

Things you will need for HW1

- Derivative of a polynomial function:
  - $F(x) = x^n + c \rightarrow F'(x) = n * x^{n-1}$
- Java exponentiation function:
  - Math.pow(x,n); // x^n
- Declaring an array in Java
  - int [] intArray = new int[10];
- Input and output
  - (Google “standard out” and “standard in”)
  - System.out.println(…)
  - BufferedReader in = **new** BufferedReader(**new** InputStrea mReader(System.in));