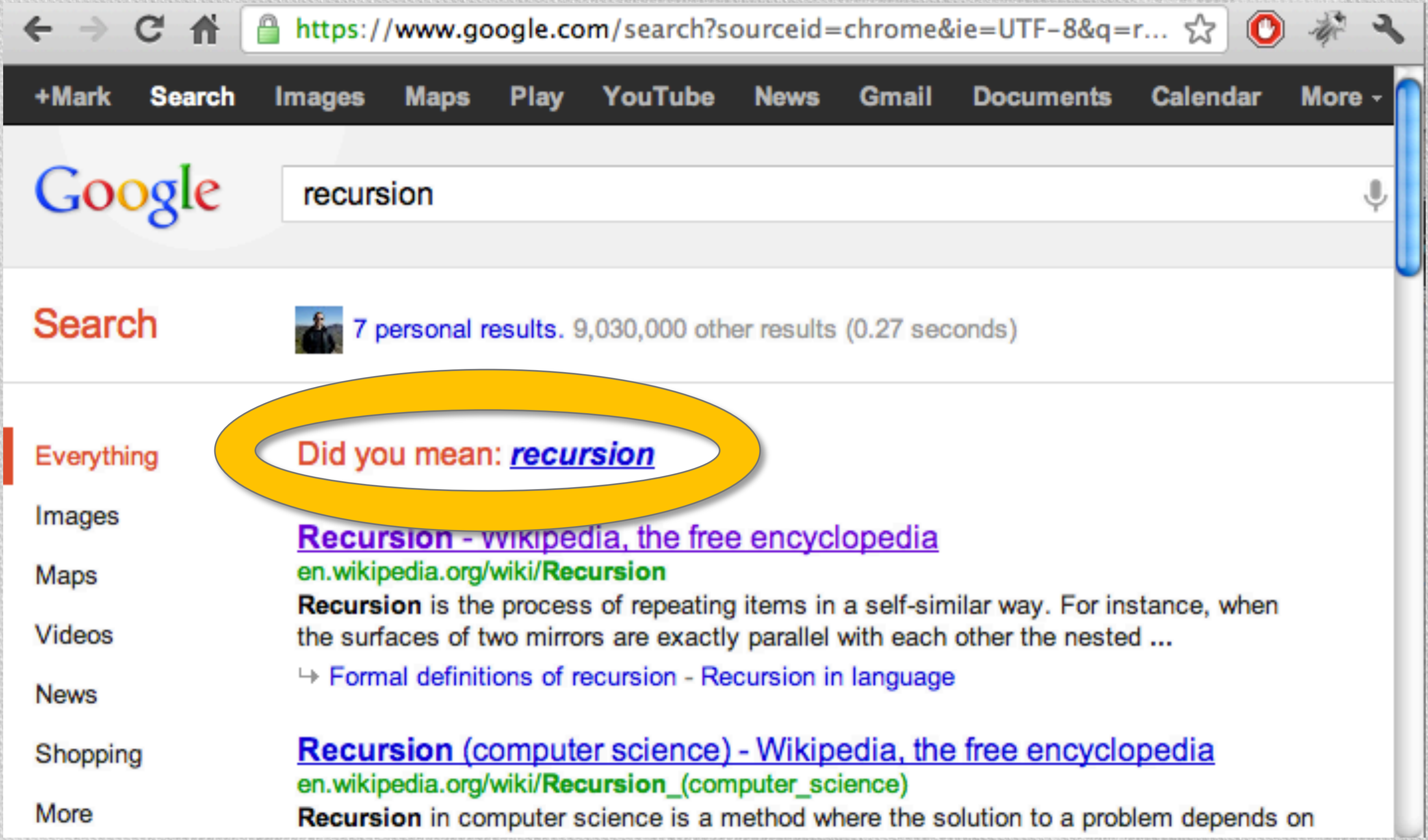
CS 211

RECURSION

Recursion



7 personal results. 9,030,000 other results (0.27 seconds)

Did you mean: ***recursion***

Recursion - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/**Recursion**
Recursion is the process of repeating items in a self-similar way. For instance, when the surfaces of two mirrors are exactly parallel with each other the nested ...
↳ Formal definitions of recursion - Recursion in language

Recursion (computer science) - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/**Recursion**_(computer_science)
Recursion in computer science is a method where the solution to a problem depends on

What is **Recursion**?

- Recursion generally means that something is defined in terms of itself.

→ functions/methods can be recursive

    → if it calls itself

→ data can be recursive

    → if a class "has-a" field of its own type

Method Recursion

- We can call a method inside its own body.
- The **recursive call** should logically solve a "smaller" problem
- We must have some way to stop, called a **base case**. (It should be checked *before* the recursive call!)
  → otherwise, it's just like an infinite loop!

Example: Factorial

- In mathematics, the factorial n! is defined as $n!=n*(n-1)*\ldots*2*1$. It is defined for all non-negative numbers, and $0! = 1$. Examples:

$5! = 5*4*3*2*1$ **$100! = 100*99*98*\ldots*3*2*1$**

$3! = 3*2*1$ **$1! = 1$** **$0! = 1$**

- The **Base Case** is when n=0: we immediately know the answer. No recursion is necessary.
- The **Recursive Case** is when n>0: we know that whatever value n has, (n-1) will be one step closer to the base case of n=0.
  → assume the method is already correct; phrase $n! = n*(n-1)!$
  → call our method on (n-1), and multiply it by n.
  → let the recursive call do the rest!

Example: Factorial

```
public static int factorial (int n) {


        //base case, no recursion
        if (n==0) {   return 1;   }

        //recursive case: n! = n*(n-1)!
        else {
                int nfact = n *  factorial(n-1);
                return nfact;
  }
}
```

Recursive Calls: Details

- When a method calls itself, each call is distinct (separate)
  → each separate call has its ***own copy of local data***
  → for `factorial`, each call has its own value for parameter `n`.

Base Case Reached! Non-recursive call can complete.

factorial (0)	0! == 1
factorial (1)	1! == 1*0! == 1
factorial (2)	2! == 2*1! == 2
factorial (3)	3! == 3*2! == 6

Recursion Recipe

- To use recursion, you might want to follow this pattern:

1. Identify the base cases: times when you already know the answer
2. Identify the recursive cases: times when you can define one step of the solution in terms of others
   - Is the recursive step using the method on a "smaller" problem? (needs to be yes!)

3. Write code for the base case *first*
4. Write code for the recursive case *second*

→ handle any error conditions like base cases: e.g., factorial shouldn't be called on negative numbers, so choose how to exit meaningfully.

Recursion Example: Fibonacci

- The fibonacci sequence looks like:

  1, 1, 2, 3, 5, 8, 13, …

  → Its first two elements are each 1.

  → the nth element is the sum of the previous two elements.

- We can number them like array slots:

  fib(0)==1, fib(6)==13, etc.

Practice Problems

Implement the fibonacci method, which accepts the 'index' number `n`, and then returns that fibonacci number.

Questions (suggested solution path):

- What are the base cases?
- What are the recursive cases?
- What are some good test cases?

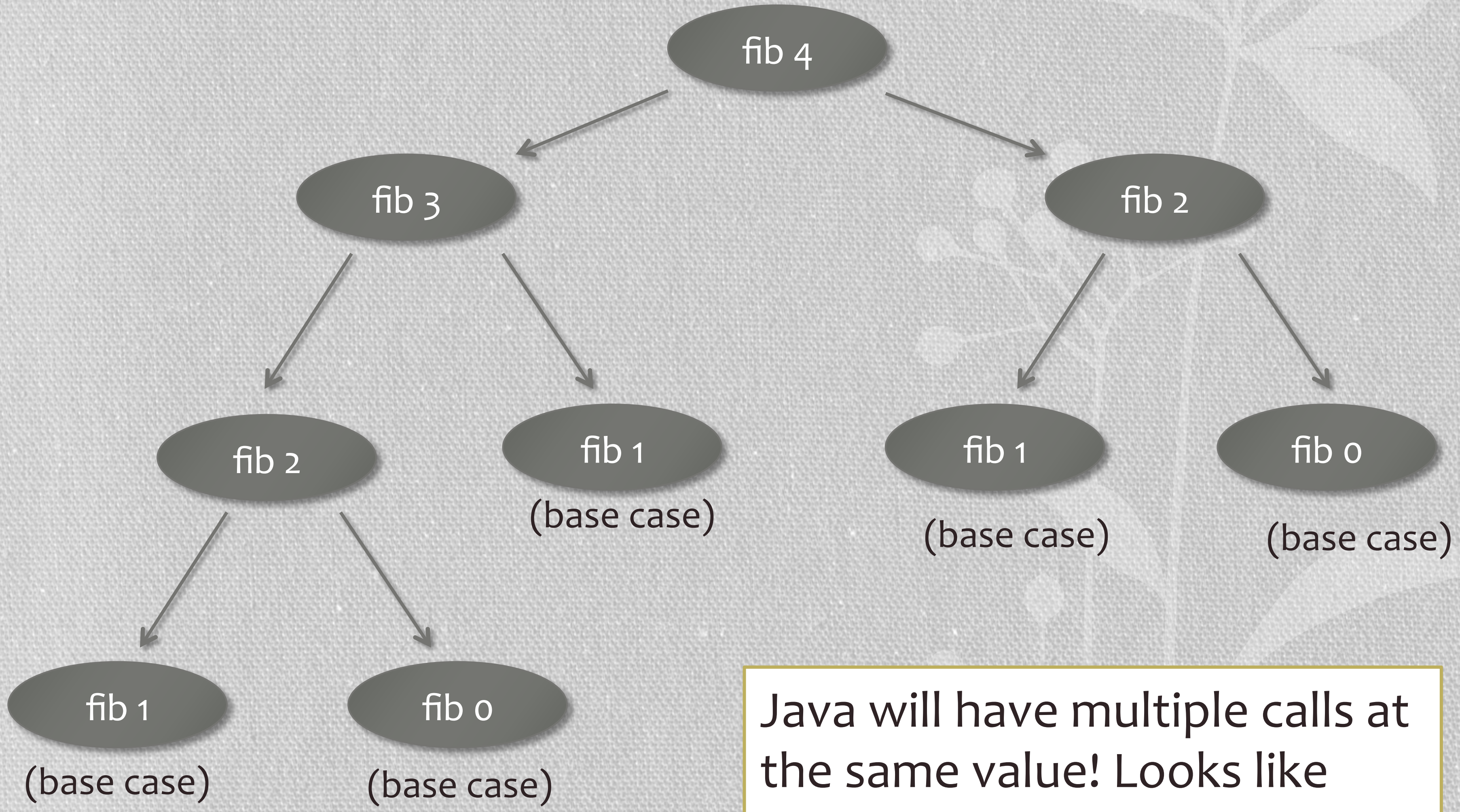
Fibonacci Code

```
public static int fib (int n) {

        // base cases
        if (n==1 || n==0) {  return 1;  }

        //recursive case
        else {
                return  fib(n-1) + fib(n-2) ;
        }
}
```

Visualizing Fibonacci Calls



Java will have multiple calls at the same value! Looks like wasted effort…

Iterative Version of Fibonacci

```
public static int fibIter (int n) {
        //base cases
        if (n==1 || n==0) { return 1; }

        //iterative cases
        int lower = 1;
        int higher = 1;
        for (int i = 2; i <=n; i++ ) {
            int temp = lower+higher;
            lower = higher;
            higher = temp;
        }
        return higher;
}
```

Considering Recursion

Recursion: **Pros**

- Sometimes much easier to reason about
- distinct method calls help separate concerns (separate our local data per call).
- Easy to maintain separate state (values) each recursive call

Recursion: **Cons**

- Sometimes, lots of work is duplicated (leading to quite long running time)
- Overhead of a method call is more than overhead of another loop iteration

Considering Iteration

Iteration: **Pros**

- quick, barebones.
- Simpler control flow (we perhaps see how iterations will follow each other easier than with recursion)
- no stack overflow errors

Iteration: **Cons**

- some tasks do not lend well to iterative definitions (especially ones with lots of bookkeeping/state)
- We tend to be given mathematical, "recursive" definitions to problems, and then have to translate to an iterative version.

Recursion versus Iteration

So, which one is better?

→ it depends on the situation.

- When might we prefer recursion?
- When might we prefer iteration?

Practice Problems

What are some cases that might merit recursion?

Thinking experiment: How can you use recursion to...
→ check if a number is even?
→ find the log of a number? (return an int)
→ solve a maze?
→ solve a sudoku?

Practice Problems

- How, in general, might we try to convert a loop to a recursive method call?

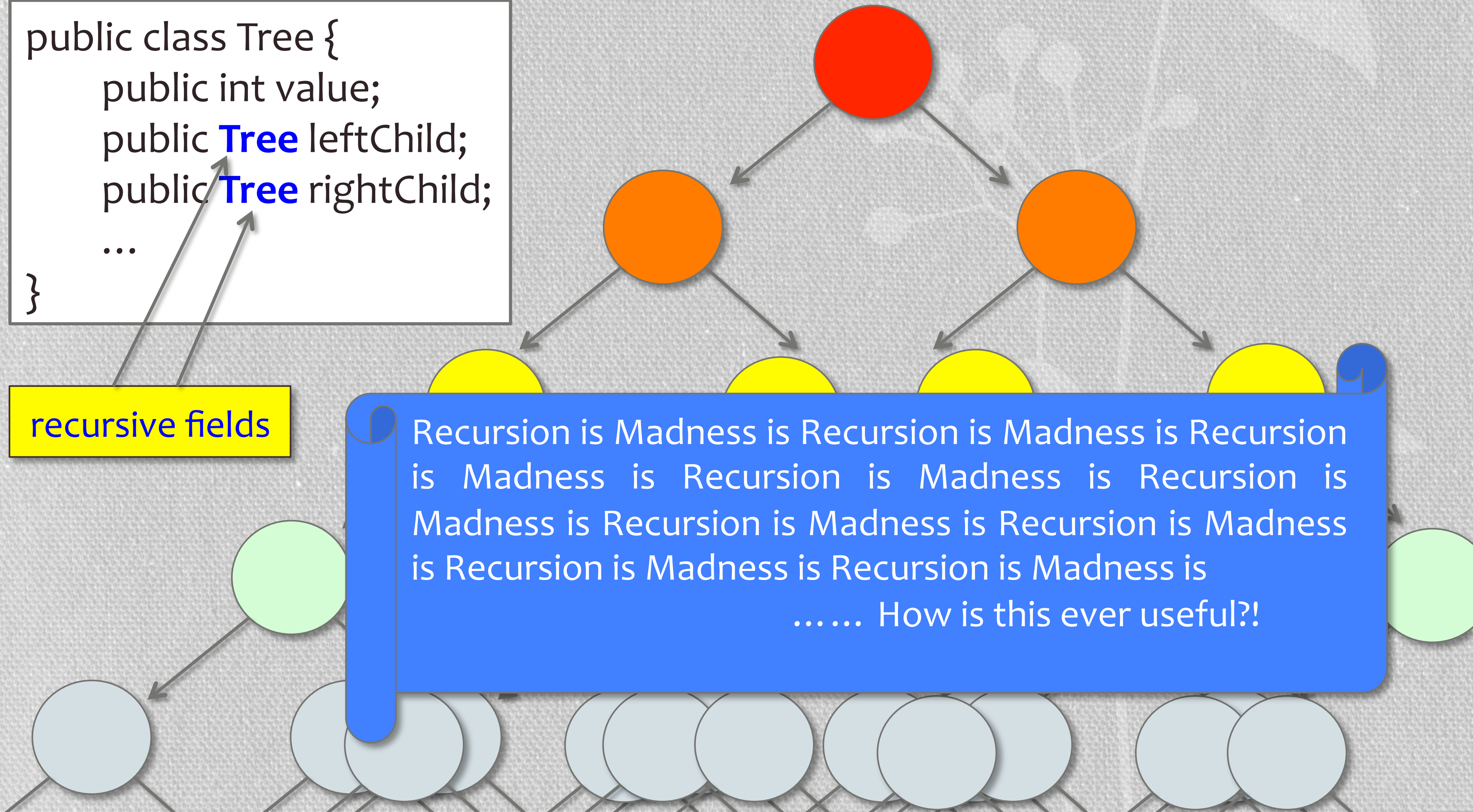
- Is there any problem that recursion or iteration can solve that we couldn't solve with the other?

Data Recursion

Data can also be recursive: when a class definition contains a field whose type is the same as the class being defined:

```
public class Tree {
    public int value;
    public Tree leftChild;
    public Tree rightChild;
    …
}
```

recursive fields



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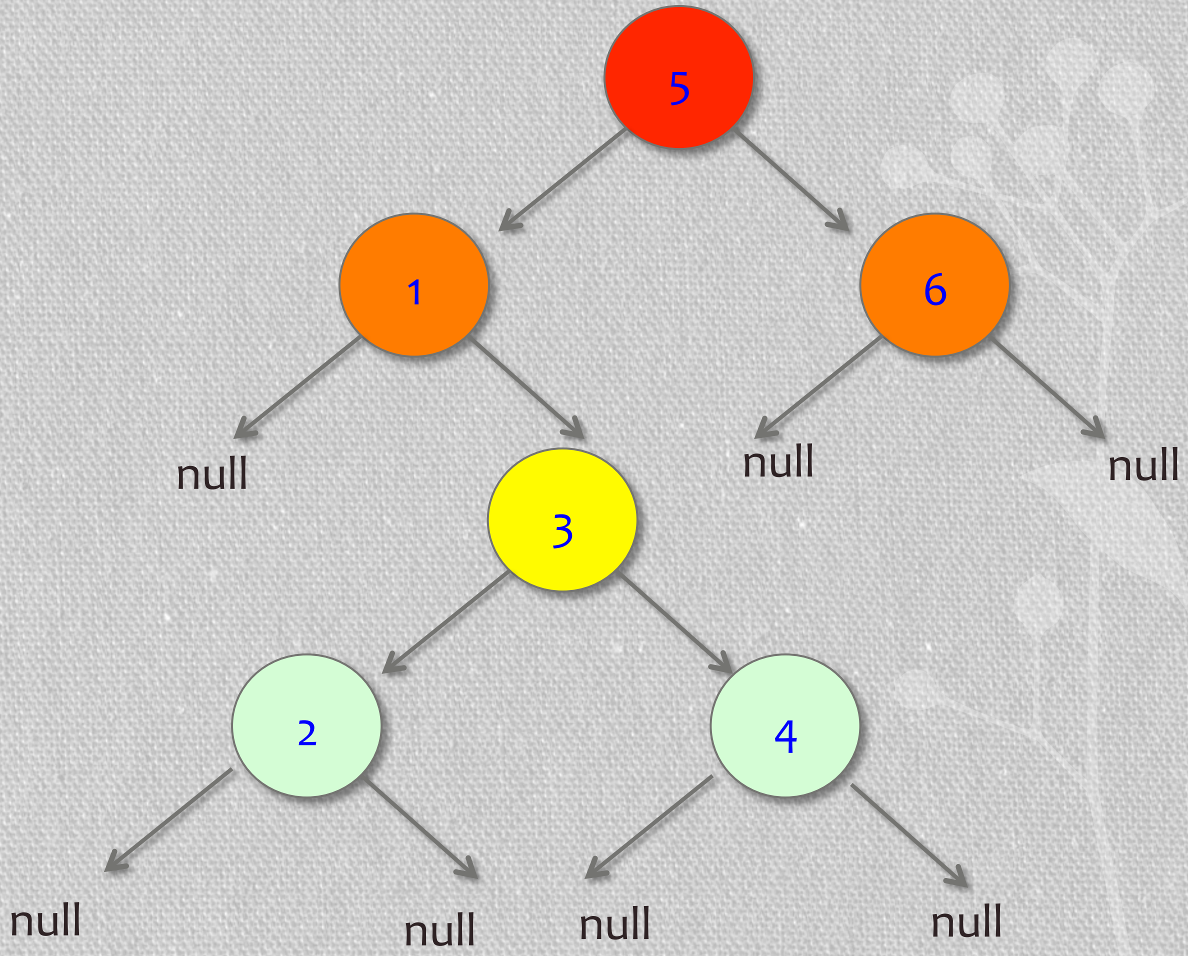
…… How is this ever useful?!

Base Cases in Data Recursion

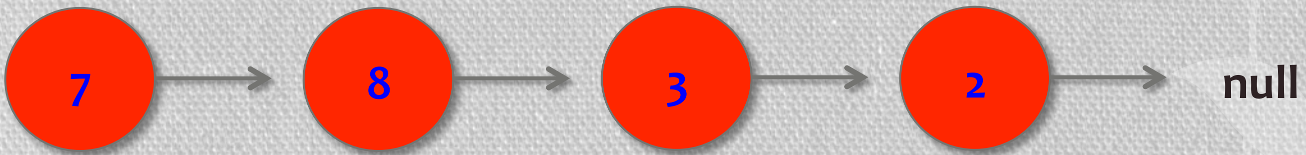
- We will again end the recursion with a base case: the `null` value.



Linked Lists

What if our `Tree` only had one branch? And we named it `IntList`?

```
public class IntList {
    public int val;
    public IntList next;
    …
}
```



It looks a lot like the array **`int[] xs = {7,8,3,2};`**
→ could we implement the usual operations over our IntList that are usually available on arrays?

Making a Linked List Useful

- We might want to add these sorts of operations over our IntList:

1. **size** (how many elements are in here?)
2. **add a value** (sorted? always at the end?)
3. **remove a value** (just tell us which value to remove)
4. **check if a value is present** (return a boolean)
5. **makeArrayVersion** (create an old-fashioned array out of it)

- We can approach these tasks thinking of the diagrams of "before" the operation, "after" the operation, and then write code that implements these changes. Now we're *really* programming with our own data structures!

More Data Structures

There are many common data structures. **CS 310** is a course entirely devoted to them! It. Is. Awesome.

Some others:

- Linear stuff → Lists, Stacks, Queues, …
- Trees → binary, balanced, …
- Graphs → networks, DiGraphs, …
- Hashes → hashes

Java Libraries for Data Structures

- We should take a look at the ArrayList class in Java:

  go to: *(google "Java ArrayList")*

http://docs.oracle.com/javase/1.5.0/docs/api/java/util/ArrayList.html