Recursion:
I’mma break yo brain

—

CTEC 243

What is?

- A recursive method is a method that calls itself

Why?

- Recursive solutions can sometimes be more “elegant” than imperative ones
  - Easier to read
  - Easier to understand
  - Avoids side-effects
- Recursive solutions can often be slower than imperative ones
  - How StackOverflow.com got its name

Understanding Recursion should help you understand other programming concepts, even if you don’t use it as often.

Solving Problems with Recursion

Recursion Terms

- Recursion Depth - how many times a method calls itself
- Base Case - a scenario in which the problem can be solved without recursion
- Recursive Case - a scenario you can use recursion to solve
- Direct Recursion - Recursion in which a method directly calls itself
- Indirect Recursion - Recursion in which a chain of two or more method calls returns to the method that originated the chain. For example, method A calls method B which in turn calls method A.

Three Questions

- Base-Case Question - is there a non-recursive way out?
- Smaller-Caller Question - does every recursive call move towards the Base-Case?
- General-Case Question - does it do what you want it to?

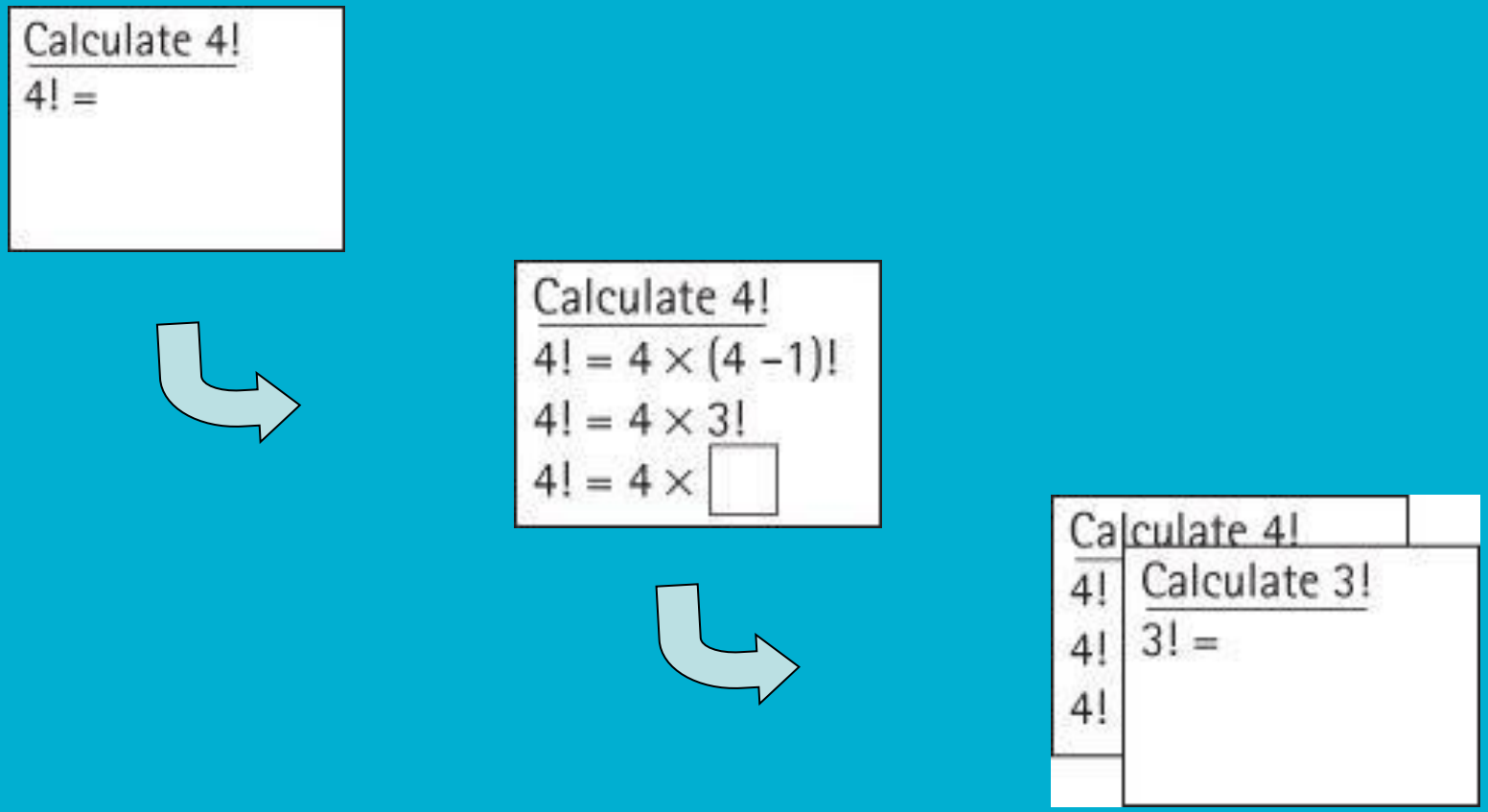
Factorials

n! = 1 * 2 * 3 * 4 * … * n

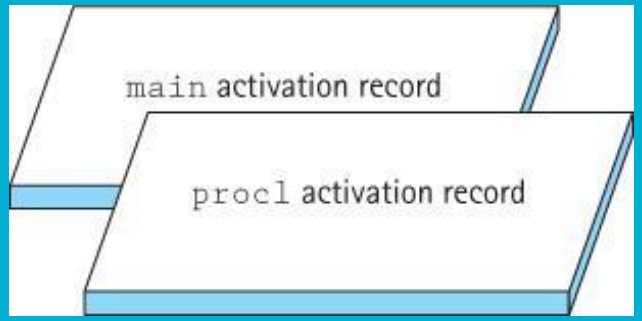
0! = 1

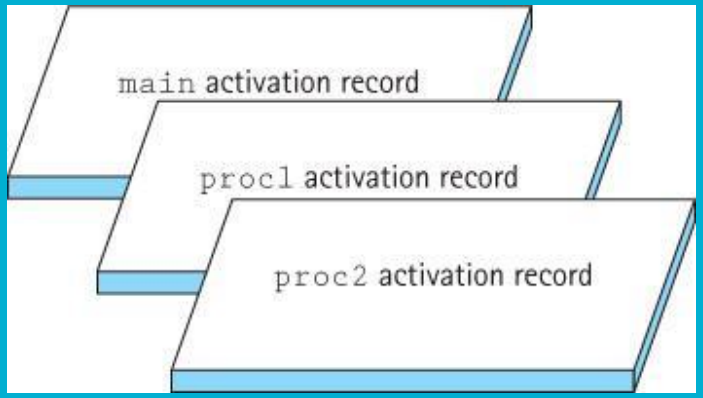
- How can we redefine this?
  - Hint: !5 = !4 * 5
- In what cases do we not need to do any more calculations?
- How can we work towards that base case?

So yeah, let’s code it


Calculate 4!
4! =
Calculate 4!
4! = 4 × (4 – 1)!
4! = 4 × 3!
4! = 4 ×
Calculate 4!
4!
4!
4!
Calculate 3!
3! =

Dynamic Storage Allocation





On Tail Recursion

- A recursive function is tail recursive when recursive call is the last thing executed by the function
- This can help optimize memory
  - ...but not in Java
- Source/More Information - https://www.geeksforgeeks.org/tail-recursion/

The Accumulator

- An extra parameter you define and pass in your recursive methods
- “Accumulates” information in each call

Let’s rewrite the Factorial sequence to use an accumulator.

Iterative Solutions

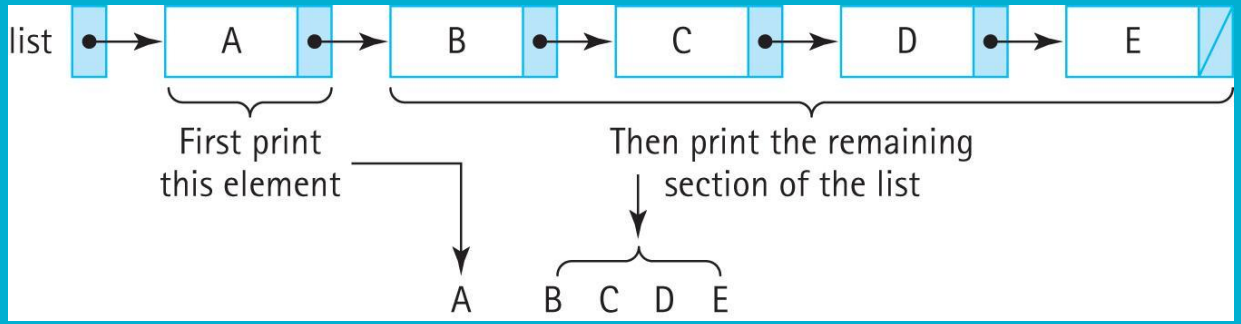
- If a recursive algorithm is Tail-Recursive, then it could be replaced with a while loop
- If a recursive algorithm is not Tail-Recursive, then you may still be able to create an iterative solution
- In many languages, Iterative solutions are more efficient than Recursive ones

Linked Lists

Recursive Processing of Linked Lists

- A linked list is a recursive structure

Printing a Linked List Recursively




```
void recPrintList(LLNode<String> listRef)
{
   if (listRef != null)
   {
      System.out.println(listRef.getInfo());
      recPrintList(listRef.getLink());
   }
}
```

Recursion Examples

Summing a Range of Array Elements

- rangeSum(arrayInQuestion, startingIndex, endingIndex)

The Fibonacci Series

- Look, I'll admit this one is a little annoying
- The Fibonacci Series - a list of numbers in which the next number is made up of the sum of the last two numbers
  - 0,1,1,2,3,5,8,13, 21… and so on
- Let's break our brains on this for a bit
  - We want to find the number in the nth place of the sequence
  - Yes, this is a common programming problem you can easily look up online, but let's just think for a moment
  - I'll even put a hint on the next slide (no peeking).

Fibonacci Hints

- Fibonacci(0) = 0
- Fibonacci(1) = 1
- Fibonacci(n) = Fibonacci(n-1) + Fibonacci(n-2) for n >= 2

Let’s write a Fibonacci function. Remember, we don’t need to output the whole sequence, we just want a function that tells us what the nth number in the sequence is.

Recursive Binary Search

- This one will require a sorted array
- If the value is in the middle, return the middle value
  If the middle value is greater than the sought value, search the lower half of the array
  If the middle value is small than the sought value, search the greater half of the array

Common Errors

- Forgetting a base case
- Not reducing the problem with each recursive call
- Writing the recursive call in such a way that the base case is never reached

Practice

Recursive Multiplication

Write a recursive function that accepts two arguments into the parameters x and y. The function should return the value of x times y.

Hint: multiplication can be performed as repeated addition.

4 * 2 = 2 + 2 + 2 + 2

Basset Hound Ears

Given n number of basset hounds, calculate how many droopy basset hound ears there should be. Use recursion to solve the problem.

All Star

Given a string, compute recursively a new string where all the adjacent chars are now separated by a “*”.

allStar(“hello”) -> “h*e*l*l*o”
allStar(“abc”) -> “a*b*c”
allStar(“ab”) -> “a*b”