BIRZEIT UNIVERSITY

Recursion

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Recursion

- To use recursion is to program using recursive methods—that is, to use methods that invoke themselves.
- A recursive method is one that invokes itself directly or indirectly.
- Case Study: Computing Factorials

```
0! = 1;
n! = n × (n - 1)!; n > 0
```

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Computing Factorial

- Let **factorial(n)** be the method for computing **n!**.
- If you call the method with **n = 0**, it immediately returns the result.
- The method knows how to solve the simplest case, which is referred to as the ***base case*** or the ***stopping condition***.
- If you call the method with **n > 0**, it reduces the problem into a **subproblem** for computing the factorial of **n** - **1**.
- The ***subproblem*** is essentially the same as the original problem, but it is simpler or smaller.

Computing Factorial

factorial(0) = 1;
factorial(n) = n*factorial(n-1);

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))
= 4 * (3 * (2 * (1 * factorial(0))))
= 4 * (3 * (2 * (1 * 1))))
= 4 * (3 * (2 * 1))
= 4 * (3 * 2)
= 4 * (6)
= 24

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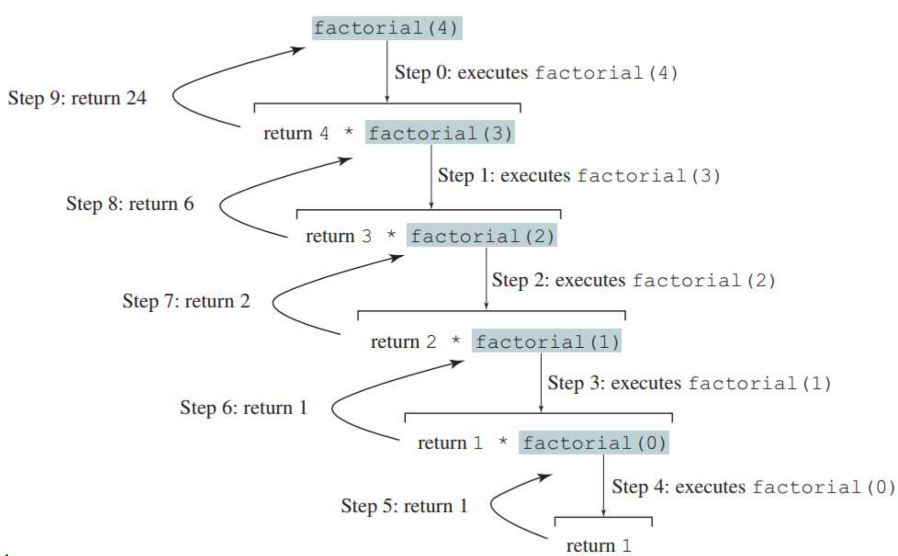
factorial(n)

```
int factorial(int n) {
    if (n == 0)                    // base case
        return 1;
    else                           // recursion
        return n * factorial(n - 1);
}
```

Notes:

- For a recursive method to terminate, the problem must eventually be reduced to a **stopping case**, at which point the method returns a result to its caller.
- If recursion does not reduce the problem in a manner that allows it to eventually converge into the base case or a base case is not specified, **infinite recursion** can occur. The method runs infinitely and causes a **StackOverflowError**.

Invoking **factorial(4)**



Fibonacci Numbers

```
Fibonacci series: 0 1 1 2 3 5 8 13 21 34 55 89…
         indices: 0 1 2 3 4 5 6 7  8  9  10 11
```

fib(0) = 0;

fib(1) = 1;

fib(index) = fib(index -1) + fib(index -2); index >=2

fib(3) = fib(2) + fib(1)
= (fib(1) + fib(0)) + fib(1)
= (1 + 0) +fib(1)
= 1 + fib(1)
= 1 + 1 = 2

Fibonnaci Numbers, cont.

```
public static long fib(long index) {
  if (index == 0) // Base case
    return 0;
  else if (index == 1) // Base case
    return 1;
  else  // Reduction and recursive calls
    return fib(index - 1) + fib(index - 2);
}
```

Characteristics of Recursion

All recursive methods have the following characteristics:

■ The method is implemented using an **if-else** or a **switch** statement that leads to different cases.

■ One or more base cases (the simplest case) are used to stop recursion.

■ Every recursive call reduces the original problem, bringing it increasingly closer to a base case until it becomes that case.

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Characteristics of Recursion

- In general, to solve a problem using recursion, you break it into subproblems.
- If a subproblem resembles the original problem, you can apply the same approach to solve the subproblem recursively.
- This subproblem is almost the same as the original problem in nature with a smaller size.

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Problem Solving Using Recursion

- Let us consider a simple problem of printing a message for n times.
- You can break the problem into two subproblems:
  - one is to print the message one time and the other is to print the message for n-1 times.
  - The second problem is the same as the original problem with a smaller size.
  - The base case for the problem is n==0. You can solve this problem using recursion as follows:

```
public static void nPrintln(String message, int times) {
  if (times >= 1) {
    System.out.println(message);
    nPrintln(message, times - 1);
  } // The base case is times == 0
}
```

Think Recursively

- Many of the problems can be solved using recursion if you *think recursively*.
- For example, the palindrome problem can be solved recursively as follows:

```
public static boolean isPalindrome(String s) {
  if (s.length() <= 1) // Base case
    return true;
  else if (s.charAt(0) != s.charAt(s.length() - 1)) // Base case
    return false;
  else
    return isPalindrome(s.substring(1, s.length() - 1));
}
```

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