Programming with Recursion

The Recursion Pattern

- Recursion: when a method calls itself
- Classic example: the factorial function:

$$n! = 1 \cdot 2 \cdot 3 \cdot \cdots \cdot (n-1) \cdot n$$

- Recursive definition:

$$f(n) = \begin{cases} 1 & \text{if } n = 0 \\ n \cdot f(n-1) & \text{else} \end{cases}$$

- As a Java method:

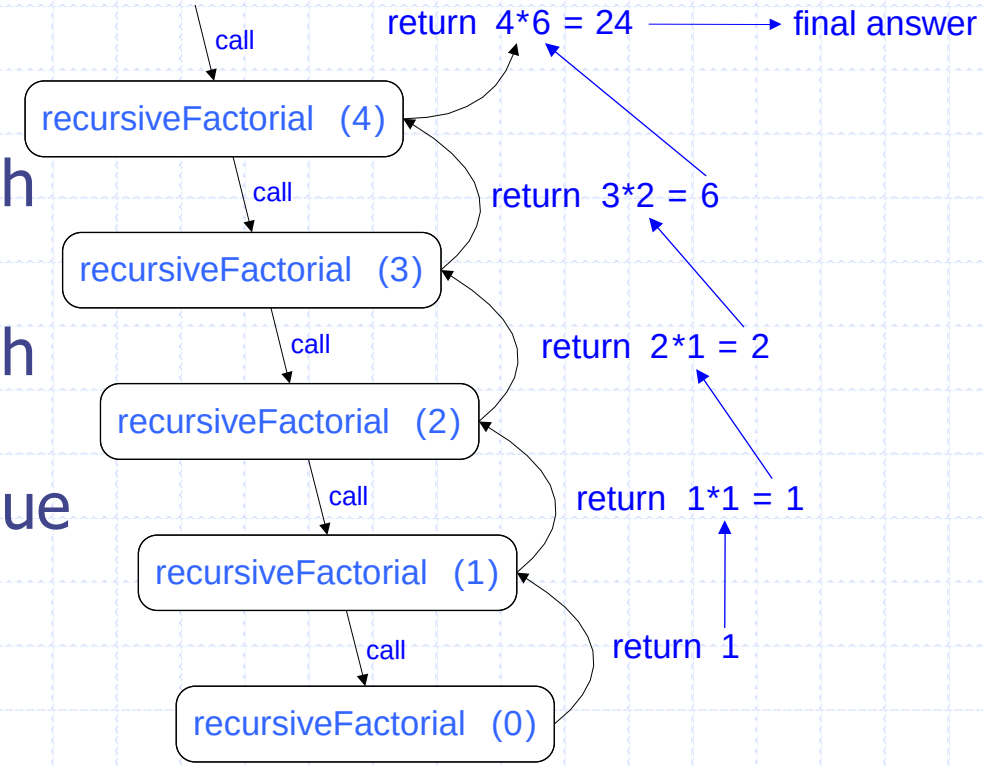
```
// recursive factorial function
public static int recursiveFactorial(int n) {
    if (n == 0) return 1;      // basis case
    else return n * recursiveFactorial(n- 1); // recursive case
}
```

Content of a Recursive Method

- Base case(s)
  - Values of the input variables for which we perform no recursive calls are called base cases (there should be at least one base case).
  - Every possible chain of recursive calls must eventually reach a base case.
- Recursive calls
  - Calls to the current method.
  - Each recursive call should be defined so that it makes progress towards a base case.

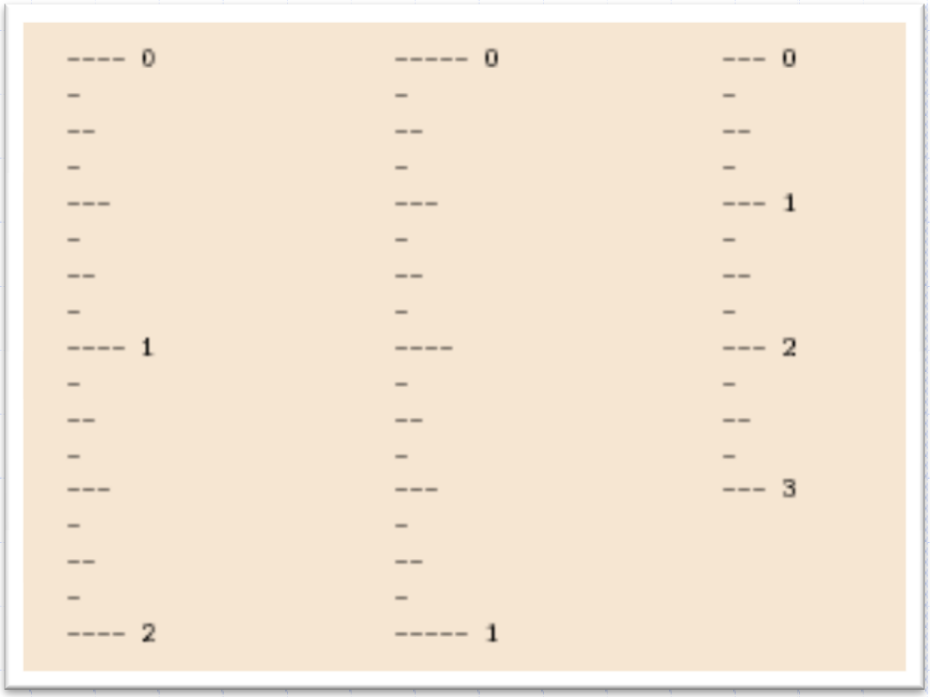
Visualizing Recursion

- Recursion trace
  - A box for each recursive call
  - An arrow from each caller to callee
  - An arrow from each callee to caller showing return value
- Example



Example: English Ruler

- Print the ticks and numbers like an English ruler:



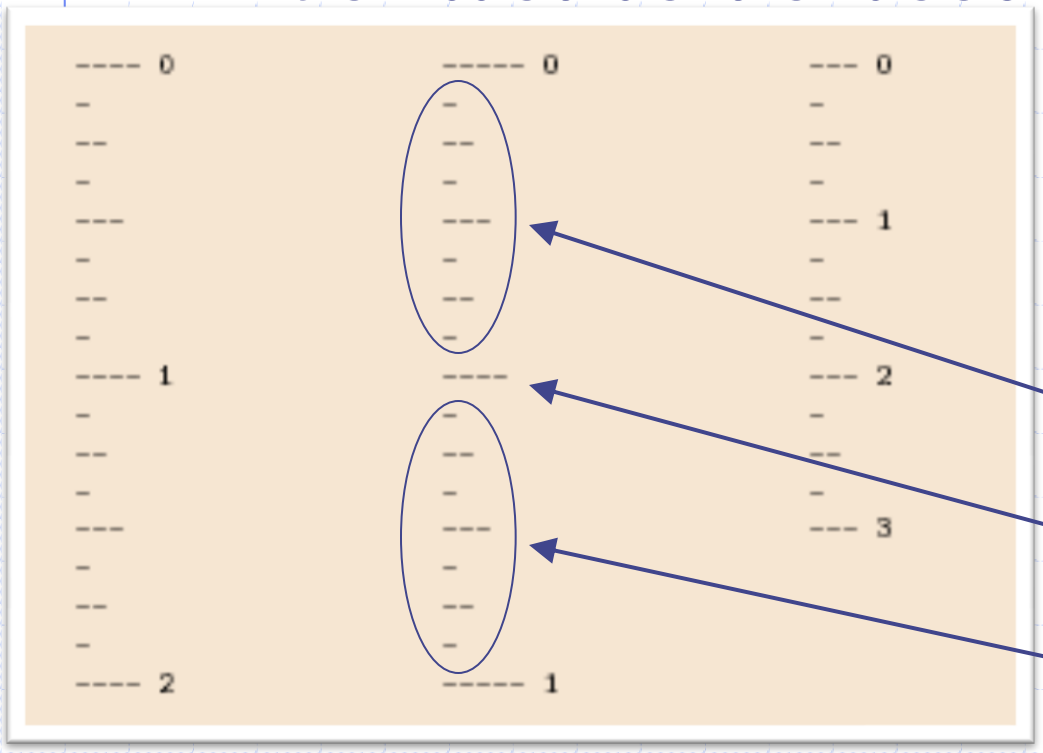
Slide by Matt Stallmann
included with permission.

Using Recursion

drawTicks(length)

Input: length of a 'tick'

Output: ruler with tick of the given length in the middle and smaller rulers on either side



drawTicks(length)

if(length > 0) then

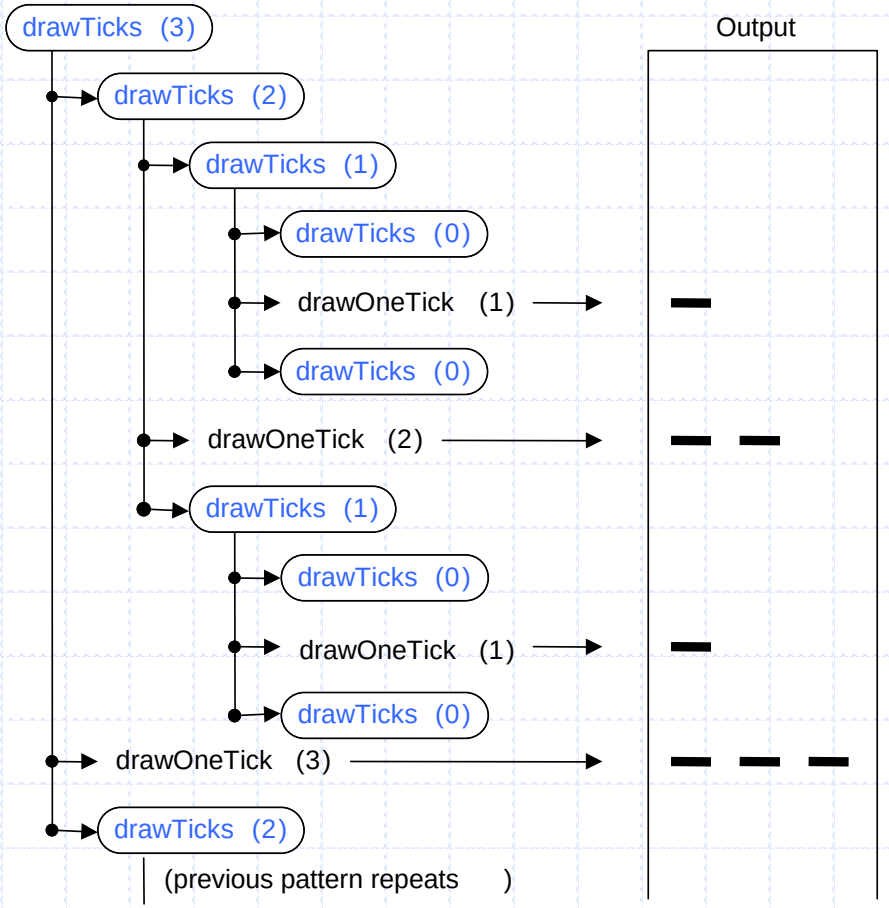
drawTicks(length – 1)

draw tick of the given length

drawTicks(length – 1)

Recursive Drawing Method

- The drawing method is based on the following recursive definition
- An interval with a central tick length L $\geq$1 consists of:
  - An interval with a central tick length L–1
  - An single tick of length L
  - An interval with a central tick length L–1



Java Implementation (1)

```
// draw ruler
public static void drawRuler(int nInches, int majorLength) {
    drawOneTick(majorLength, 0);                    // draw tick 0 and its label
    for (int i = 1; i <= nInches; i++){
        drawTicks(majorLength- 1);                  // draw ticks for this inch
        drawOneTick(majorLength, i);                // draw tick i and its label
    }
}

// draw ticks of given length
public static void drawTicks(int tickLength) {
    if (tickLength > 0) {                           // stop when length drops to 0
        drawTicks(tickLength- 1);                   // recursively draw left ticks
        drawOneTick(tickLength);                    // draw center tick
        drawTicks(tickLength- 1);                   // recursively draw right ticks
    }
}
```

Java Implementation (2)

```
// draw a tick with no label
public static void drawOneTick(int tickLength) {
    drawOneTick(tickLength, - 1);
}

// draw one tick
public static void drawOneTick(int tickLength, int tickLabel) {
   for (int i = 0; i < tickLength; i++)
       System.out.print("-");
   if (tickLabel >= 0) System.out.print(" " + tickLabel);
   System.out.print("\n");
}
```