Methods

Introduction to Programming and Computational Problem Solving - 2

CSE 8B

Lecture 6

Announcements

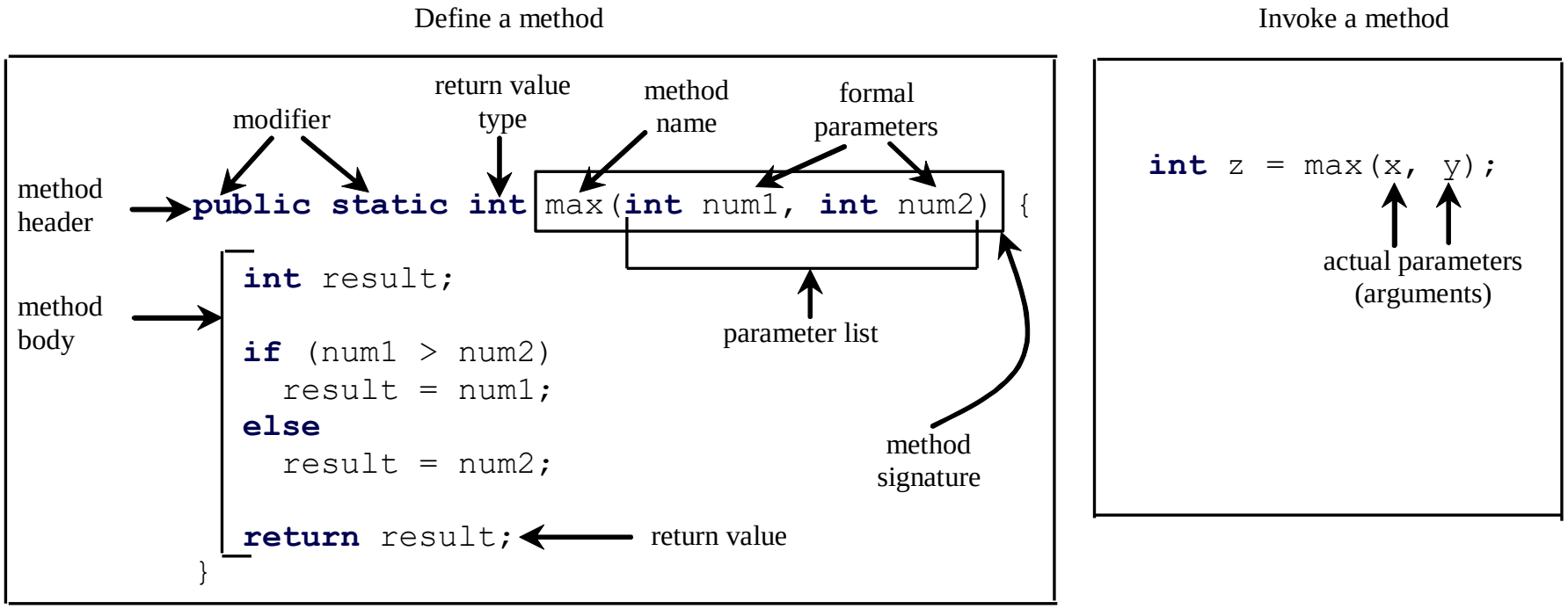
- Assignment 2 is due today, 11:59 PM
  - Upgrade beginning Apr 22, 12:01 PM
- Assignment 3 will be released today
  - Due Apr 26, 11:59 PM
- Educational research study
  - Apr 21, weekly survey

Variable and method names

- Naming convention: Use lowercase. If the name consists of several words, concatenate all in one, use lowercase for the first word, and capitalize the first letter of each subsequent word in the name
  - For example, the variables `radius` and `area`, and the method `computeArea`.

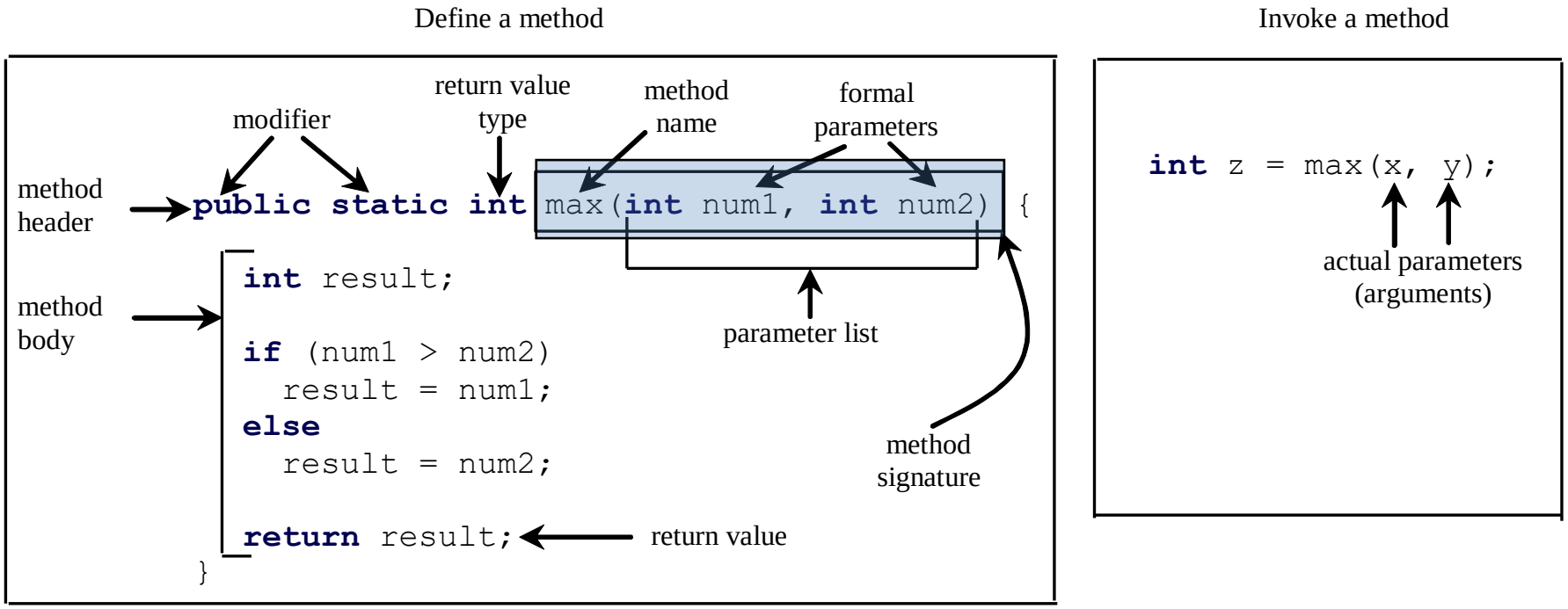
Defining methods

- A method is a collection of statements that are grouped together to perform an operation



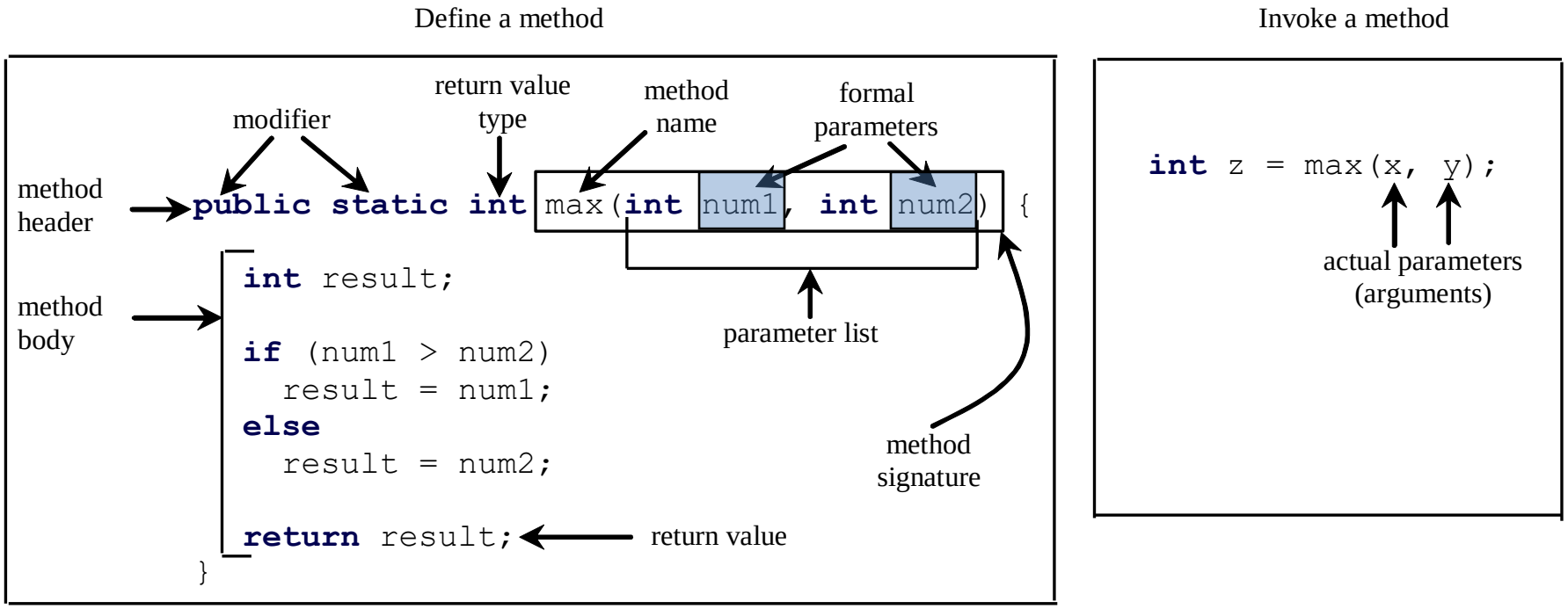
Method signature

- The *method signature* is the combination of the method name and the parameter list



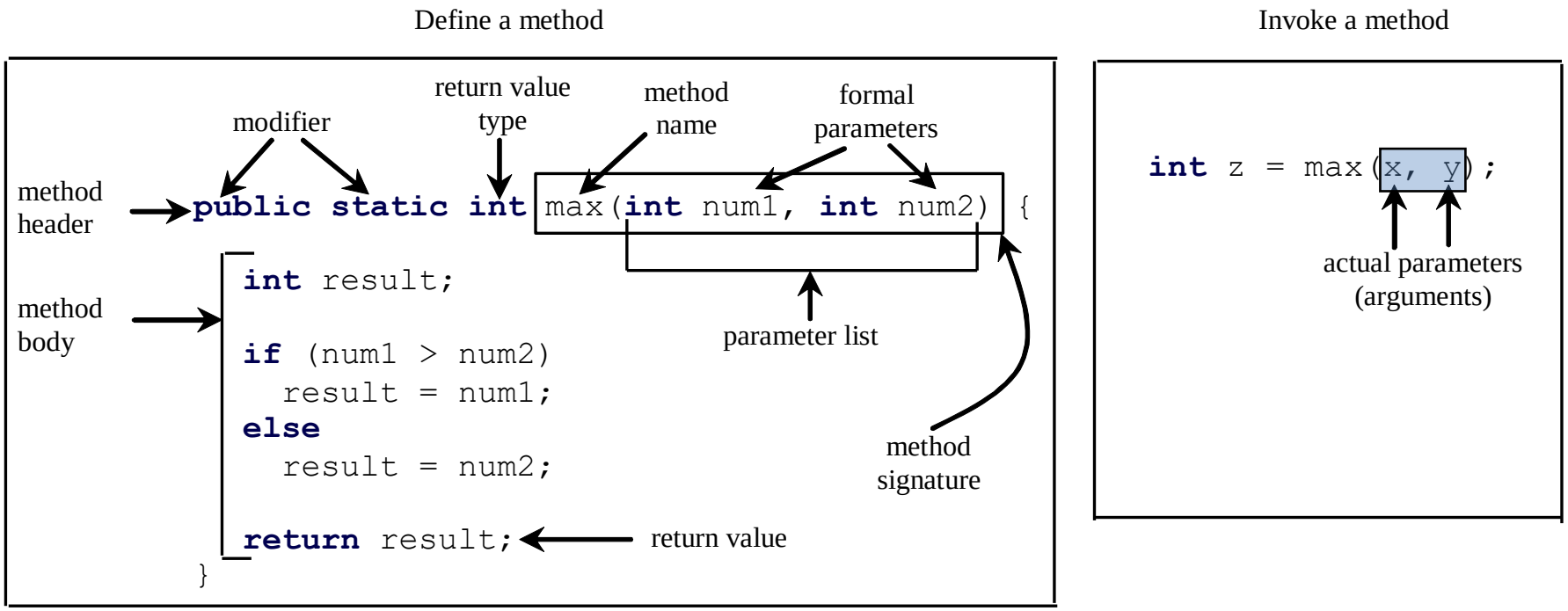
Formal parameters

- The variables defined in the method header are known as *formal parameters*



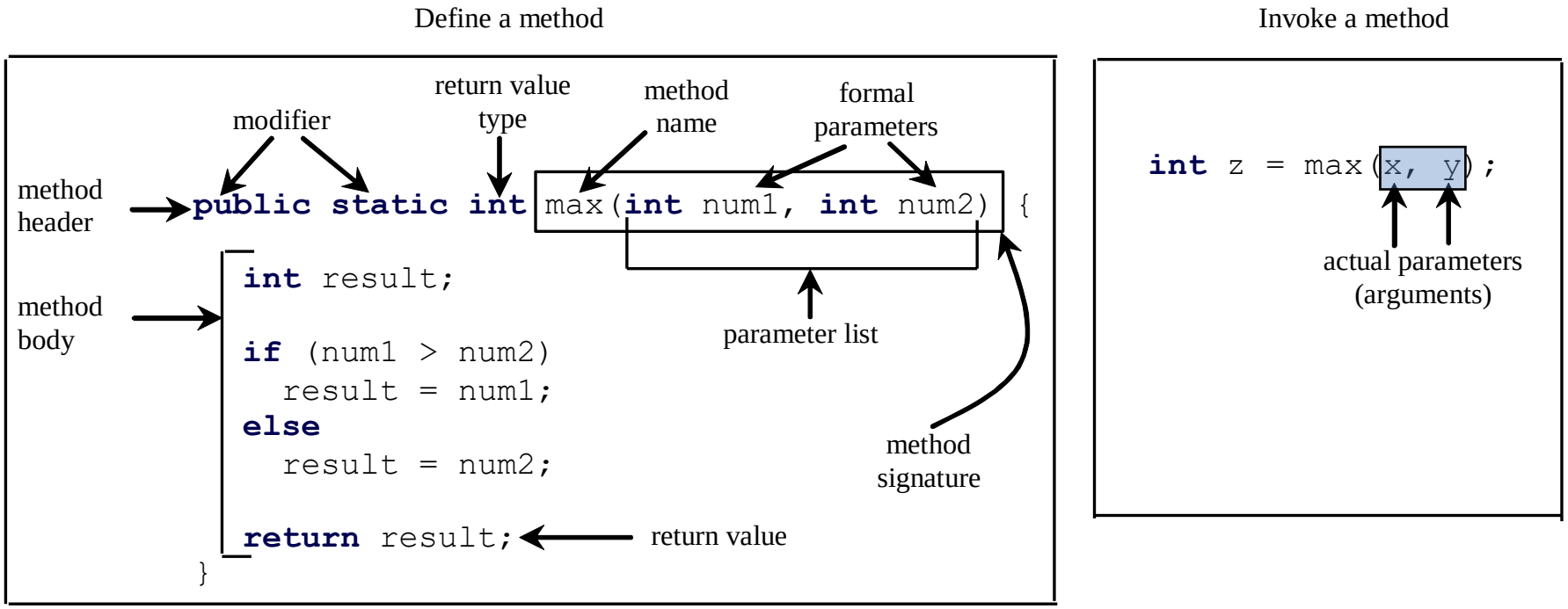
Actual parameters

- When a method is invoked, you pass a value to the parameter
  - This value is referred to as *actual parameter* or *argument*



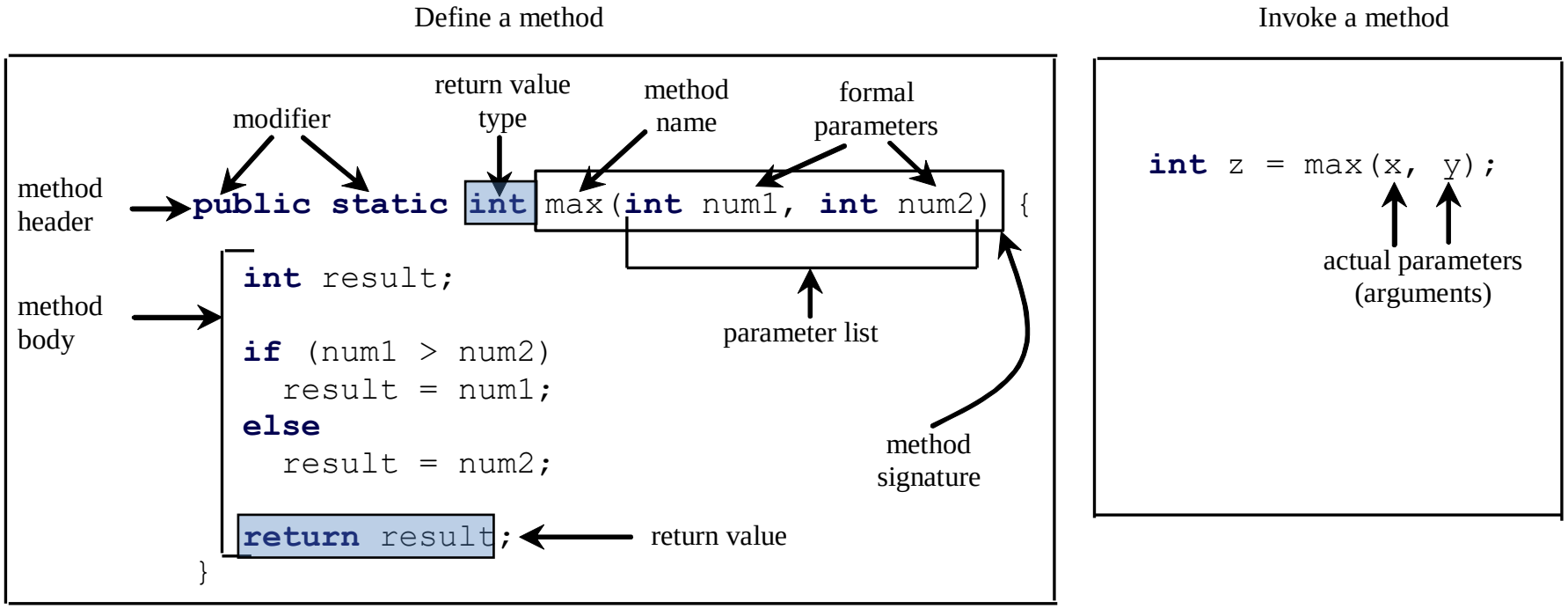
Pass by value

- Java uses **pass by value** to pass arguments to a method
- For example, modifying num1 does not modify x



Return value type

- A method may return a value
- The *return value type* is the data type of the value the method returns
  - If the method does not return a value, the *return value type* is the keyword `void`



return statement

- A return statement is required for a value-returning method

```
public static int sign(int n) {
  if (n > 0)
    return 1;
  else if (n == 0)
    return 0;
  else if (n < 0)
    return -1;
}
```

(a)

Should be

```
public static int sign(int n) {
  if (n > 0)
    return 1;
  else if (n == 0)
    return 0;
  else
    return -1;
}
```

(b)

Delete `if (n < 0)` in (a), so the compiler will see a `return` statement is reached regardless of how the `if` statement is evaluated

Reuse methods from other classes

- One of the benefits of methods is for reuse
  - Call (i.e., invoke) a static method using `ClassName.methodName`
- Calling a method executes the code in the method

Instance methods vs static methods

- Instance methods can only be invoked from a specific instance of a class
  - The syntax to invoke an instance method is
    ```
    referenceVariable.methodName(arguments)
    ```
  - For example, the simple `String` methods
    ```
    String message = "Welcome to Java";
    int messageLength = message.length(); // Not String.length()
    ```
- Static methods can be invoked without using an object (i.e., they are not tied to a specific instance)
  - All static methods are non-instance methods
  - The syntax to invoke a static method is
    ```
    ClassName.methodName(arguments)
    ```
  - For example, all the methods defined in the `Math` class are static methods
    ```
    double x = -1.2345;
    double absx = Math.abs(x); // Not x.abs()
    ```

Reuse methods from other classes

- For example, the `max` method is member of the class `TestMax`
- The `max` method can be invoked from any class besides `TestMax`
- If you create a new class `Test`, you can invoke the max method using `TestMax.max`

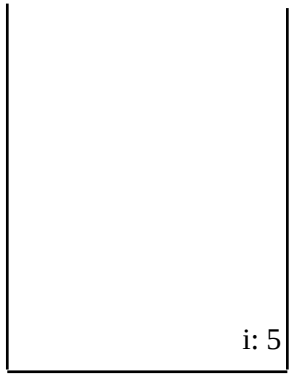
```
public class TestMax {
  public static int max(int num1, int num2) {
    int result;

    if (num1 > num2)
      result = num1;
    else
      result = num2;

    return result;
  }
}
```

Trace code

i is declared and initialized

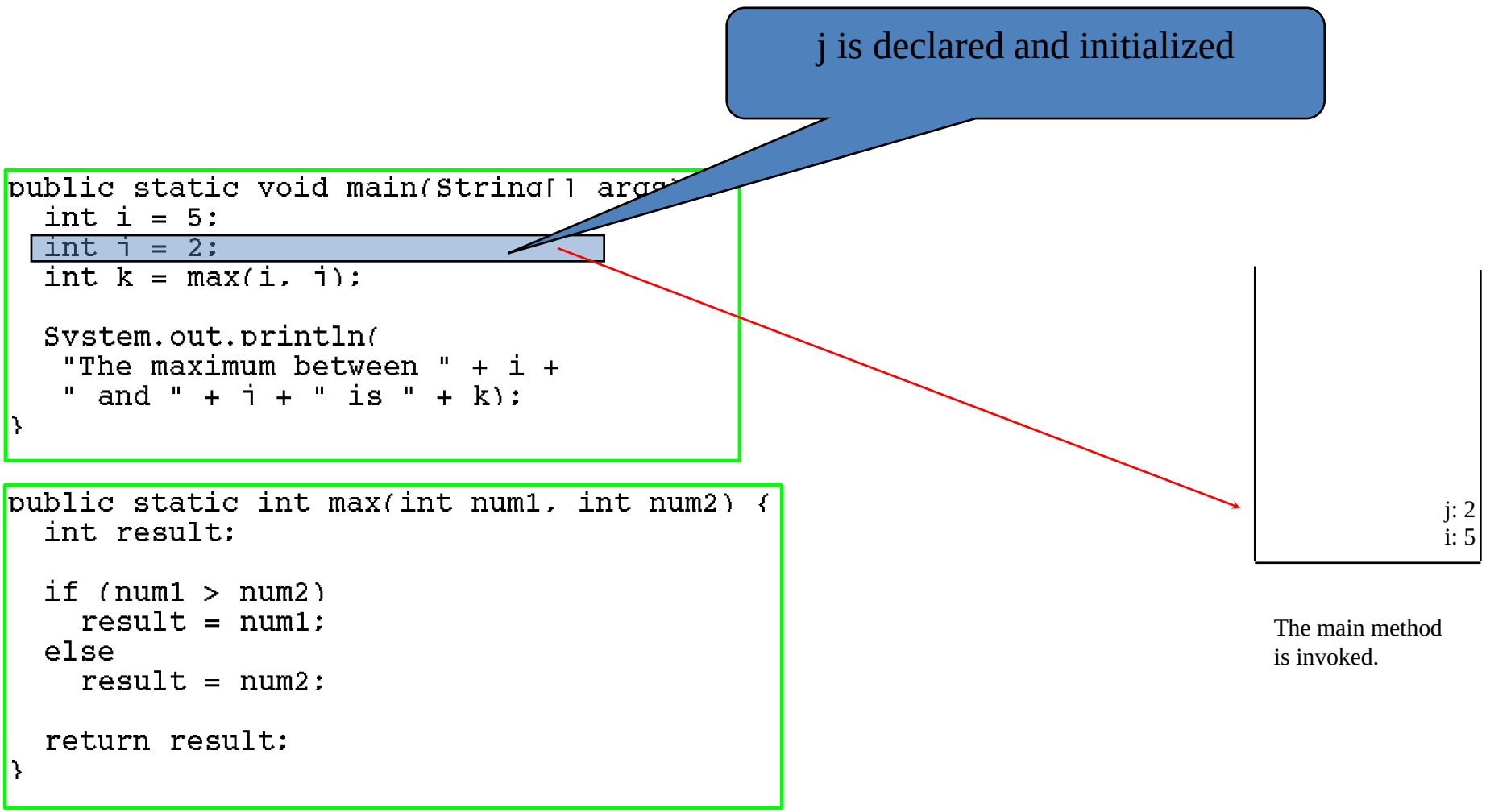
```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
    "The maximum between " + i +
    " and " + j + " is " + k);
}
```

```
public static int max(int num1, int num2) {
  int result;

  if (num1 > num2)
    result = num1;
  else
    result = num2;

  return result;
}
```

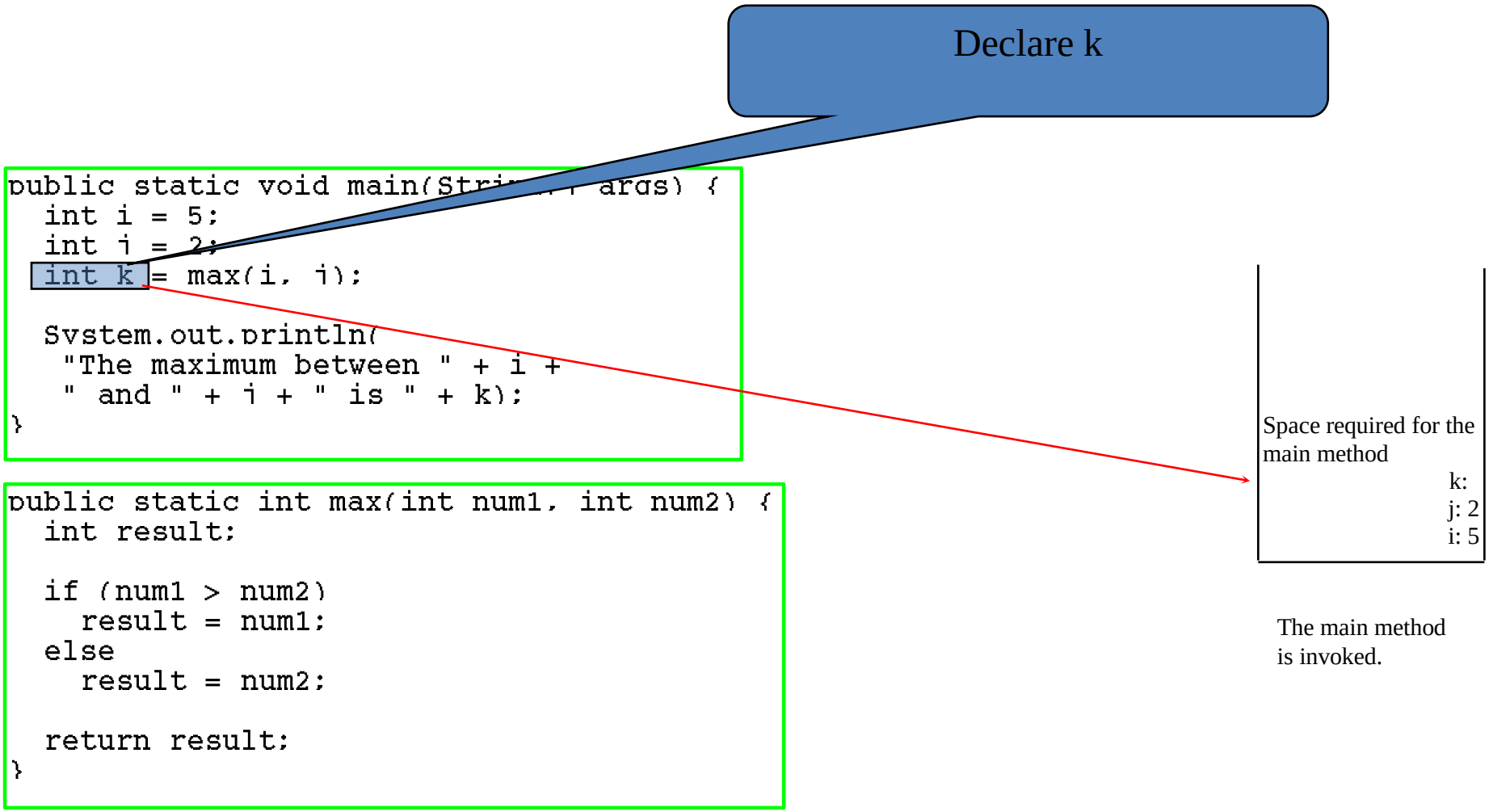


The main method is invoked.

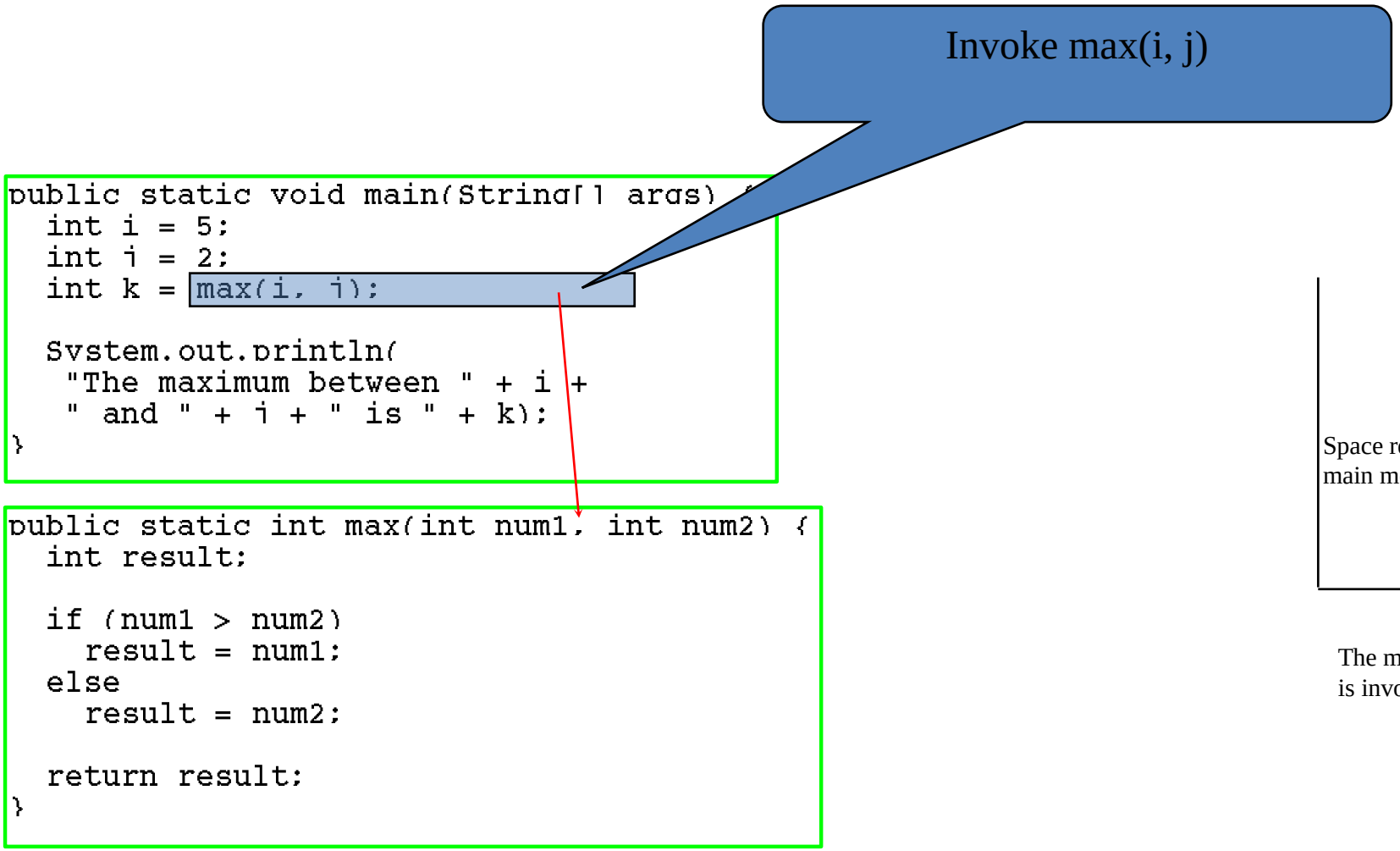
Trace code


j is declared and initialized
public static void main(String[] args) {
int i = 5;
int j = 2;
int k = max(i, j);
System.out.println(
"The maximum between " + i +
" and " + j + " is " + k);
}
public static int max(int num1, int num2) {
int result;
if (num1 > num2)
result = num1;
else
result = num2;
return result;
}
j: 2
i: 5
The main method is invoked.

Trace code


Declare k
public static void main(String[] args) {
int i = 5;
int j = 2;
int k = max(i, j);
System.out.println(
"The maximum between " + i +
" and " + j + " is " + k);
}
public static int max(int num1, int num2) {
int result;
if (num1 > num2)
result = num1;
else
result = num2;
return result;
}
Space required for the main method
k:
j: 2
i: 5
The main method is invoked.

Trace code

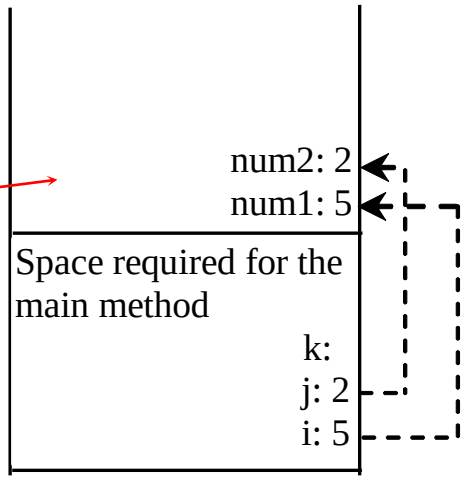

Invoke max(i, j)
public static void main(String[] args) {
int i = 5;
int j = 2;
int k = max(i, j);
System.out.println(
"The maximum between " + i +
" and " + j + " is " + k);
}
public static int max(int num1, int num2) {
int result;
if (num1 > num2)
result = num1;
else
result = num2;
return result;
}
Space required for the main method
k:
j: 2
i: 5
The main method is invoked.

Trace code

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
    "The maximum between " + i +
    " and " + j + " is " + k);
}
```

```
public static int max(int num1, int num2) {
  int result;

  if (num1 > num2)
    result = num1;
  else
    result = num2;

  return result;
}
```

pass the values of i and j to num1 and num2



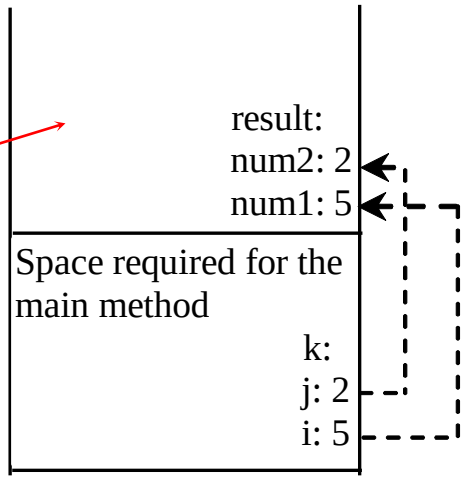
The max method is invoked.

Trace code

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
    "The maximum between " + i +
    " and " + j + " is " + k);
}
```

```
public static int max(int num1, int num2) {
  int result;

  if (num1 > num2)
    result = num1;
  else
    result = num2;

  return result;
}
```

Declare result



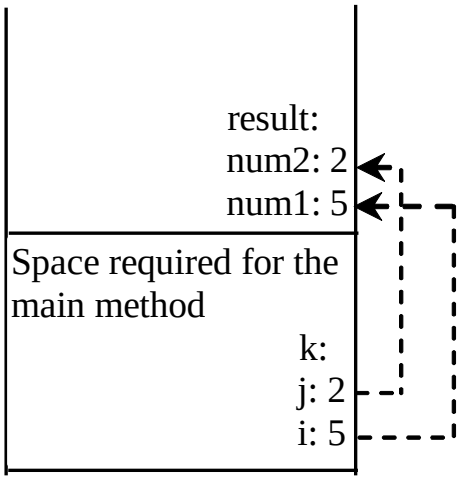
The max method is invoked.

Trace code

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
    "The maximum between " + i +
    " and " + j + " is " + k);
}
```

```
public static int max(int num1, int num2) {
  int result;

  if (num1 > num2)
    result = num1;
  else
    result = num2;

  return result;
}
```

(num1 > num2) is true



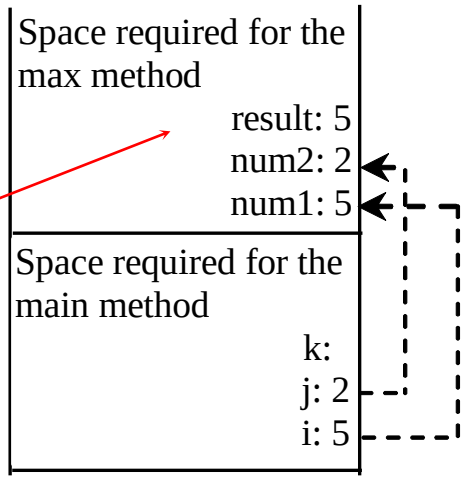
The max method is invoked.

Trace code

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
    "The maximum between " + i +
    " and " + j + " is " + k);
}
```

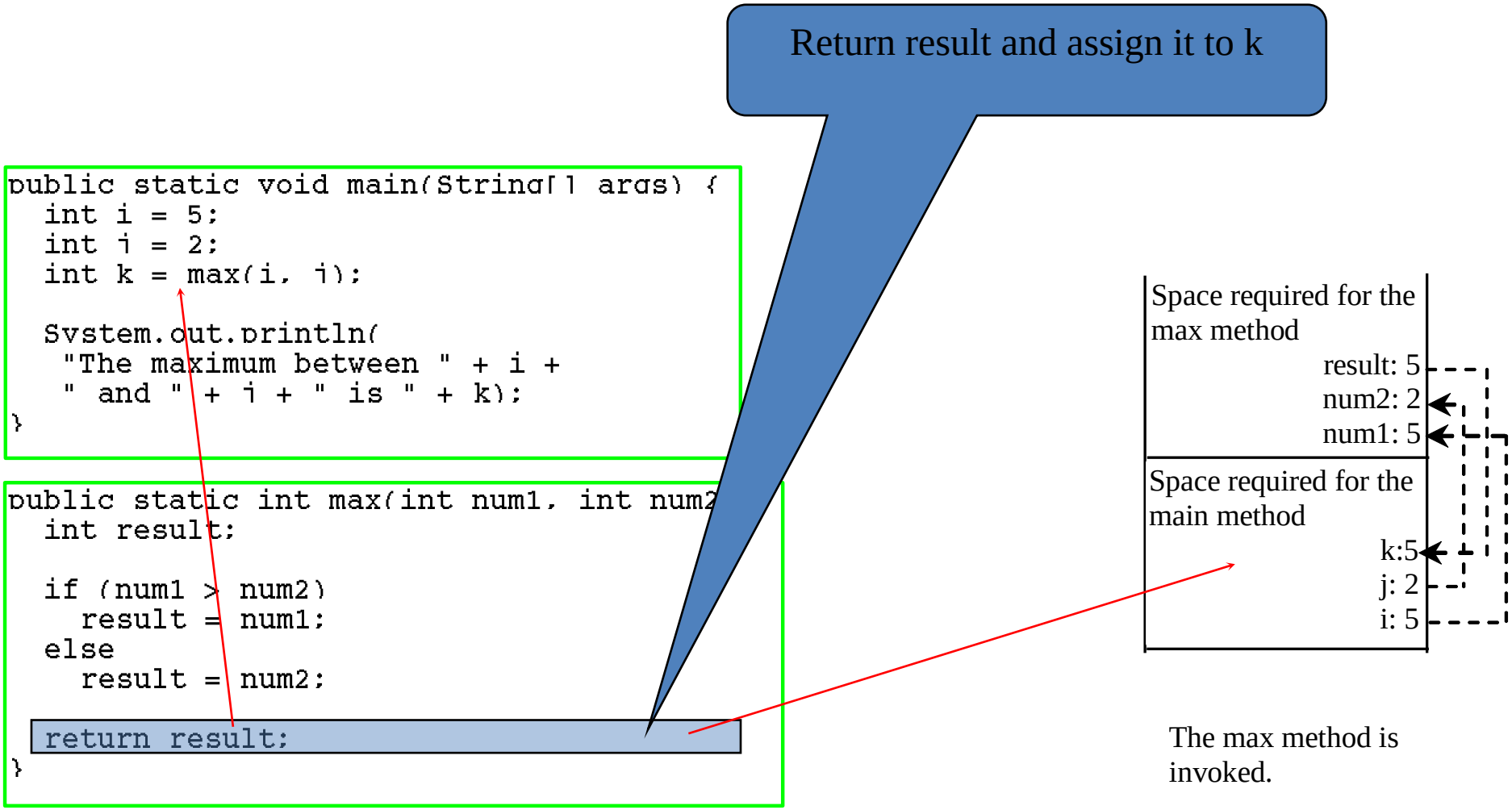
```
public static int max(int num1, int num2)
  int result;

  if (num1 > num2)
    result = num1;
  else
    result = num2;

  return result;
}
```

Assign num1 to result



The max method is invoked.

Trace code


Return result and assign it to k
public static void main(String[] args) {
int i = 5;
int j = 2;
int k = max(i, j);
System.out.println(
"The maximum between " + i +
" and " + j + " is " + k);
}
public static int max(int num1, int num2
int result;
if (num1 > num2)
result = num1;
else
result = num2;
return result;
}
Space required for the max method
result: 5
num2: 2
num1: 5
Space required for the main method
k:5
j: 2
i: 5
The max method is invoked.

Modularizing code

- Methods can be used to reduce redundant coding and enable code reuse
- Methods can also be used to modularize code and improve the quality of the program

Overloading methods

- Overloading methods enable you to define the methods with the same name **as long as their parameter lists are different**
- For example, overloading the `max` method

```
public static double max(double num1, double num2) {
  if (num1 > num2)
    return num1;
  else
    return num2;
}
```

Ambiguous invocation

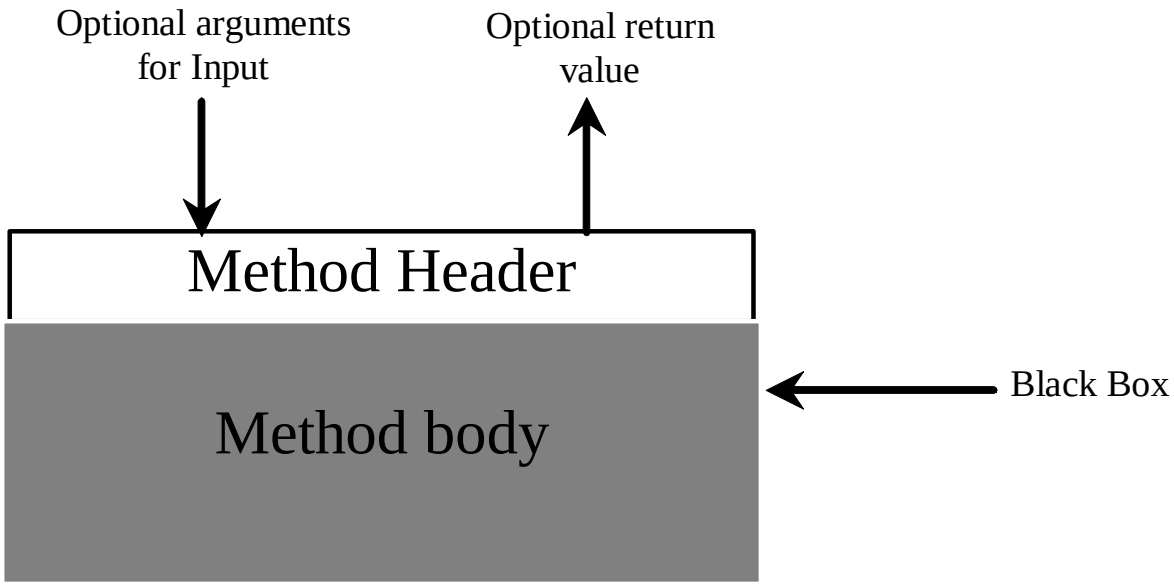
- The Java compiler determines which method to use based on the method signature
- Sometimes there may be two or more possible matches for an invocation of a method, but the compiler cannot determine the most specific match
- This is referred to as *ambiguous invocation*
- Ambiguous invocation is a compile error

Scope of local variables

- A local variable is a variable defined inside a method
- Scope is the part of the program where the variable can be referenced
- The scope of a local variable **starts from its declaration** and **continues to the end of the block** that contains the variable
- A local variable must be declared before it can be used
- You can declare a local variable with the same name multiple times in different *non-nesting* blocks in a method, but you cannot declare a local variable twice in nested blocks

Method abstraction

- You can think of the method body as a black box that contains the detailed implementation for the method (i.e., encapsulation)



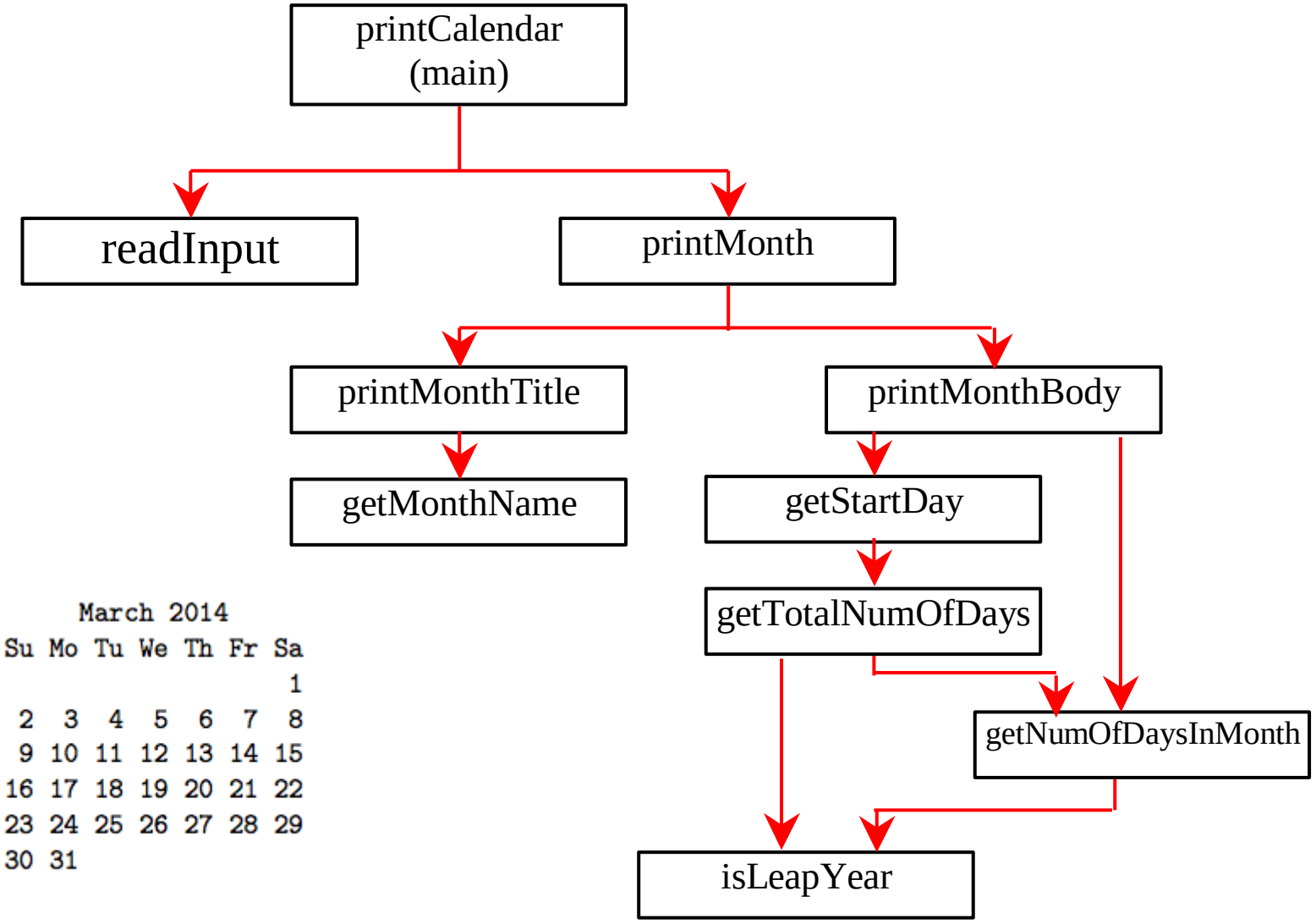
Benefits of methods

- Write a method once and reuse it anywhere
- Information hiding
  - Hide the implementation from the user
- Reduce complexity

Stepwise refinement

- The concept of method abstraction can be applied to the process of developing programs
- When writing a large program, you can use the "divide and conquer" strategy, also known as *stepwise refinement*, to decompose it into subproblems
- The subproblems can be further decomposed into smaller, more manageable problems

Example design diagram




```
     March 2014
Su Mo Tu We Th Fr Sa
                   1
 2  3  4  5  6  7  8
 9 10 11 12 13 14 15
16 17 18 19 20 21 22
23 24 25 26 27 28 29
30 31
```

Bottom-up implementation

- Bottom-up approach is to implement one method in the structure chart at a time from the bottom to the top
- For each method implemented, write a test program to test it

Top-down implementation

- Top-down approach is to implement one method in the structure chart at a time from the top to the bottom
- Stubs can be used for the methods waiting to be implemented
  - A *stub* is a simple but incomplete version of a method
  - The use of stubs enables you to test invoking the method from a caller
- In the example, implement the `main` method first and then use a stub for the `printMonth` method
  - For example, let `printMonth` display the year and the month in the stub

Implementation

- Both top-down and bottom-up methods are fine
- Both approaches implement the methods incrementally and help to isolate programming errors and makes debugging easy
- Sometimes, they can be used together

Stepwise refinement

- Simpler program
- Reusing methods
- Easier developing, debugging, and testing
- Better facilitating teamwork

Next Lecture

- Loops and recursion