Loops and Methods

Introduction to Programming and Computational Problem Solving - 2

CSE 8B

Lecture 4

Announcements

- Assignment 1 is due today, 11:59 PM
- Assignment 2 will be released today
  - Due Apr 13, 11:59 PM
- Reading
  - Liang
    - Chapters 5 and 6

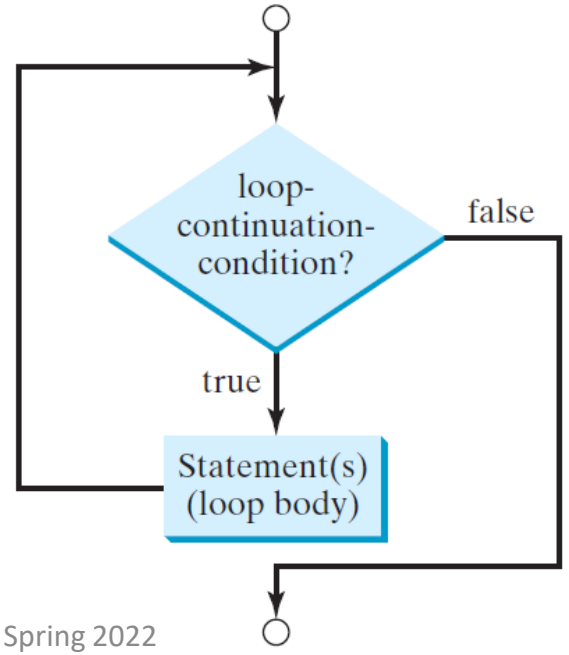
Loops

- `while` loops
- `do-while` loops
- `for` loops

`while` loops

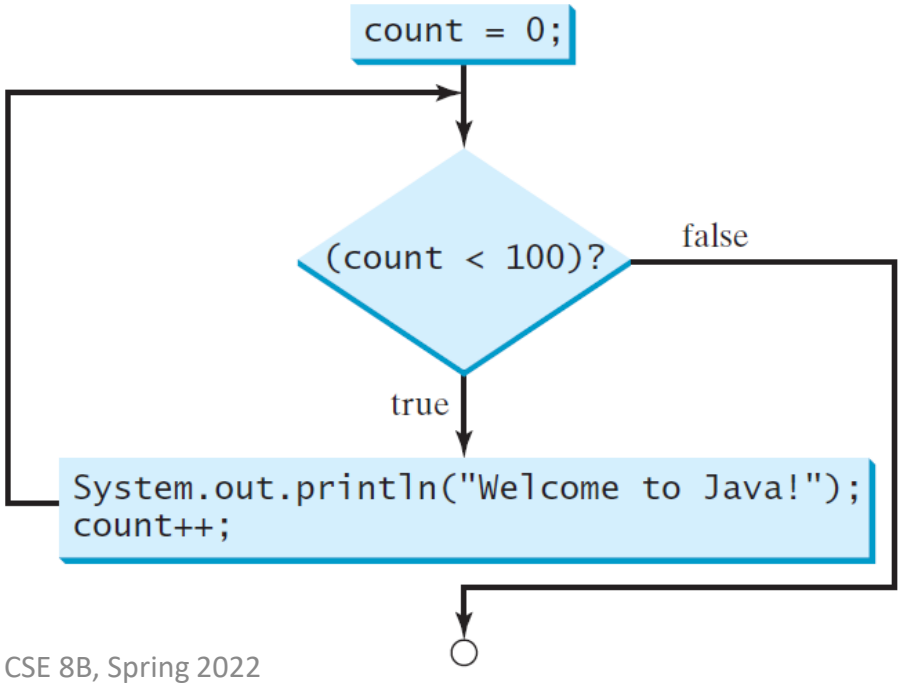
- Executes statements repeatedly while the condition is true

```
while (loop-continuation-condition) {
  // loop-body
  Statement(s);
}
```



while loops

```
int count = 0;
while (count < 100) {
  System.out.println("Welcome to Java");
  count++;
}
```



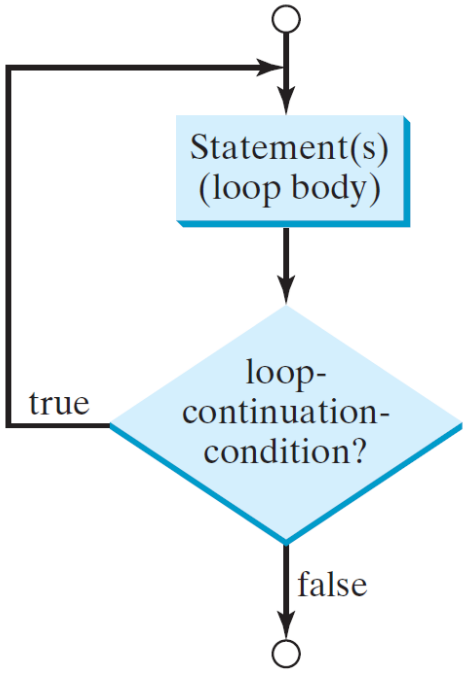
Ending a loop with a sentinel value

- Often the number of times a loop is executed is not predetermined
- You may use an input value to signify the end of the loop
- Such a value is known as a *sentinel value*
- For example, a program reads and calculates the sum of an unspecified number of integers. The input 0 signifies the end of the input.

do-while loops

- Execute the loop body first, then checks the loop continuation condition

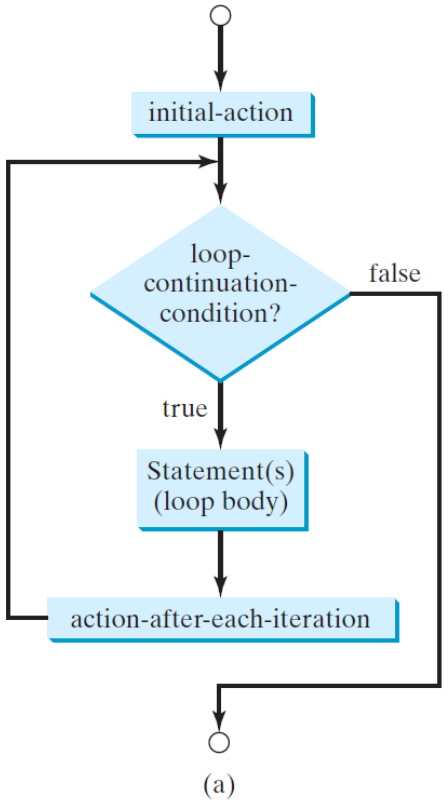
```
do {
  // Loop body
  Statement(s);
} while (loop-continuation-condition);
```



for loops

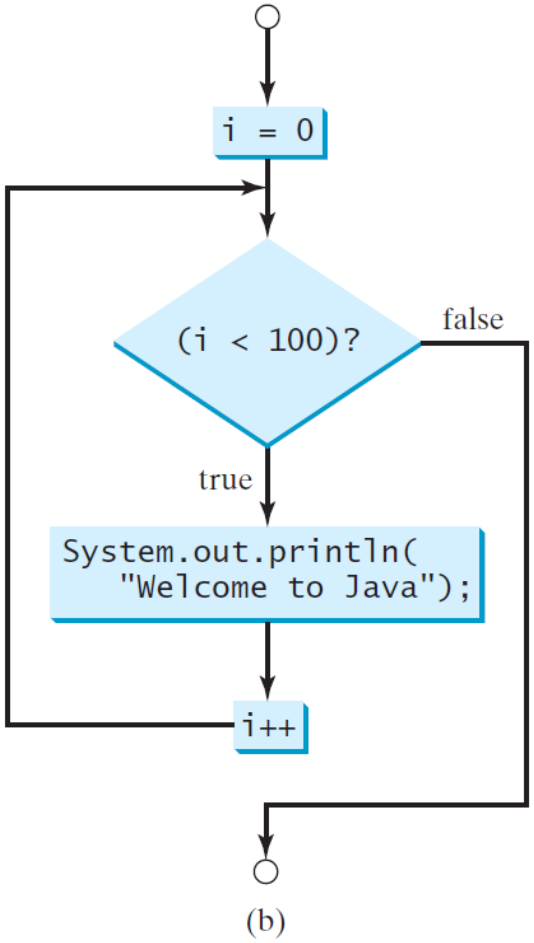
- A concise syntax for writing loops

```
for (initial-action; loop-continuation-condition;
   action-after-each-iteration) {
    // loop body
    Statement(s);
}
```



for loops

```
int i;
for (i = 0; i < 100; i++) {
  System.out.println(
     "Welcome to Java!");
}
```



(b)

for loops

- The initial-action in a for loop can be a list of zero or more comma-separated expressions
- The action-after-each-iteration in a for loop can be a list of zero or more comma-separated statements
- However, it is best practice (less error prone) **not to use comma-separated** expressions and statements

```
for (int i = 0, j = 0; (i + j < 10); i++, j++) {
  // Do something
}
```

Loops and floating-point accuracy

- Remember, calculations involving floating-point numbers are approximated because these numbers are not stored with complete accuracy
- As such, **do not use floating-point values for equality checking in a loop control**

```
double sum = 0;
double item = 1;
while (item != 0) { // No guarantee item will be 0
   sum += item;
   item -= 0.1;
}
System.out.println(sum);
```

Infinite loops

- If the loop-continuation-condition in a for loop is omitted, it is implicitly true

```
for ( ; ; ) {
  // Do something
}
```

(a)

Equivalent

```
while (true) {
  // Do something
}
```

(b)

Loops

- The three forms of loop statements, `while`, `do-while`, and `for`, are expressively equivalent
  - You can write a loop in any of these three forms

```
while (loop-continuation-condition) {
  // Loop body
}
```

(a)

Equivalent

```
for ( ; loop-continuation-condition; )
  // Loop body
}
```

(b)

```
for (initial-action;
     loop-continuation-condition;
     action-after-each-iteration) {
  // Loop body;
}
```

(a)

Equivalent

```
initial-action;
while (loop-continuation-condition) {
  // Loop body;
  action-after-each-iteration;
}
```

(b)

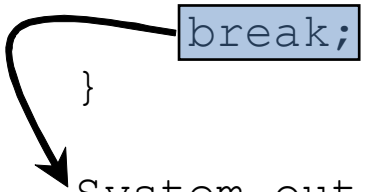
Loops

- Use the loop form that is most intuitive and comfortable
  - A `for` loop may be used if the number of repetitions is known
  - A `while` loop may be used if the number of repetitions is not known
  - A `do-while` loop can be used to replace a `while` loop if the loop body must be executed before testing the continuation condition

break

- Immediately terminate the loop

```
public class TestBreak {
  public static void main(String[] args) {
    int sum = 0;
    int number = 0;

    while (number < 20) {
      number++;
      sum += number;
      if (sum >= 100)
        break;
    }

    System.out.println("The number is " + number);
    System.out.println("The sum is " + sum);
  }
}
```



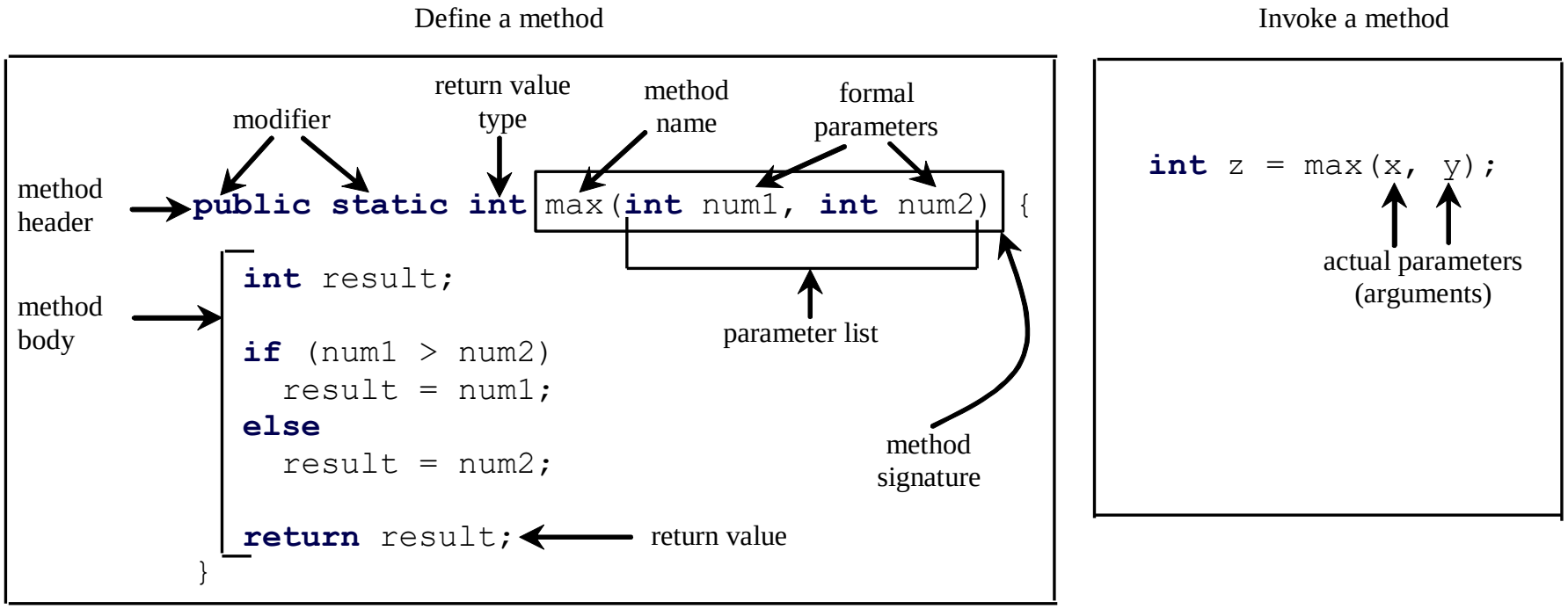
continue

- End the current iteration
  - Program control goes to the end of the loop body

```
public class TestContinue {
  public static void main(String[] args) {
    int sum = 0;
    int number = 0;

    while (number < 20) {
      number++;
      if (number == 10 || number == 11)
        continue;
      sum += number;
    }

    System.out.println("The sum is " + sum);
  }
}
```

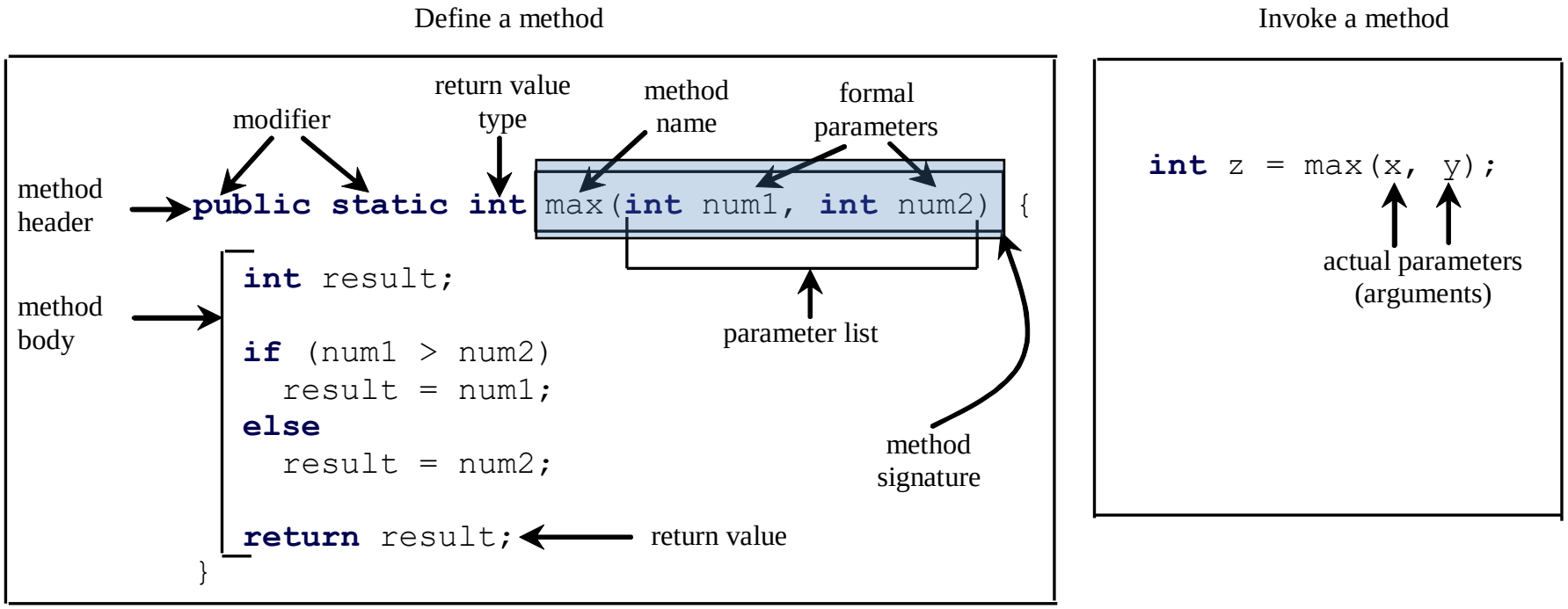
Defining methods

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



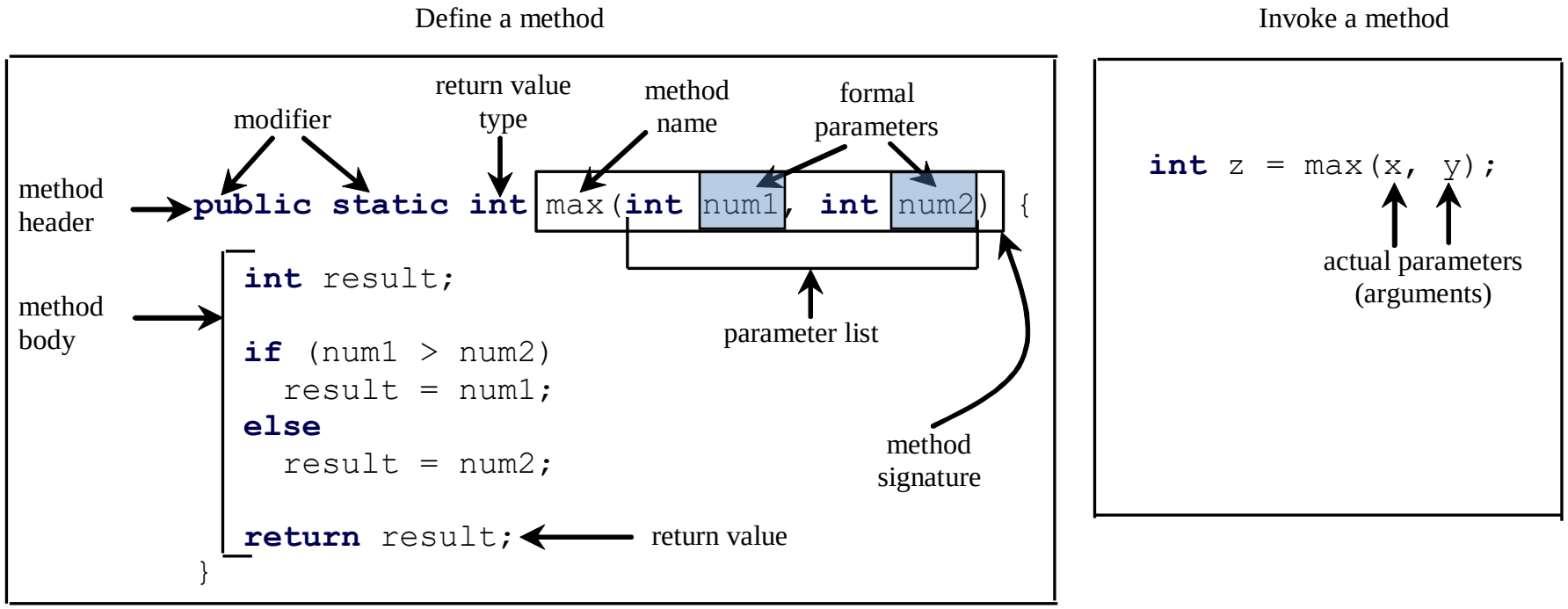
Method signature

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



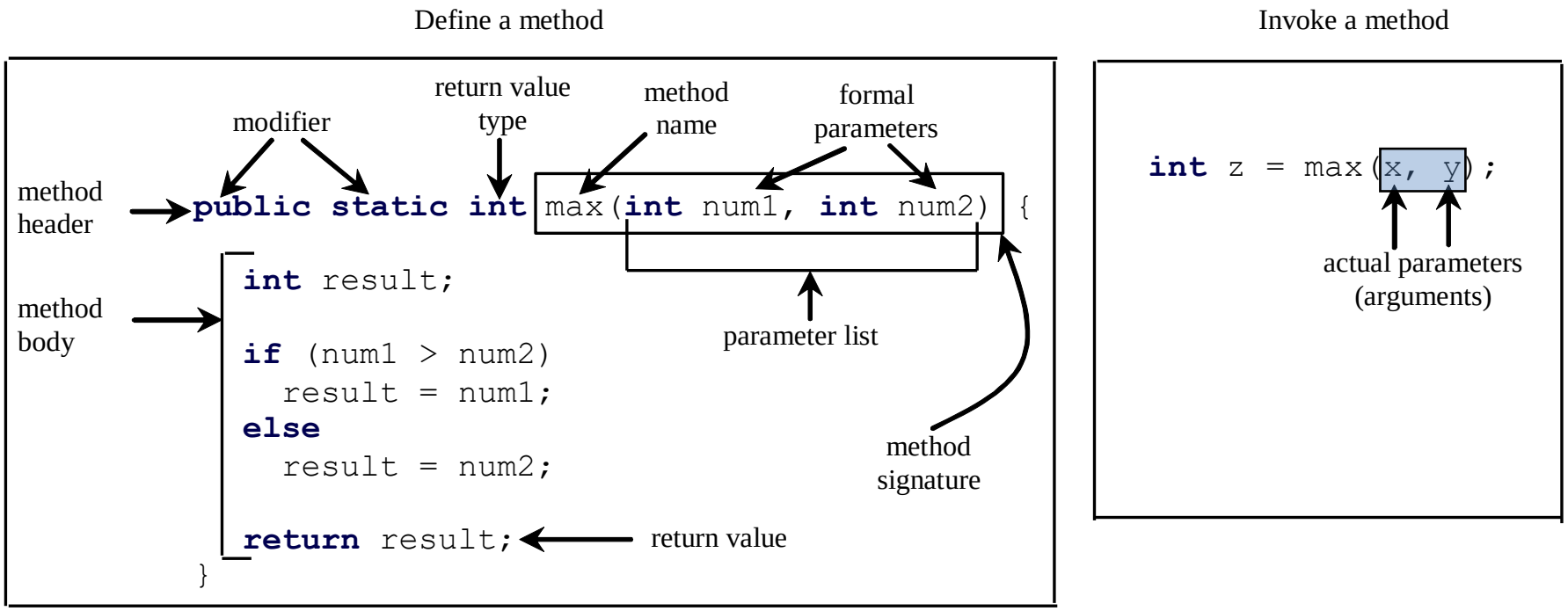
Formal parameters

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



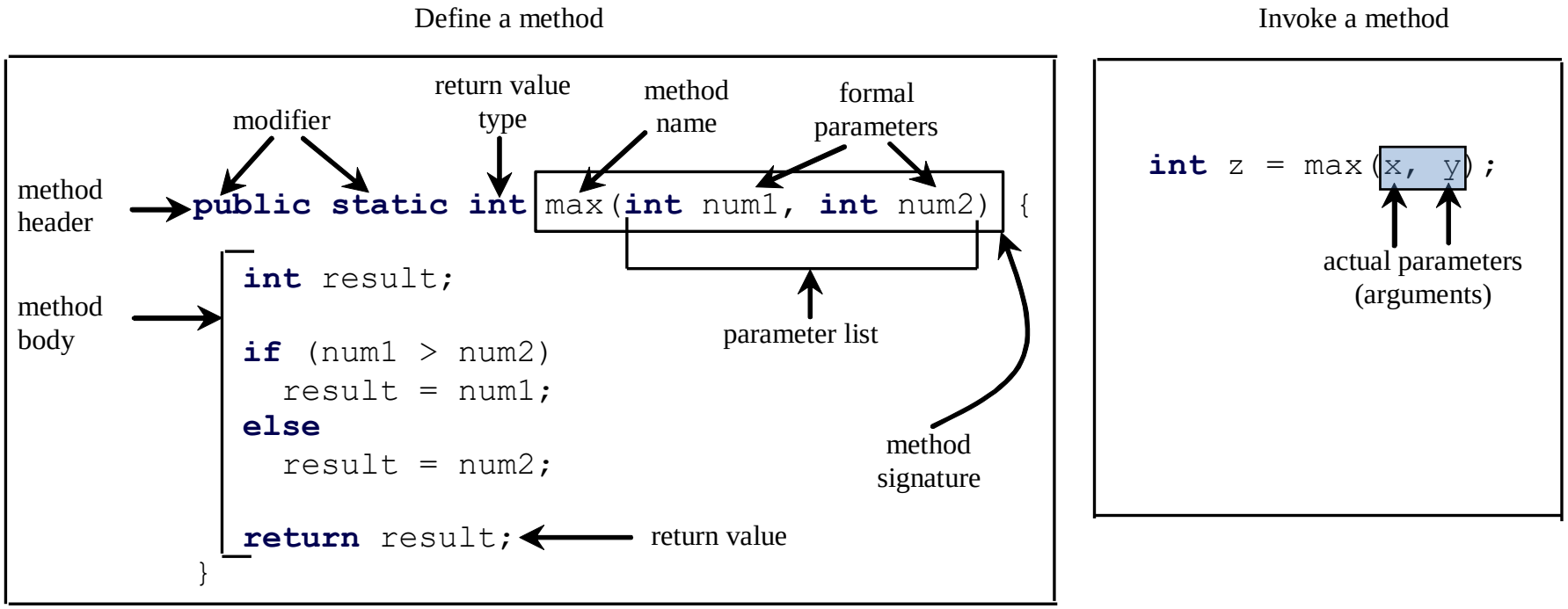
Actual parameters

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



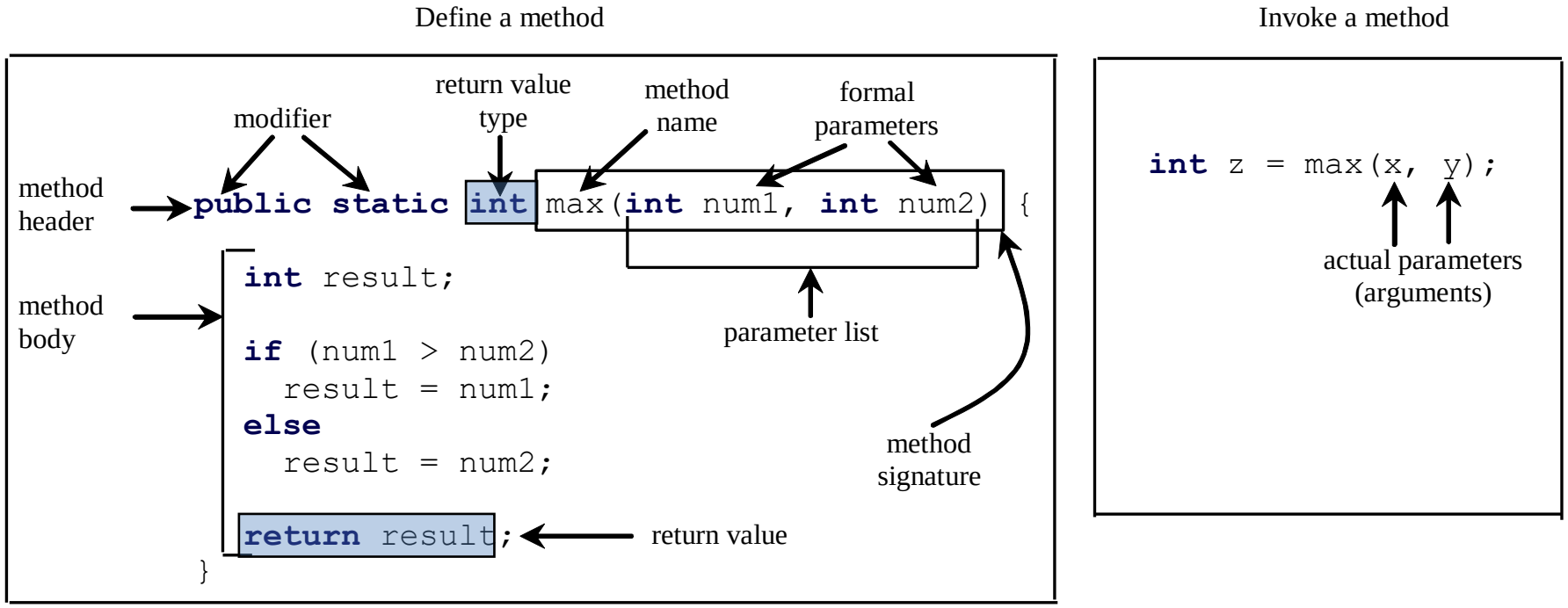
Pass by value

- 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

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`

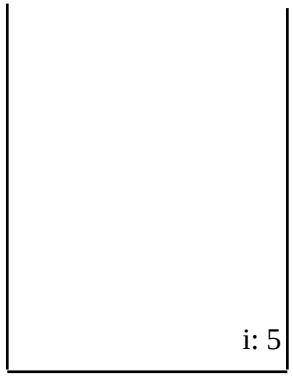
```
public class TestMax {
  public static int max(int num1, int num2) {
    int result;

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

    return result;
  }
}
```

Trace code

i is declared and initialized

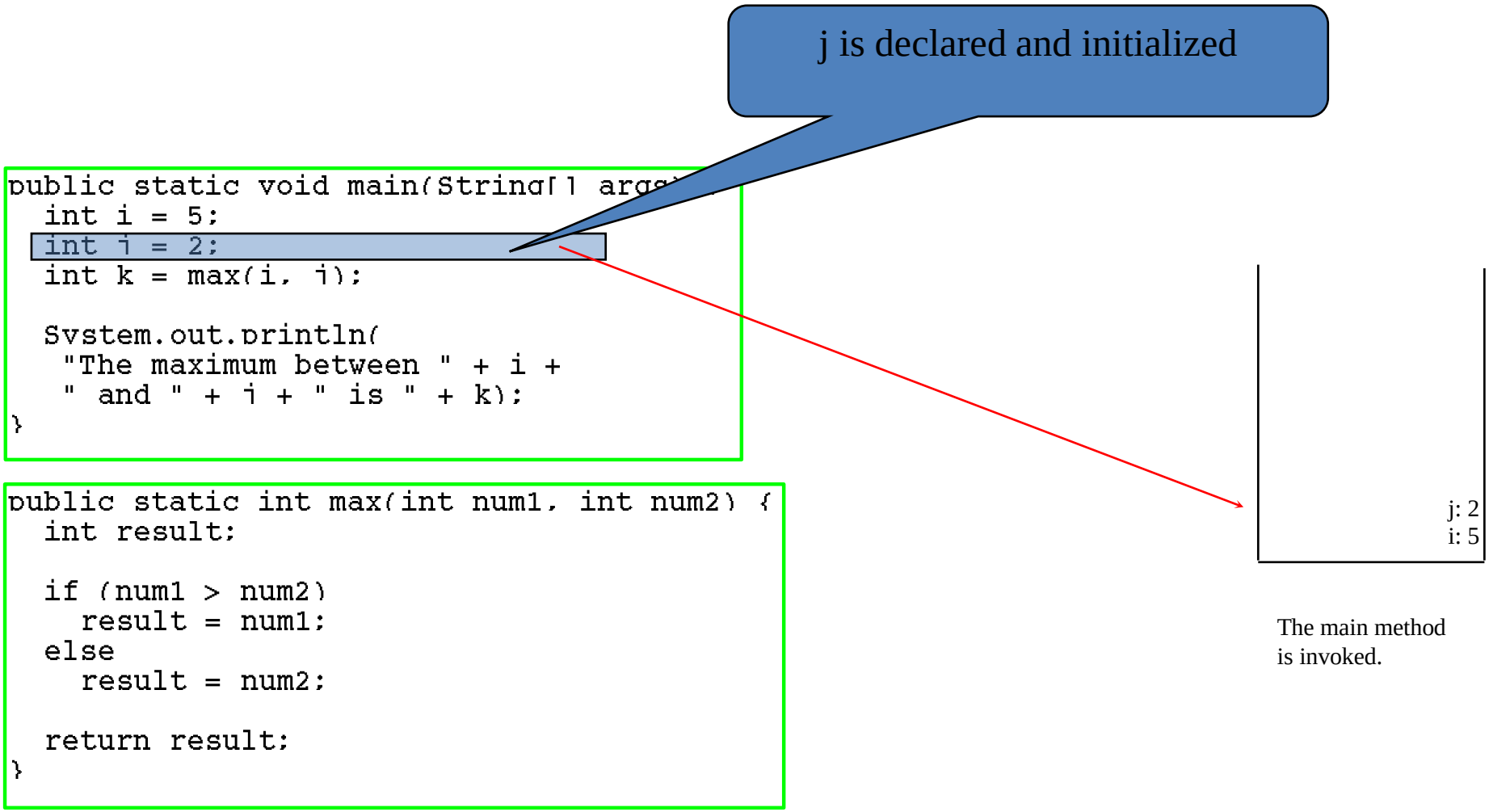
```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  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;
}
```

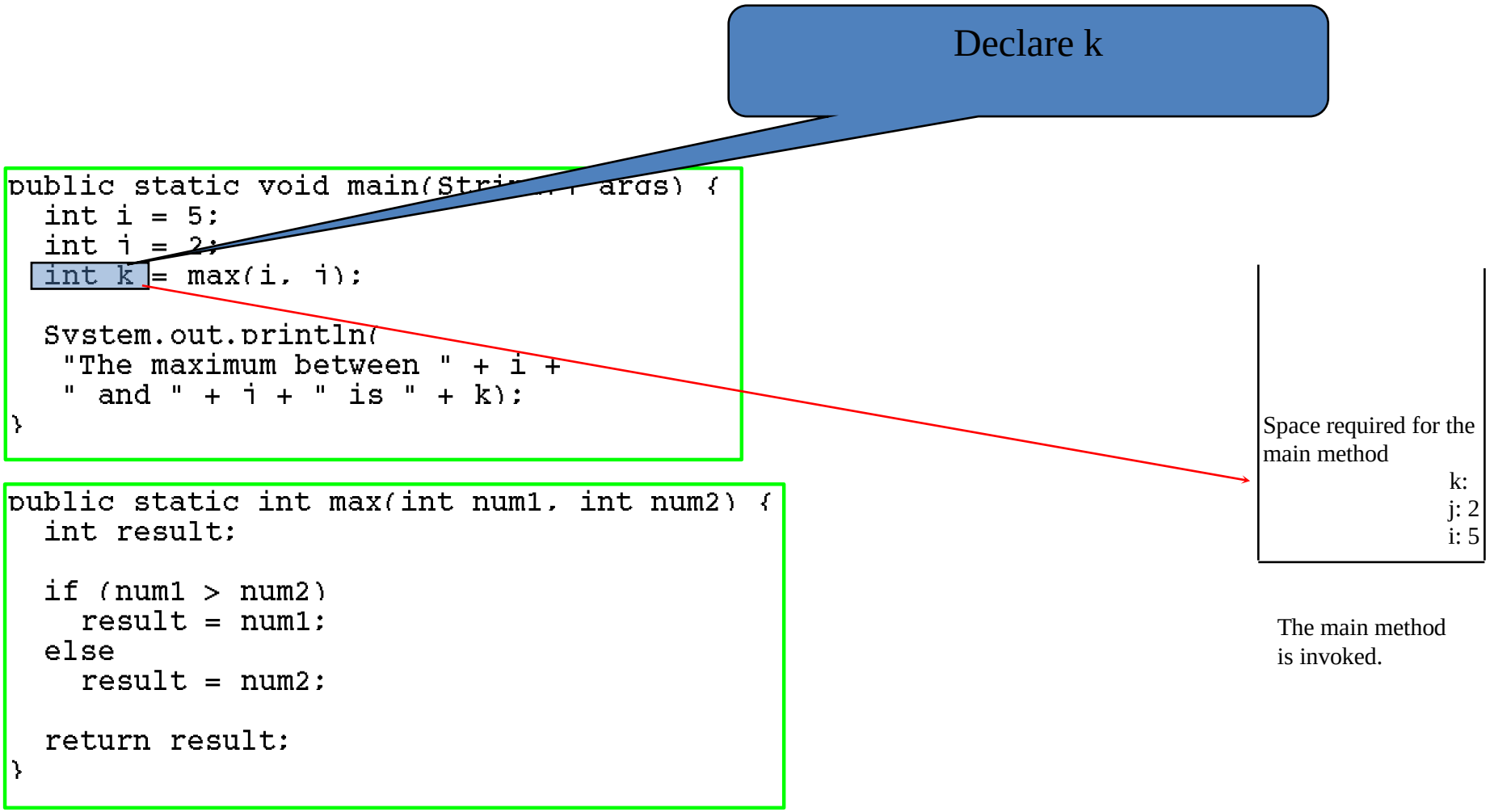


The main method is invoked.

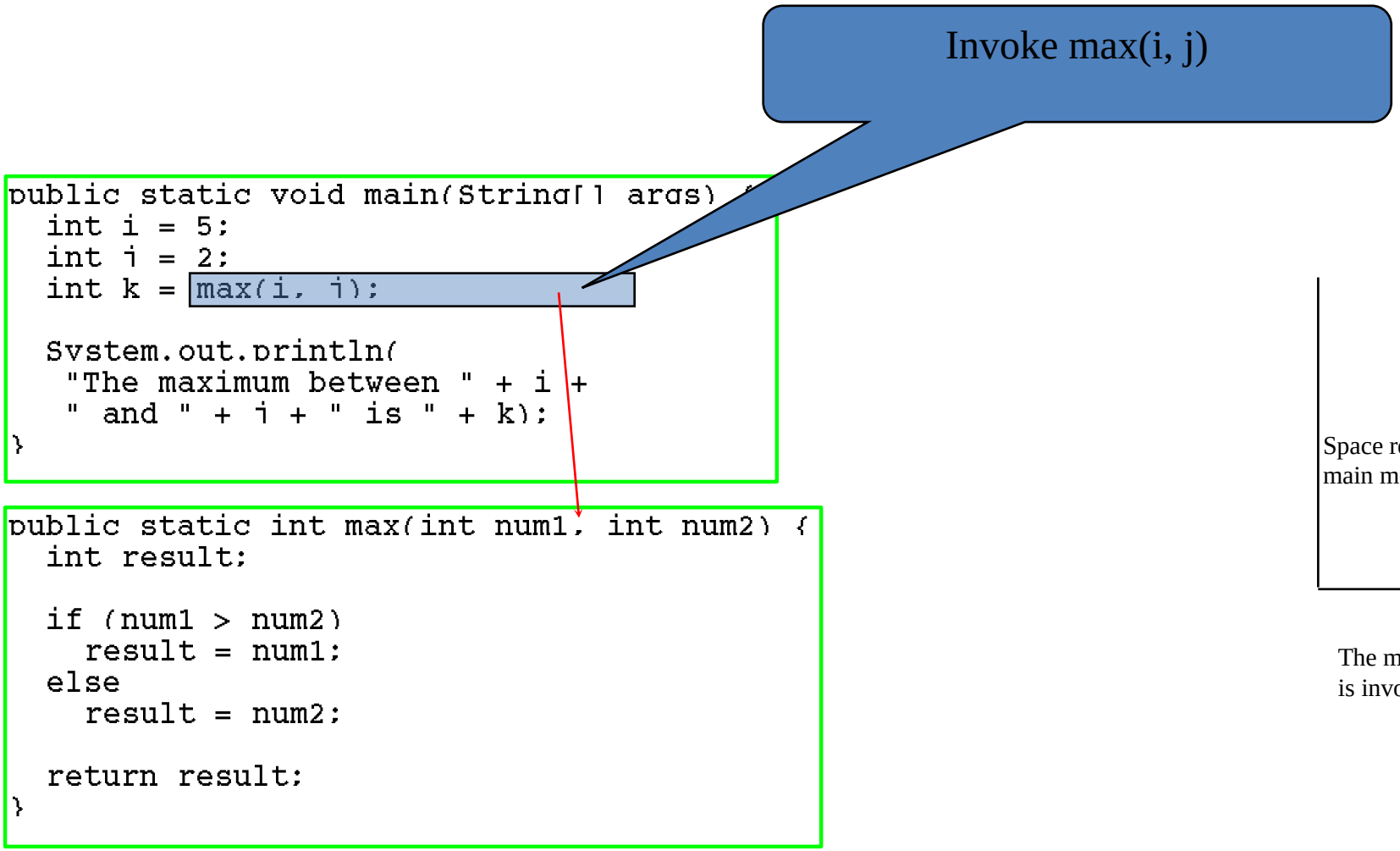
Trace code


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

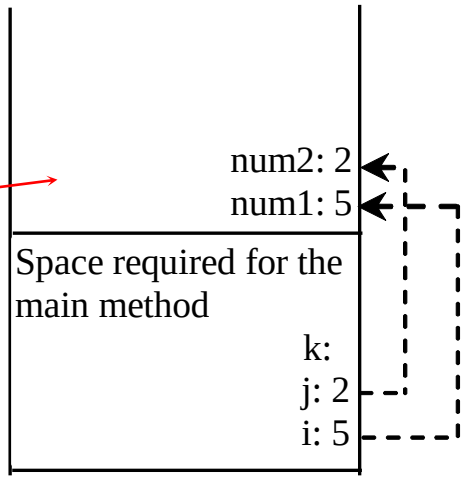

Invoke max(i, j)
public static void main(String[] args) {
int i = 5;
int j = 2;
int k = max(i, j);
System.out.println(
"The maximum between " + i +
" and " + j + " is " + k);
}
public static int max(int num1, int num2) {
int result;
if (num1 > num2)
result = num1;
else
result = num2;
return result;
}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



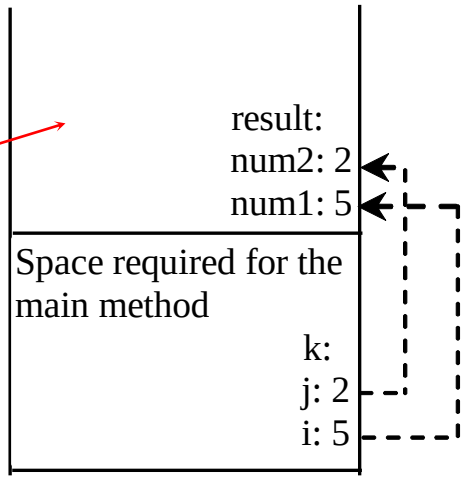
The max method is invoked.

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



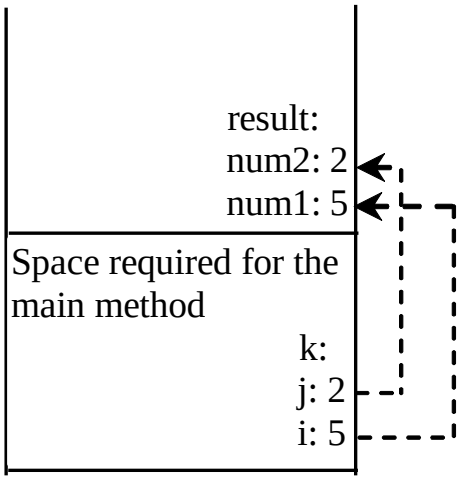
The max method is invoked.

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



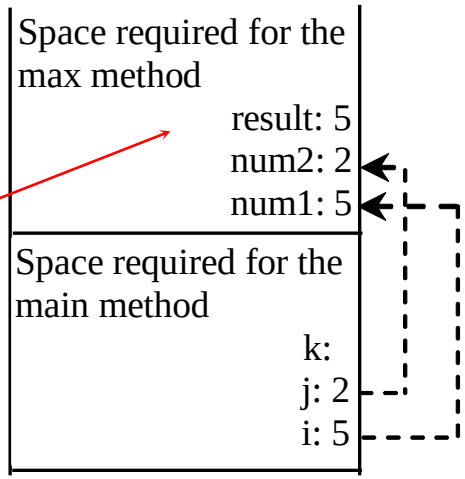
The max method is invoked.

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);
}
```

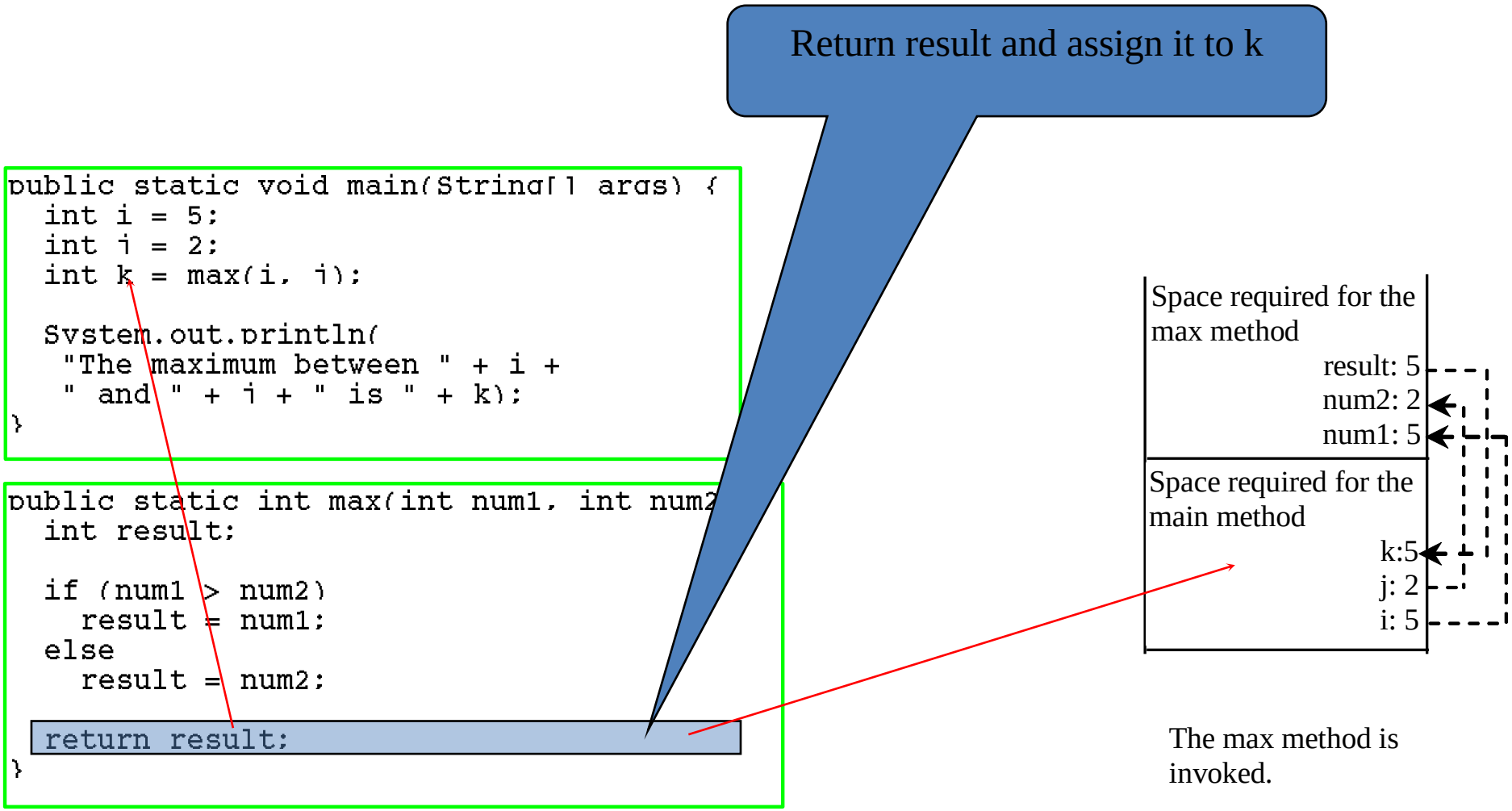
```
public static int max(int num1, int num2)
  int result;

  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

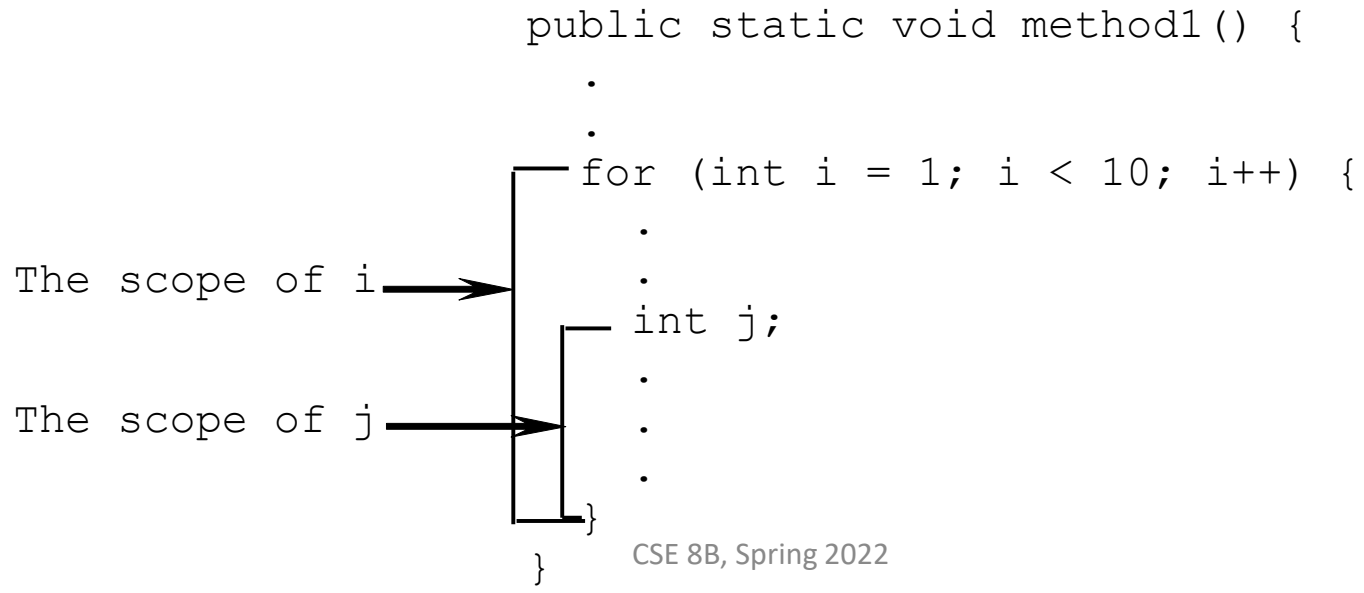
- The Java compiler determines which method to use based on the method signature
- Sometimes there may be two or more possible matches for an invocation of a method, but the compiler cannot determine the most specific match
- This is referred to as *ambiguous invocation*
- Ambiguous invocation is a compile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

Scope of local variables

- A variable declared in the initial action part of a `for` loop header has its scope in the entire loop
- A variable declared inside a `for` loop body has its scope limited in the loop body from its declaration and to the end of the block that contains the variable

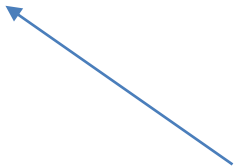


Scope of local variables

```
// Fine with no errors
public static void correctMethod() {
  int x = 1;
  int y = 1;
  // i is declared
  for (int i = 1; i < 10; i++) {
    x += i;
  }
  // i is declared again
  for (int i = 1; i < 10; i++) {
    y += i;
  }
}
```

Scope of local variables

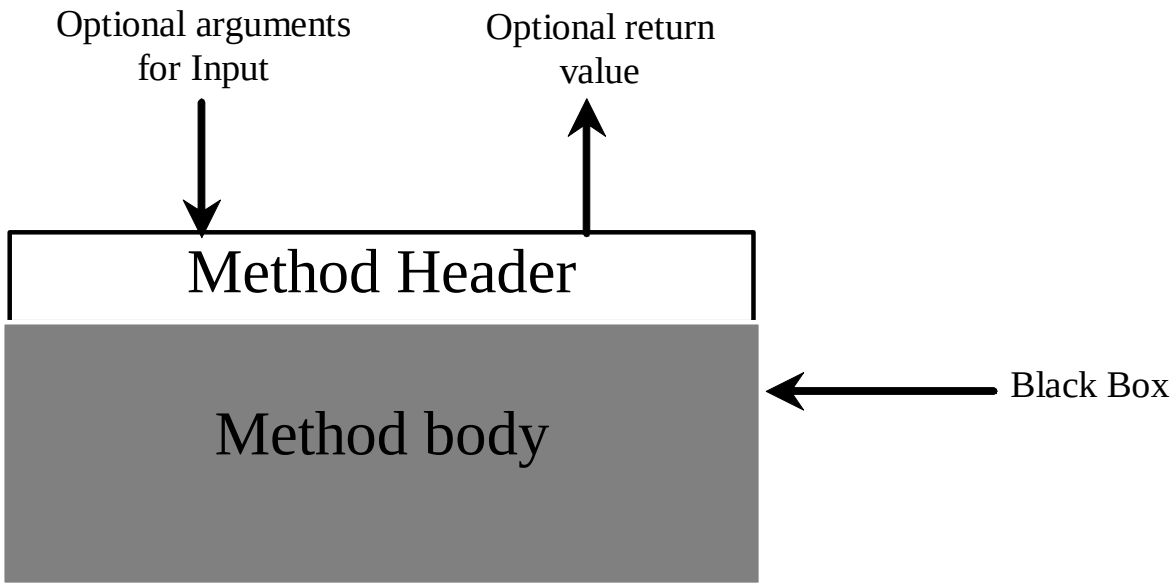
```
// With errors
public static void incorrectMethod() {
  int x = 1;
  int y = 1;
  for (int i = 1; i < 10; i++) {
    int x = 0;
    x += i;
  }
}
```



Compile error: duplicate local variable

Method abstraction

- You can think of the method body as a black box that contains the detailed implementation for the method



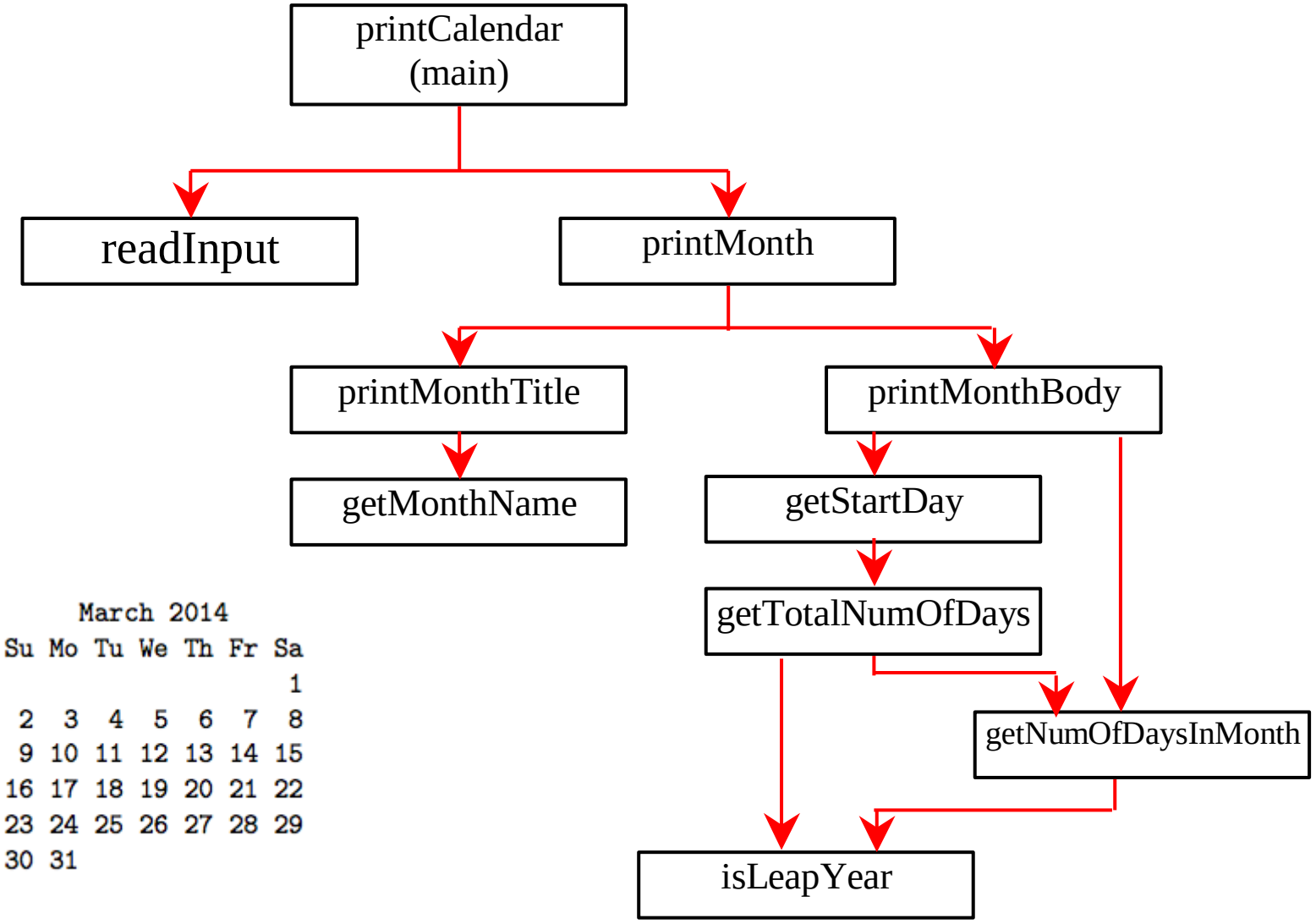
Benefits of methods

- 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
```

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

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

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

- Single-dimensional arrays
- Multidimensional arrays
- Reading
  - Liang
    - Chapters 7 and 8