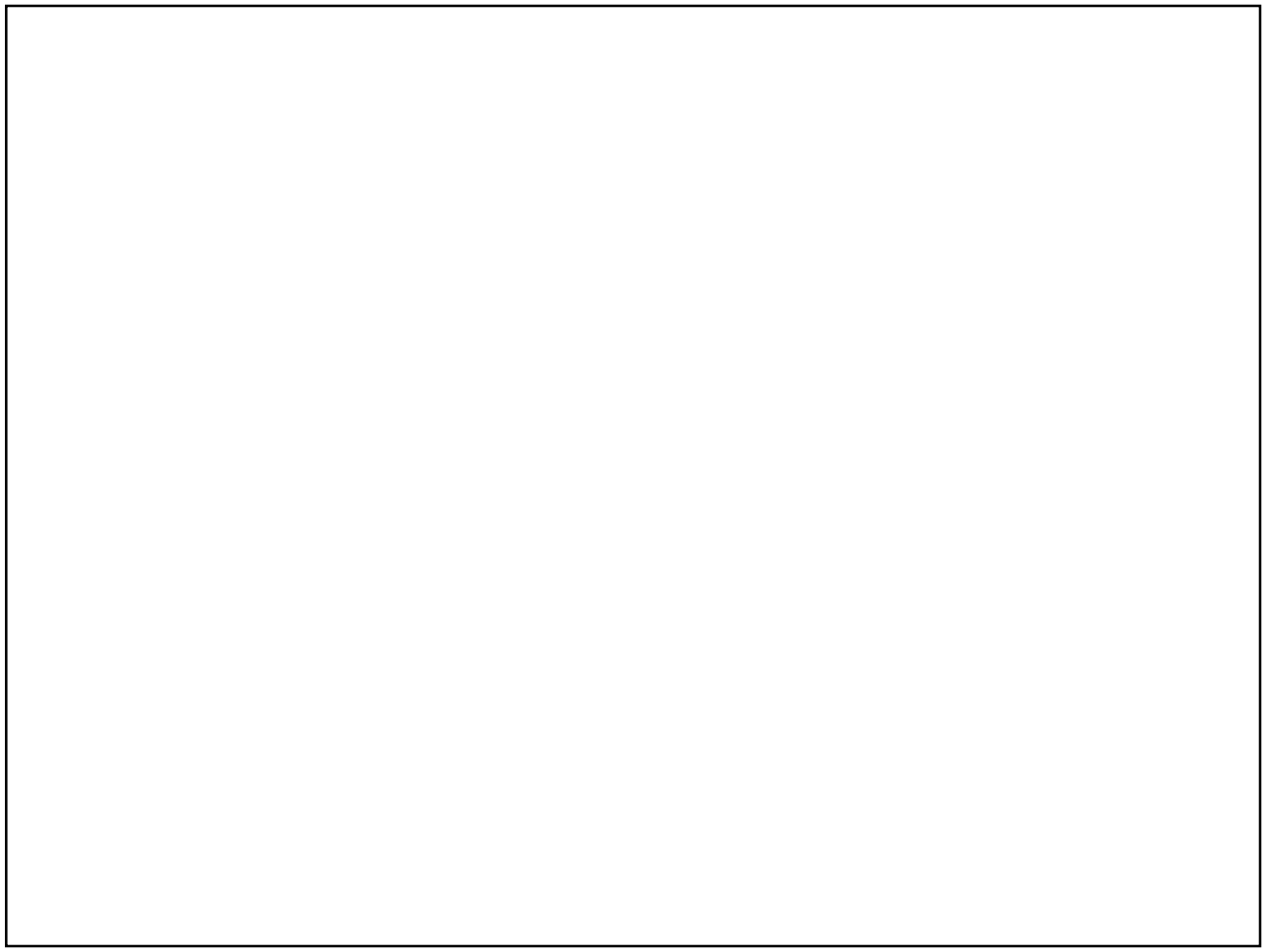
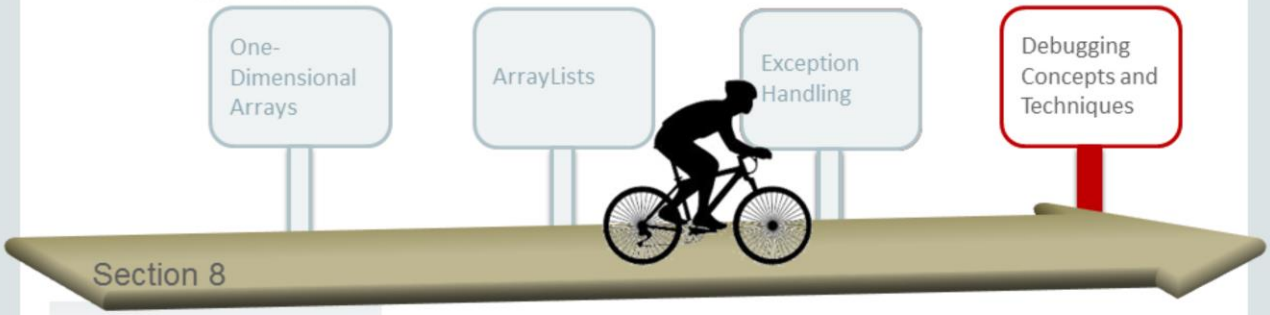


Topics

- Testing and Debugging a Java Program
- Three Types of Errors
- Debugging Techniques: `print` Statements
- Debugging Techniques: NetBeans Debugger
- Debugging Tips



Testing a Java Program

Richie wrote a Java program to find the maximum among three integers:

```
public static void main(String[] args) {
    int num1 = 3, num2 = 3, num3 = 3;
    int max = 0;
    if (num1 > num2 && num1 > num3) {
        max = num1;
    }
    if (num2 > num1 && num2 > num3) {
        max = num2;
    }
    if (num3 > num1 && num3 > num2) {
        max = num3;
    }
    System.out.println(" The max of 3 numbers is " + max);
}
```

Testing a Java Program

- Richie tested it on many sets of data, such as <3,5,9>, <12,1,6>, and <2,7,4>.
- The program works for all data.
- However, he was told that the program doesn't work and he couldn't figure out why.

Exercise 1

- Import and open the `DebuggingEx` project.
- Observe `MaxIntegers.java`.
- Can you identify what Richie missed in his testing?

Identify the Error

- The program fails when it's tested with **duplicate values**, such as <3,3,3> and <7,2,7>, and it displays the output as zero.
- You identified the error.
- The next step is to fix the error.

Fix the Error

Modify the program and test it on many data sets, including duplicate values.

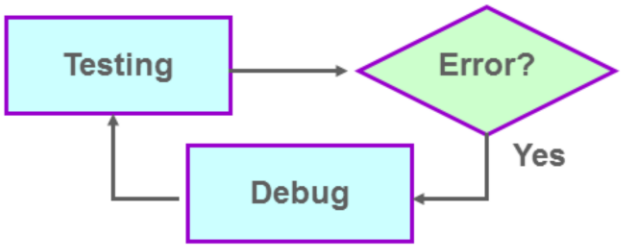
```
public static void main(String[] args) {
    int num1 = 3, num2 = 3, num3 = 3;
    int max = 0;
    if (num1 > max) {
        max = num1;
     }
     if (num2 > max) {
        max = num2;
     }
     if (num3 > max) {
         max = num3;
     }
     System.out.println(" The max of 3 numbers is " + max);
}
```

Testing and Debugging

As you observed from the previous example, testing and debugging are important activities in software development.

Testing and Debugging

- Testing:
  - To determine if a code contains errors
- Debugging:
  - To identify an error and fix it



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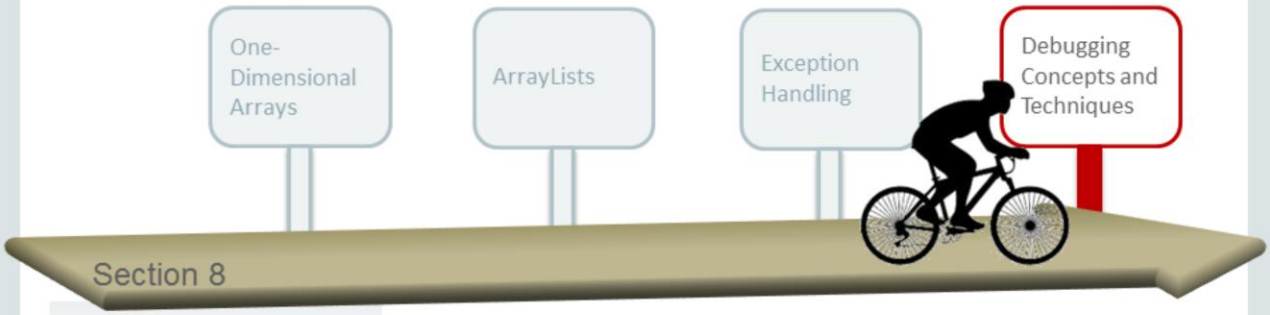

Three Types of Errors

- Compilation errors
- Logic errors
- Runtime errors

Compilation Errors

- Syntax error
- Easiest type of errors to fix
- Examples:
  - Example 1: Missing semicolon

```
int a = 5 // semicolon is missing
```

  - Example 2: Errors in expression

```
x = ( 3 + 5; // missing closing parenthesis
y = 3 + * 5;// missing argument between '+' and '*'
```

Logic Errors

- Program runs but produces incorrect result.
- Hard to characterize, and so it's hardest to fix.
- Example: Noninitialized variable

```
int i;
i++;  // the variable  i  isn't initialized
```

Runtime Errors

- These errors occur at run time.
- Java's exception handling mechanism can catch such errors.
- Some of the common exceptions:
  - `ArrayIndexOutOfBounds`
  - `NullPointerException`
  - `ArithmeticException`

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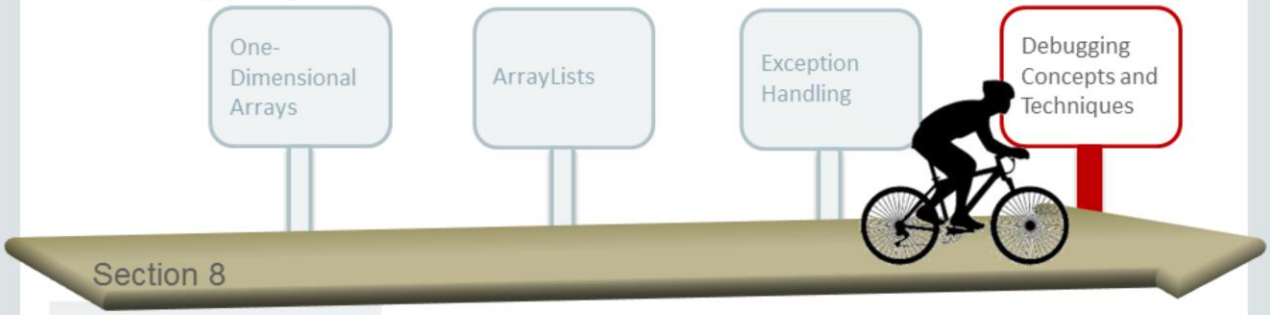

Debugging Techniques

Let's look at two debugging techniques:

- Using `print` statements
- Using the NetBeans debugger

`print` Statements: Advantages

- Easy to add
- Provide information
  - Which methods have been called
  - The value of parameters
  - The order in which methods have been called
  - The values of local variables and fields at strategic points

`print` Statements: Disadvantages

- It isn't practical to add `print` statements to every method.
- Too many `print` statements lead to information overload.
- Removal of `print` statements is tedious.

`print` Statements: Example

- Consider this Java code :

```
int n = 10;
int sum = 10;
while (n > 1){
    sum = sum + n;
    n--;
}
System.out.println("The sum of the integers 1 to 10 is " + sum);
```

- On running this program, it doesn't work correctly.
- To find out what's wrong, you can trace the value of the `n` and `sum` variables by inserting `print` statements.

Modified Program with Additional `print` Statements for Debugging

```
int n = 10;
int sum = 10;
while (n > 1) {
    System.out.println("At the beginning of the loop: n = " + n);
    System.out.println( "At the beginning of the loop:sum="+ sum);
   n--;
    System.out.println("At the end of the loop: n = " + n);
    System.out.println("At the end of the loop: sum = " + sum);
}
System.out.println("The sum of the integers 1 to 10 is " + sum);
```

Output

- Here are the first four lines of the output after the **first iteration** of the loop:

```
At the beginning of the loop: n = 10
At the beginning of the loop: sum = 10
At the end of the loop: n = 9
At the end of the loop: sum = 20
```

- You can see that something is wrong:

  The variable `sum` has been set to 20. Because it was initialized to 10, it's set to 10 + 10, which is incorrect if you want to add the numbers from 1 to 10.

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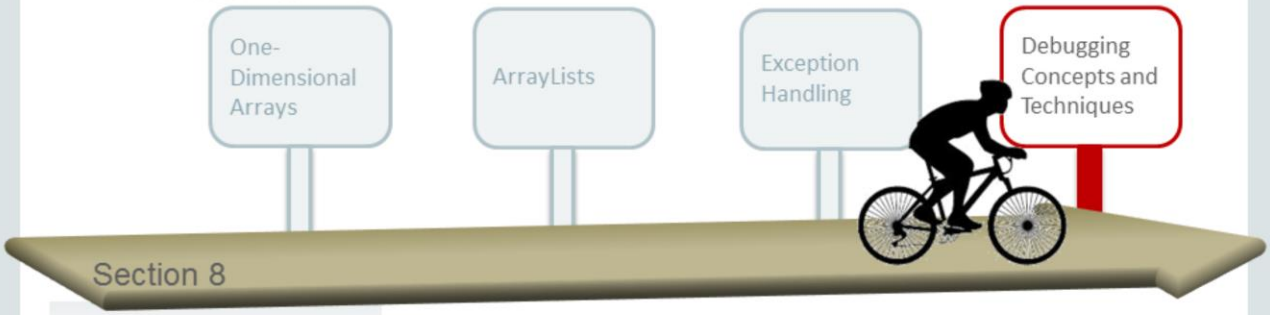


The NetBeans Debugger

- You have already used the NetBeans graphical-based debugging environment.
- You have used the following features of the debugger:
  - Set breakpoints
  - Trace through a program one line at a time
- Let's use another very important feature to view the contents of variables.

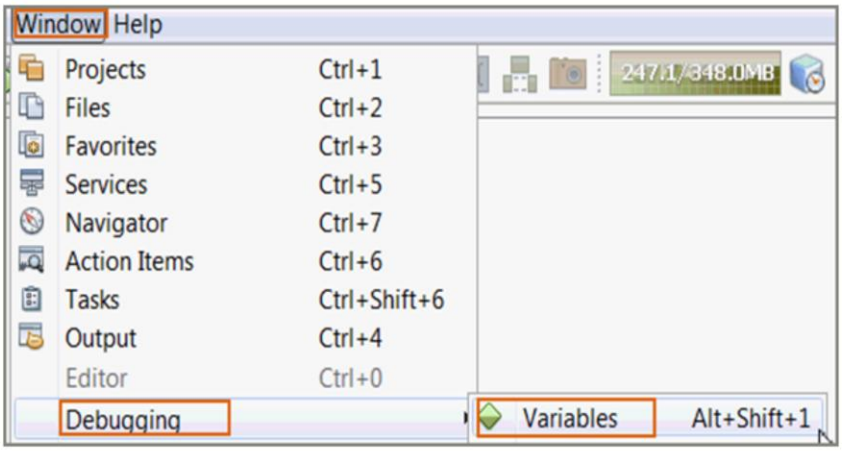
Variables Window

- When you reach a set breakpoint, you can use the Variables window to see the value of the variables at that moment.
- You can find out values of variables without having to put a lot of `print` statements in your program.

Accessing the Variables Window

To see the Variable window, in the NetBeans main menu:

Click Window > Debugging > Variables.



Exercise 2: Scenario

- Let's assume you have a car, and you want to go to the gas station. You have the following details:
  - Car's current position: x1 and y1
  - Gas station's location: x2 and y2
  - Speed of the car

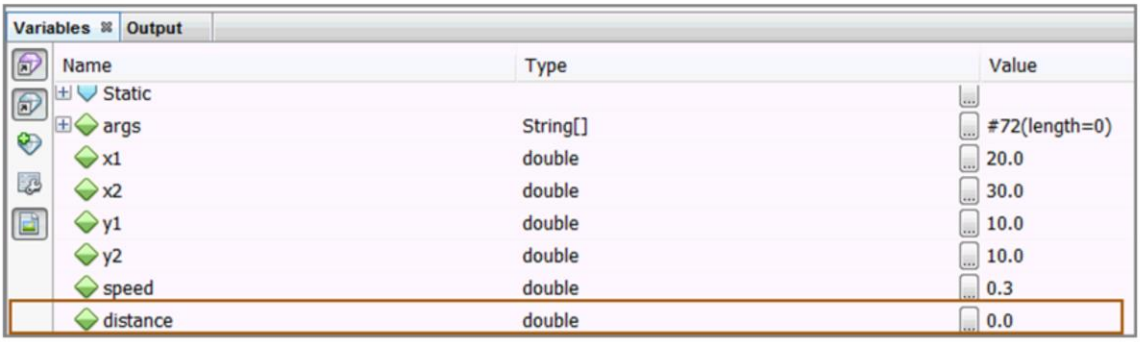
- You want to compute the time it will take for the car from its current position (x1,y1) to reach the gas station (x2,y2).
- A Java program to compute the time by using the time=distance/speed formula is available in the `ComputeTime` project.

Exercise 2

- Import and open the `DebuggingEx` project.
- Observe `ComputeTime.java`.
- Run the program with the NetBeans debugger to debug this program:
  - Set the breakpoint in the `getDistance` method.
  - Press **Step In** to go to the next line  .
  - Observe the values of the `x1, x2, y1, y2, speed, distance,` and `time` variables.
- Can you identify the bug?

Observe the Value of `distance`

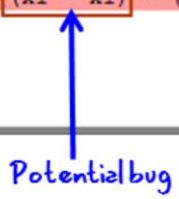
- In the previous exercise using the NetBeans debugging features, you identified the bug:



- As you can see, `distance` is 0.0, the formula for computing distance was wrong, and it caused an incorrect return value for the `distance` variable.

Identifying the Potential Bug

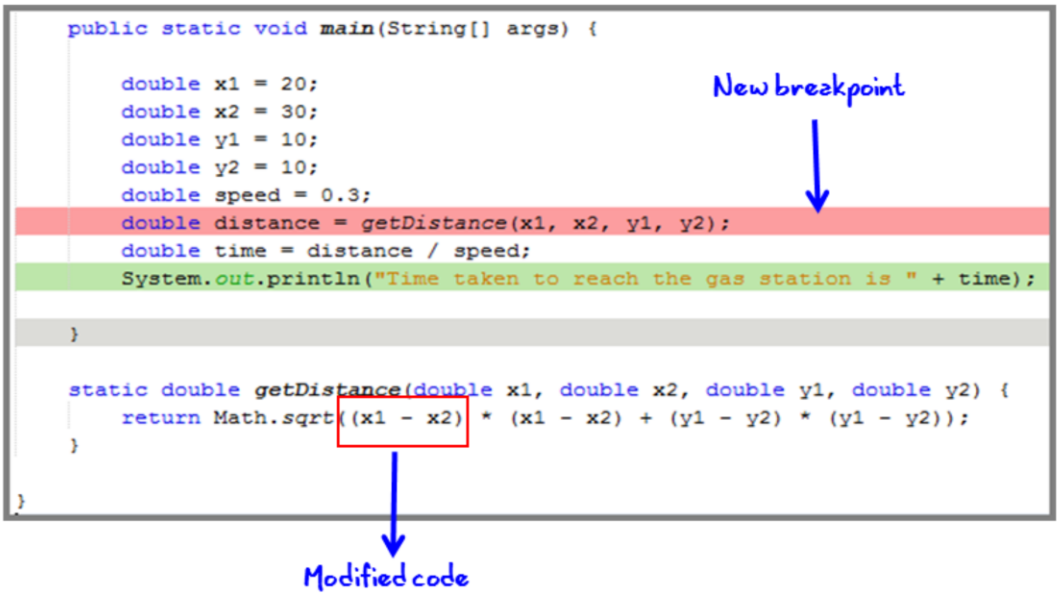
```
    public static void main(String[] args) {

        double x1 = 20;
        double x2 = 30;
        double y1 = 10;
        double y2 = 10;
        double speed = 0.3;
        double distance = getDistance(x1, x2, y1, y2);
        double time = distance / speed;
        System.out.println("Time taken to reach the gas station is " + time);

    }

    static double getDistance(double x1, double x2, double y1, double y2) {
        return Math.sqrt (x1 - x1) * (x1 - x2) + (y1 - y2) * (y1 - y2));
    }

}
```



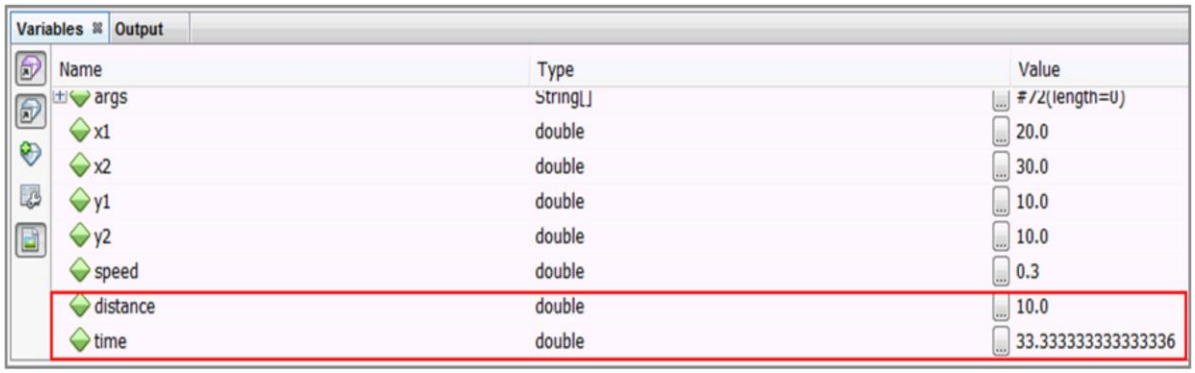
Fixing the Bug

- Because you identified the bug, you can change the location of the breakpoint to where the `getDistance()` method is called.
- This saves having to step through code that you already looked at.
- So let's modify the code and rerun the debugger with the new breakpoint to see what we get.

Rerunning the Debugger



Observing the Variables



- We fixed the bug!
- The `distance` variable is now reporting a value of 10.0, and the `time` variable is now reporting a value of 33.33.

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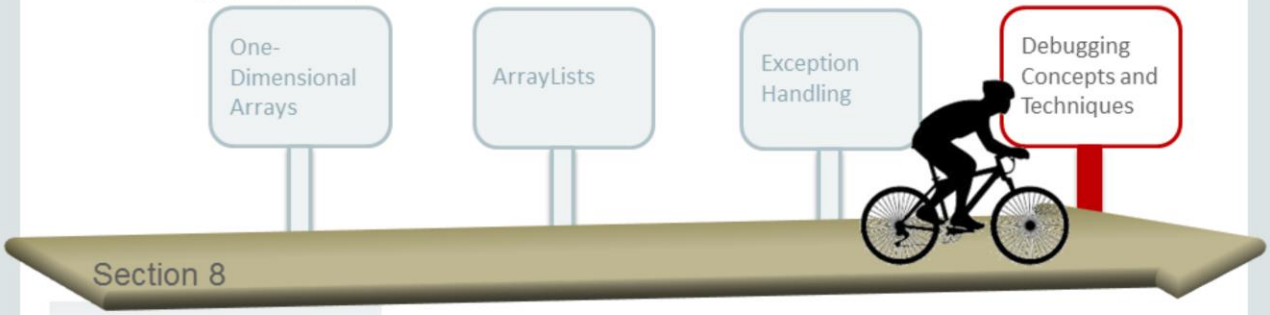

Single Versus Double Equals Operator

Assignment (=) versus Comparison (==) Operator

1. Comparison operator

   `if( x = 0)` instead of `if(x == 0)`

   Look for it in `if`, `for`, and `while` statements.

2. Assignment operator

   `int x == 1;` instead of `int x = 1;`

Misplaced Semicolon

Check for the semicolon after the `if` statement or the `for/while` loop statements.

```
if (x == 0); {
 <statements>
}

instead of

if(x == 0) {
 <statements>
}
```

```
while(<boolean expression>); {
 <statements>
}

instead of

while(<boolean expression>) {
 <statements>
}
```

Invoking Methods with Wrong Arguments

- Method call parameter types must match method definition parameter types.
- For example:
  - Given a method definition:

```
void methodName(int x, char y) I
```

  - Invoke this method:

```
methodName(a, b)
```

Boundary Conditions

- It's important to test the **boundary conditions**.
- The rationale behind testing them is that errors tend to occur near the boundary values of an input variable.
- For example, boundary condition for:
  - Input data (test with valid versus invalid)
  - Loops (beginning and ending of loops)

Testing Boundary Conditions for Loops

- This allows for boundary case tests like “less than” and “greater than” for loop iteration conditions to be accurately tested.
- For example, given this loop:

```
if ( num >= 50 && num <= 100 ) {
//do stuff
}
```

- To test boundary conditions, you would test with numbers near 50 and 100, that is, 49, 50, 51, 99, 100 and 101.

Exercise 3

- Import and open the `DebuggingEx` project.
- Observe `BoundaryTesting.java`.
- Validate the input by executing the program with the following boundary test values for year and month:

Year	Month
1582	2
1583	0
1583	13
1583	1
1583	12

Summary

In this lesson, you should have learned how to:

- Test and debug a Java program
- Identify the three types of errors
- Apply debugging techniques
  - `print` statements
  - NetBeans debugger
- Apply some debugging tips and techniques


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