



Java Foundations

8-4

Debugging Concepts and Techniques



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Objectives

This lesson covers the following objectives:

- 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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Topics

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



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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);  
}
```



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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.



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Exercise 1



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



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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.



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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);  
}
```



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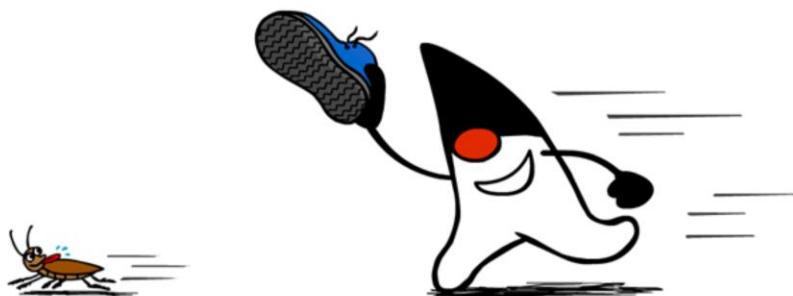
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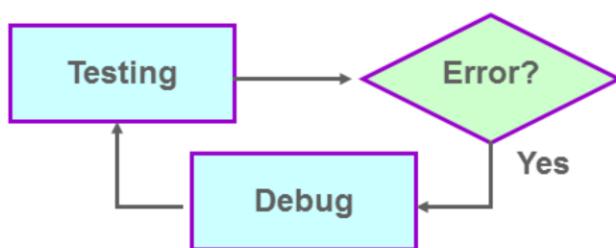
Testing and Debugging

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
- Debugging Techniques: print Statements
- Debugging Techniques: NetBeans Debugger
- Debugging Tips

One-Dimensional
Arrays

ArrayLists

Exception
Handling

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Three Types of Errors

- Compilation errors
- Logic errors
- Runtime errors



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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 '*'



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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
```



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Runtime Errors

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



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Debugging Techniques

Let's look at two debugging techniques:

- Using print statements
- Using the NetBeans debugger



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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



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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.



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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);
```



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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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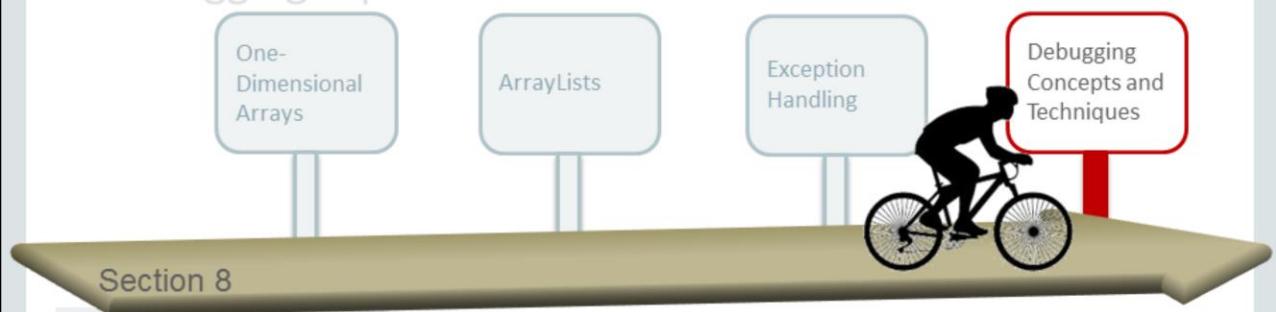
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The NetBeans Debugger

- 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.



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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.



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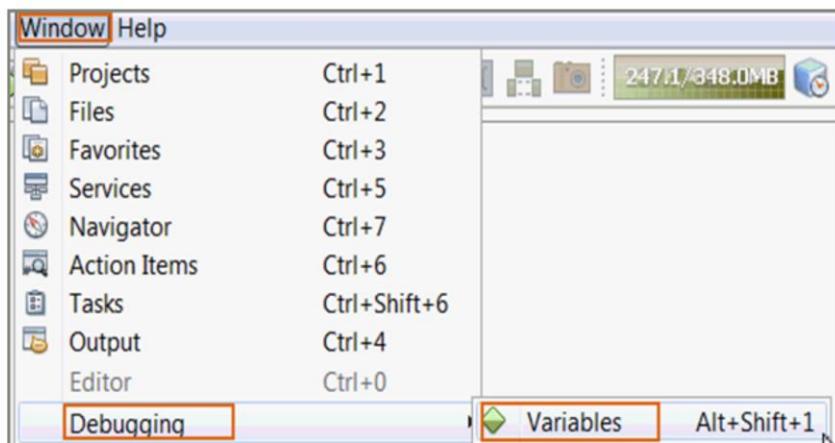
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Accessing the Variables Window

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: x_1 and y_1
 - Gas station's location: x_2 and y_2
 - Speed of the car
- You want to compute the time it will take for the car from its current position (x_1, y_1) to reach the gas station (x_2, y_2) .
- 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:

Variables		Output
Name	Type	Value
Static	String[]	#72(length=0)
args	double	20.0
x1	double	30.0
x2	double	10.0
y1	double	10.0
y2	double	0.3
speed	double	0.0
distance	double	0.0

- 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));  
}
```

Potential bug



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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.



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Rerunning the Debugger

```
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 - x2) * (x1 - x2) + (y1 - y2) * (y1 - y2));  
}  
}
```

New breakpoint

Modified code



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Observing the Variables

Variables		Output	
	Name	Type	Value
args	x1	double	20.0
	x2	double	30.0
	y1	double	10.0
	y2	double	10.0
	speed	double	0.3
	distance	double	10.0
	time	double	33.33333333333336

- 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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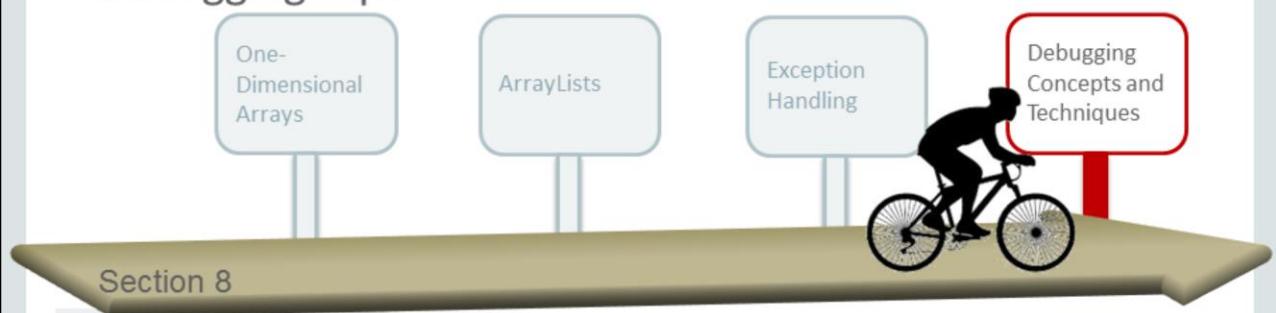
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Single Versus Double Equals Operator

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;`



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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>  
}
```



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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) {
```

- Invoke this method:

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



a must be an int and b must be a char.

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)



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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.



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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



