

Please use the following QR code to check in and record your attendance.

CS 1027

Fundamentals of Computer  
Science II

# Debugging and Testing

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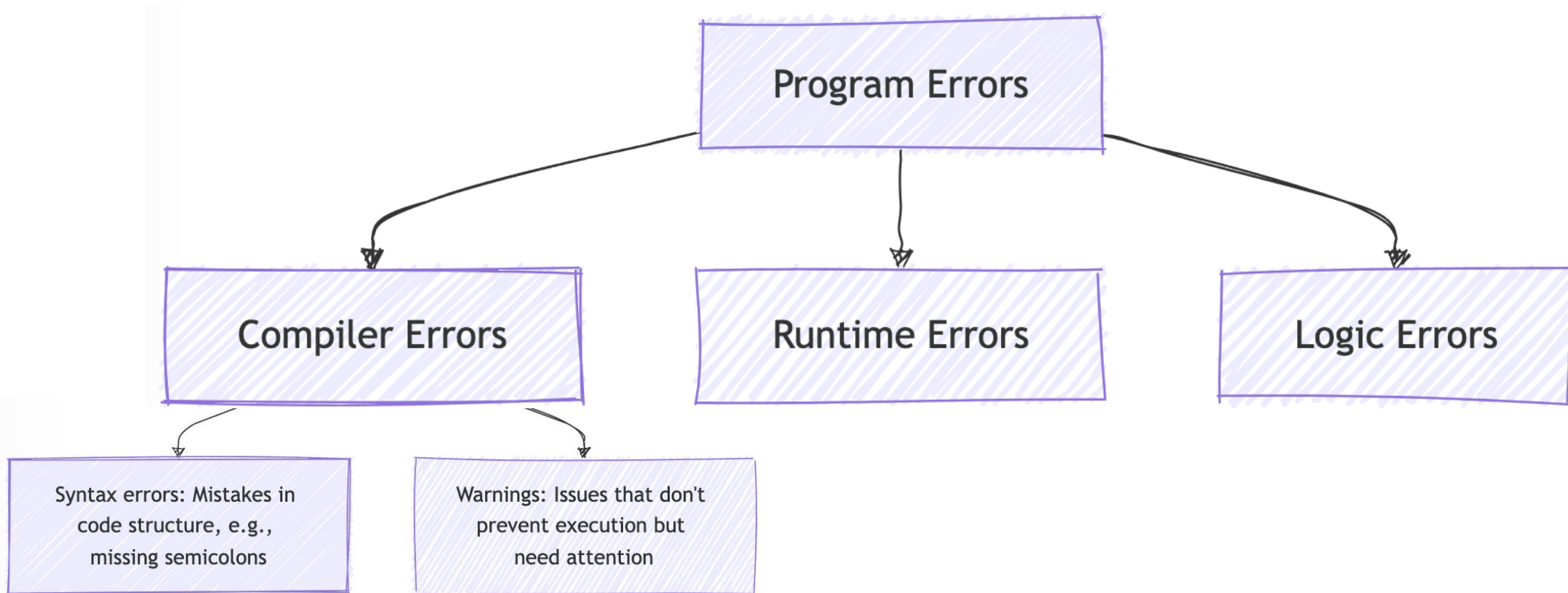
# Debugging



Understanding and Fixing Program Errors

# Recall: Testing and Debugging

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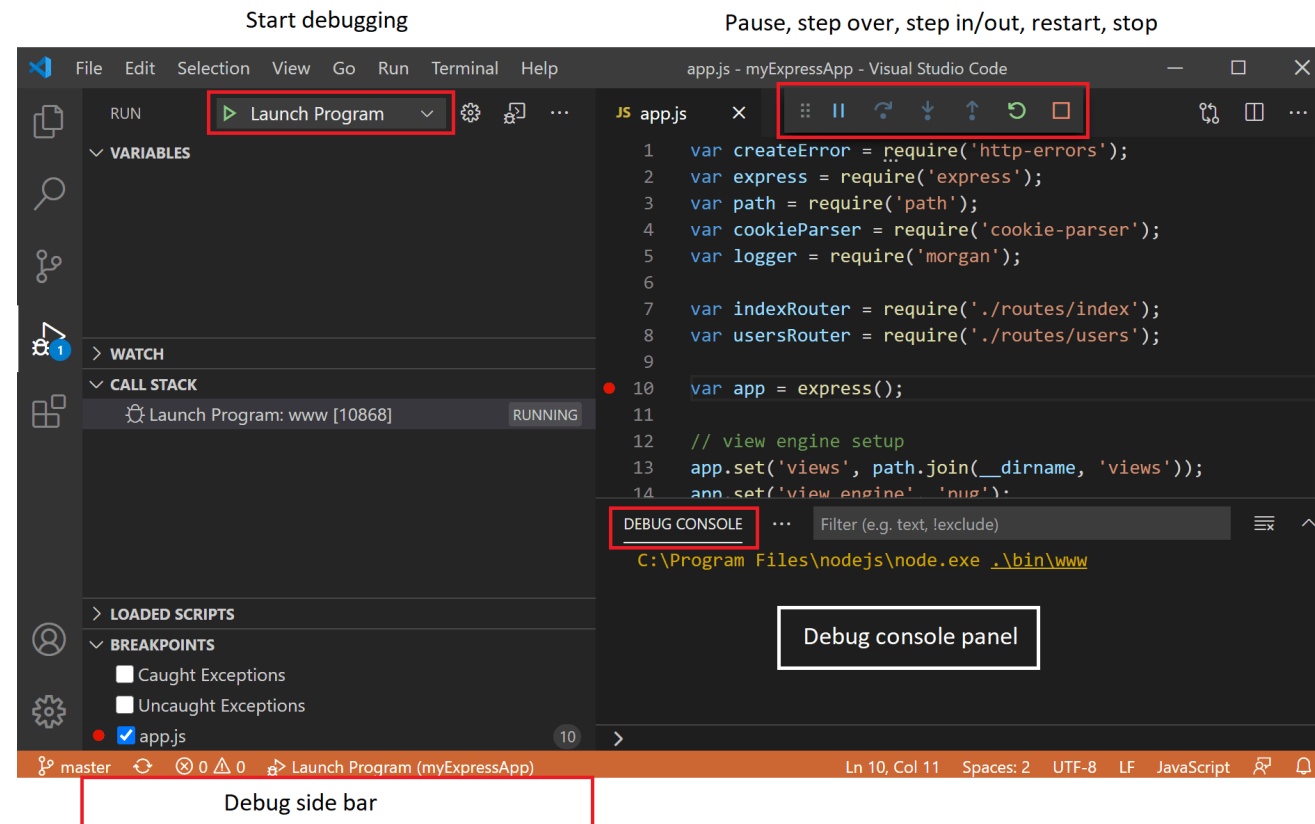


# Recall:

## Why Are Compiler Errors Confusing?

- **Error Location** – The compiler might point to a line that is different from where the actual error is.
- **Unclear Messages** – Sometimes, the error messages are unclear and might require careful interpretation to understand the root cause.

# Using the IDE Debugger



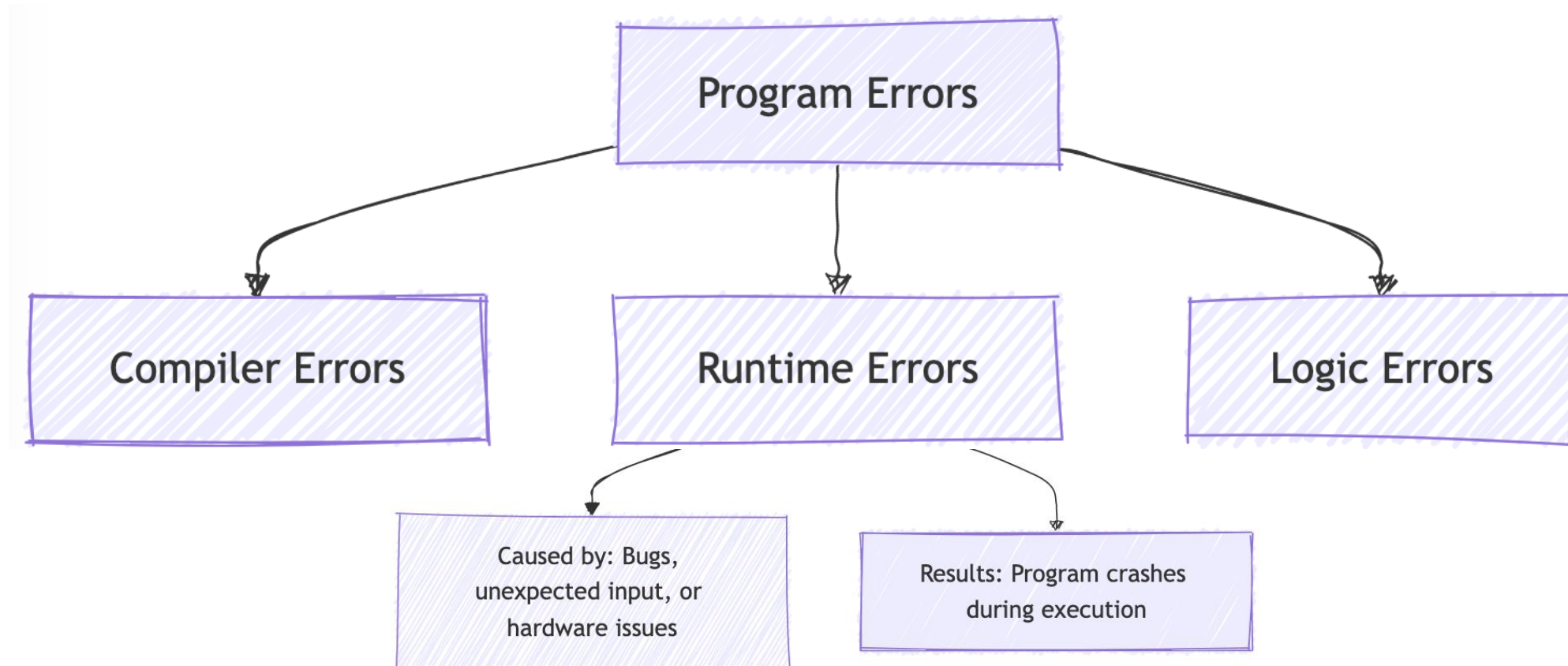
Source: <https://youtu.be/3HiLLByBWkg>

# Tips for Troubleshooting Compiler Errors

- Read error messages carefully: They often indicate the line number and type of issue.
- Fix errors one by one: Resolving one error might eliminate others.
- Check for missing or extra symbols: Pay attention to semicolons, brackets, and parentheses.

# Testing and Debugging (cont.)

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# Understanding Runtime Errors

- Occur when the program crashes during execution
- Caused by **bugs**, **unexpected input**, or **hardware issues**
- Check the exception message and the line number to troubleshoot

# Example of A Runtime Errors

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- **ArrayIndexOutOfBoundsException** occurs at runtime because the code attempts to access an index of the array that doesn't exist.

```
1 public class RunTimeError {  
2     public static void main(String[] args) {  
3         int[] nums = new int[10];  
4         for (int j = 0; j <= 10; j++)  
5             nums[j] = j;  
6     }  
7 }
```

This code produces this error message:

- Exception in thread "main"  
java.lang.ArrayIndexOutOfBoundsException:  
Index 10 out of bounds for length 10
- at RunTimeError.main(RunTimeError.java:5)

Description  
of error

Line and file that  
caused error

Method that caused error

# Another Example

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- **NullPointerException** occurs because you are trying to call a method on a null object.

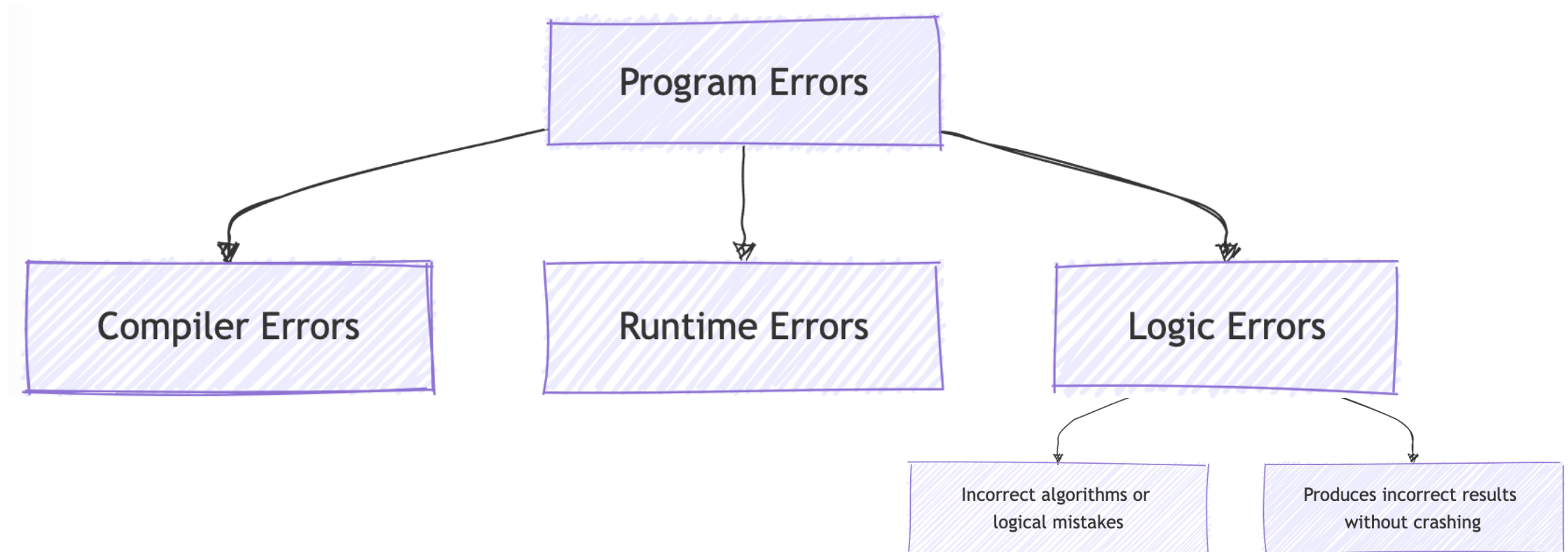
```
1 public class RunTimeError {
2     public static void main(String[] args) {
3         Rectangle[] arr = new Rectangle[10];
4         int counter = 0;
5         for (int j = 0; j < 10; j++)
6             if (arr[j].getLength() == 1)
7                 ++counter;
8         System.out.println(counter);
9     }
10 }
```

Why is this error message printed?

- Exception in thread "main" [java.lang.NullPointerException](#): Cannot invoke "Rectangle.getLength()" because "arr[j]" is null
- at RunTimeError.main([RunTimeError.java:6](#))

# Testing and Debugging (cont.)

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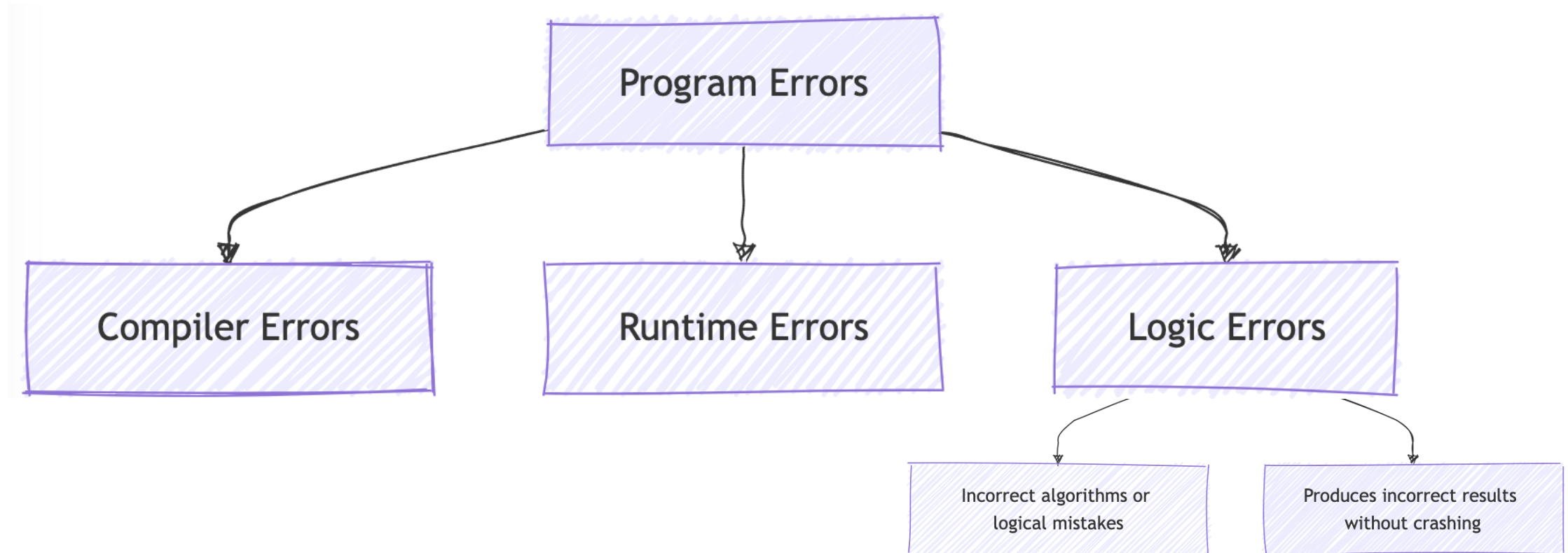


# Identifying and Resolving Runtime Errors

- Check the exception message for the method and line number from which it came.
- Note that the line in the code that caused the exception may not be in line with the error.

# Testing and Debugging (cont.)

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# Common Logic Errors

- Using `==` instead of a method like `equals` to compare the content of objects
- infinite loops
- Misunderstanding precedence of mathematical operators
- Starting or ending at the wrong index of an array
- Misplaced parentheses (so code is either inside a block when it should not be or vice versa)

# Common Logic Errors: Declare Multiple Variables with the Same Name

- Try not to declare multiple variables with the same **name**, as this might lead to program errors.
- Example:

```
// instance variable
private int numStudents;
...
public void someMethod(){
    // not the instance variable!
    int numStudents = ...;
    ...
}
```



# Common Logic Errors: Infinite Loops 1/2

- Another kind of runtime error that can occur is an infinite loop. The program doesn't crash but your program runs infinitely until you manually stop it.
- Example:

```
int i = 0;
while (i < 100) {
    int x = (i + 10) * 25;
}
```
- What is the problem here?
  - There is no update to the variable `i` inside the loop.

# Common Logic Errors: Infinite Loops 2/2

```
boolean done = false;
int a = 25000, b = 0;
while (!done) {
    a = a / 10;
    if (a < b) done = true;
}
```

- What is the problem here?  
The condition  $a < b$  will never be true  
(because  $a == b$ ).

# Infinite Loops

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- Detecting and debugging infinite loops can be challenging. They frequently occur in while loops where the condition remains true indefinitely.
- A useful strategy for identifying these loops is to add a counter that forces the loop to stop after a certain number of iterations.

```
boolean done = false;
int a = 25000, b = 0;
// probably big enough
int maxCheck = 10000;
while (!done && maxCheck > 0) {
    a = a / 10;
    if (a < b) done = true;
    maxCheck--;
}
if (maxCheck == 0)
    System.out.println("probably infinite loop");
```

# Testing & Debugging

- **Testing:** to identify any problems before software is put to use
  - “Testing can show the presence of bugs but can never show their absence”.
- **Debugging:** locating bugs and fixing them

# Hints for Success

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When writing code:

- Make sure your algorithm is correct before you start coding.

Start small:

- Write and test first simpler methods (e.g. getters, setters, toString). Then, write and test each of the more complex methods individually
- Check your code first with a preliminary hand trace
- Then try running it

# Debugging Strategies

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- Trace or run your code by hand
- When testing, add a **main** method to each class and invoke all other methods from the **main** method to check that they work as expected. **Once you are done testing, delete these main methods.**
- Add **print** statements to your code
- Use a debugger (we have already reviewed that!)

# Defensive Programming

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## Write robust programs:

- Include checking for **exceptional conditions**;
- try to think of situations that might reasonably happen, and check for them
  - Examples: files that don't exist, bad input data

**Generate appropriate error messages** and allow the user to re-enter the data or exit the program.

# Test-Driven Development (TDD)



Tests are written before the actual code!



# Test-based Programming in Java

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- Test-based programming in Java, often called Test-Driven Development (TDD), is a development approach where tests are written before the actual code is implemented.
- Java provides several tools and frameworks for test-based programming, with **JUnit** being one of the most popular.
- **JUnit** allows developers to create unit tests that can automatically verify the correctness of small code components, like methods or classes

The process typically involves the following steps:

1. **Write a Test:** Create a unit test to define the desired functionality.
2. **Write the Code:** Write just enough code to pass the test.
3. **Run the Test:** Ensure the code works as expected.
4. **Refactor:** Improve the code while keeping the test passing.
5. **Repeat:** Continue the process with new tests for additional features.

# Test-based Programming in Java

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```
import static org.junit.Assert.assertEquals;
import org.junit.Test;

public class CalculatorTest {

    @Test
    public void testMultiply() {
        Calculator calculator = new Calculator();
        int result = calculator.multiply(3, 4);
        // Expect 3 * 4 to equal 12
        assertEquals(12, result);
    }
}

-----

public class Calculator {
    public int multiply(int a, int b) {
        return a * b;
    }
}
```

The process typically involves the following steps:

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Thank  
you