

# Debugging

Help with finding bugs in your code

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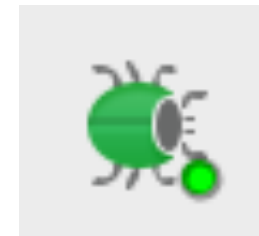
# Topic List

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1. What are **bugs**?



2. What are **debuggers**?



3. How do I use them?

# What are bugs?



A software **bug** is an error, flaw, failure or fault in a **computer** program or system that causes it to produce an incorrect or unexpected result, or to behave in unintended ways.

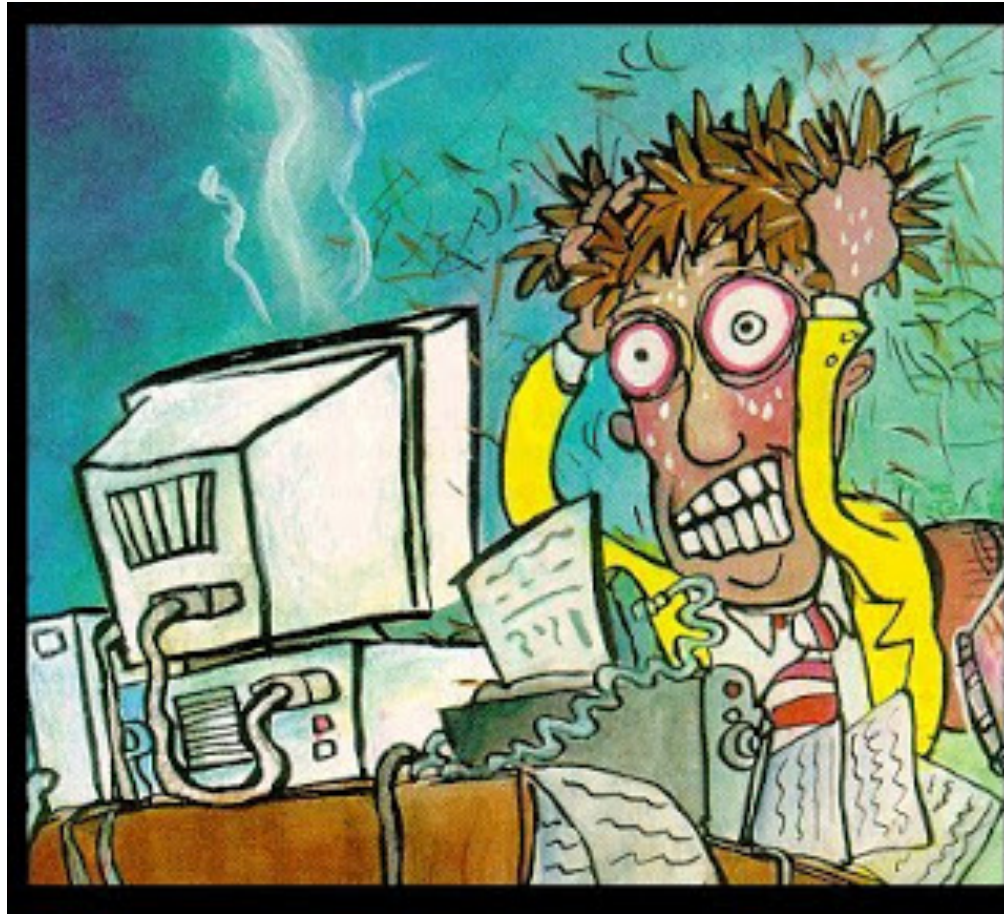


Software bug - Wikipedia, the free encyclopedia

[https://en.wikipedia.org/wiki/Software\\_bug](https://en.wikipedia.org/wiki/Software_bug)

# Bugs can be frustrating to find/fix

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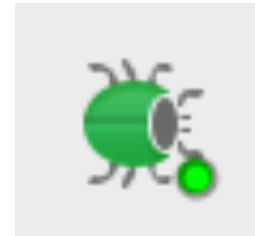
# Topic List

---

1. What are **bugs**?



2. What are **debuggers**?



3. How do I use them?

# Help is at hand...debuggers!

---

A debugger can be **used to fix bugs**

...hence the name debugger!

# Debugger

---



- A **debugger** is a software tool that
  - helps in examining how an application executes
  - lets programmers execute an application one statement at a time. (**Step, step into, step out**)
  - typically provides functions
    - to stop and start a program at selected points in the source code (**breakpoints**)
    - to examine the values of variables (**watch, trace**)

# Debugger



- Debuggers are especially useful when your program contains **logical errors**.
  - i.e. errors that the compiler will not pickup but that lead to incorrect results

e.g. if your syntax is correct but the logic of your problem solution is faulty.



- Using the debugger, you can **trace** how each of the calculations and changes made to fields/variables happen and hopefully **figure out where the error is occurring**.



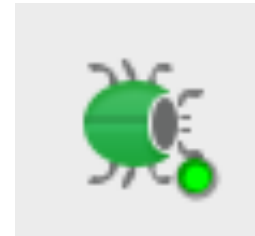
# Topic List

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1. What are **bugs**?



2. What are **debuggers**?



3. How do I use them?

# Debugger

---



- Most IDEs come with a debugger; **IntelliJ** has one.
- We are going to use the **IntelliJ Debugger** to **step** through the debugging of a small program
  - The program iterates over a primitive array of int and prints out the largest number in the array.

```
public class Driver {  
  
    public static void main(String args[])  
    {  
        int list[] = {2,5,3,4};  
        int largestNumber = Largest.findLargest(list);  
        System.out.println("Largest number is: " + largestNumber);  
    }  
}
```

Given this code...

**We are expecting this output:**

Largest number is: 5

**But we get:**

Largest number is: 2147483647

```
public class Largest {  
  
    public static int findLargest (int[] list) {  
        int index = 0;  
        int max = Integer.MAX_VALUE;  
  
        for (index = 0; index < list.length; index++) {  
            if (list[index] > max) {  
                max = list[index];  
            }  
        }  
  
        return max;  
    }  
}
```



Let's debug the code  
in **IntelliJ**  
to help us find the error...

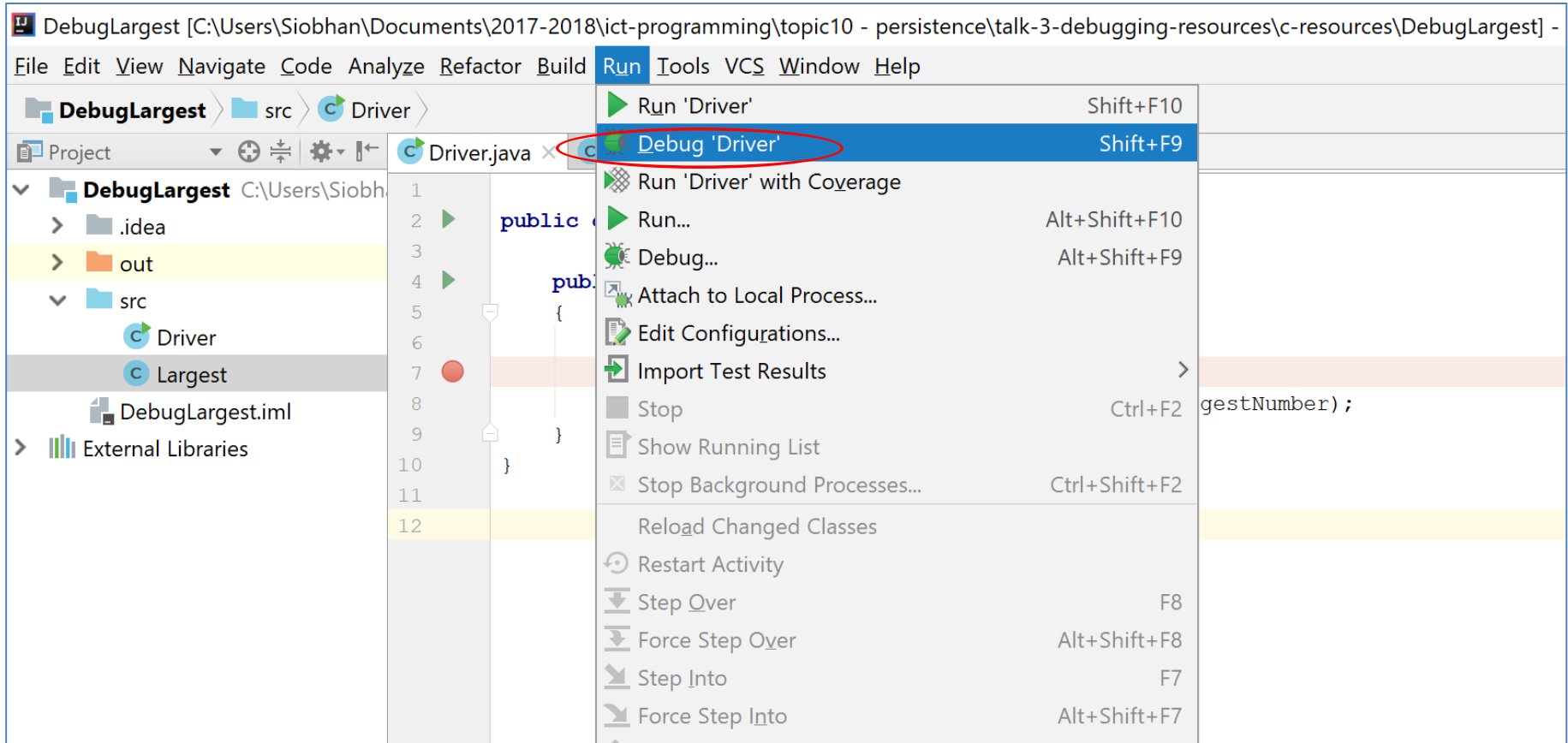
The screenshot shows the IntelliJ IDEA IDE interface. The top menu bar includes File, Edit, View, Navigate, Code, Analyze, Refactor, Build, Run, Tools, VCS, Window, and Help. The breadcrumb navigation shows the path: DebugLargest > src > Driver. The Project tool window on the left displays the project structure, with the 'Driver' folder selected. The main editor window shows the code for 'Driver.java' with the following content:

```
1 public class Driver {
2
3
4     public static void main(String args[])
5     {
6         int list[] = {2,5,3,4};
7         int largestNumber = Largest.findLargest(list);
8         System.out.println("Largest number is: " + largestNumber);
9     }
10 }
11
12
```

A red circle highlights a breakpoint set on line 7 in the grey margin. The Run tool window at the bottom shows the execution output: "C:\Program Files\Java\jdk-9.0.1\bin\java" "-javaagent:C:\Program Files\JetBrains\IntelliJ IDEA Communi Largest number is: 2147483647" and "Process finished with exit code 0". The status bar at the bottom indicates "Compilation completed successfully in 4s 93ms (yesterday 16:40)" and the system tray shows the time 12:1, CRLF, UTF-8, and a notification icon.

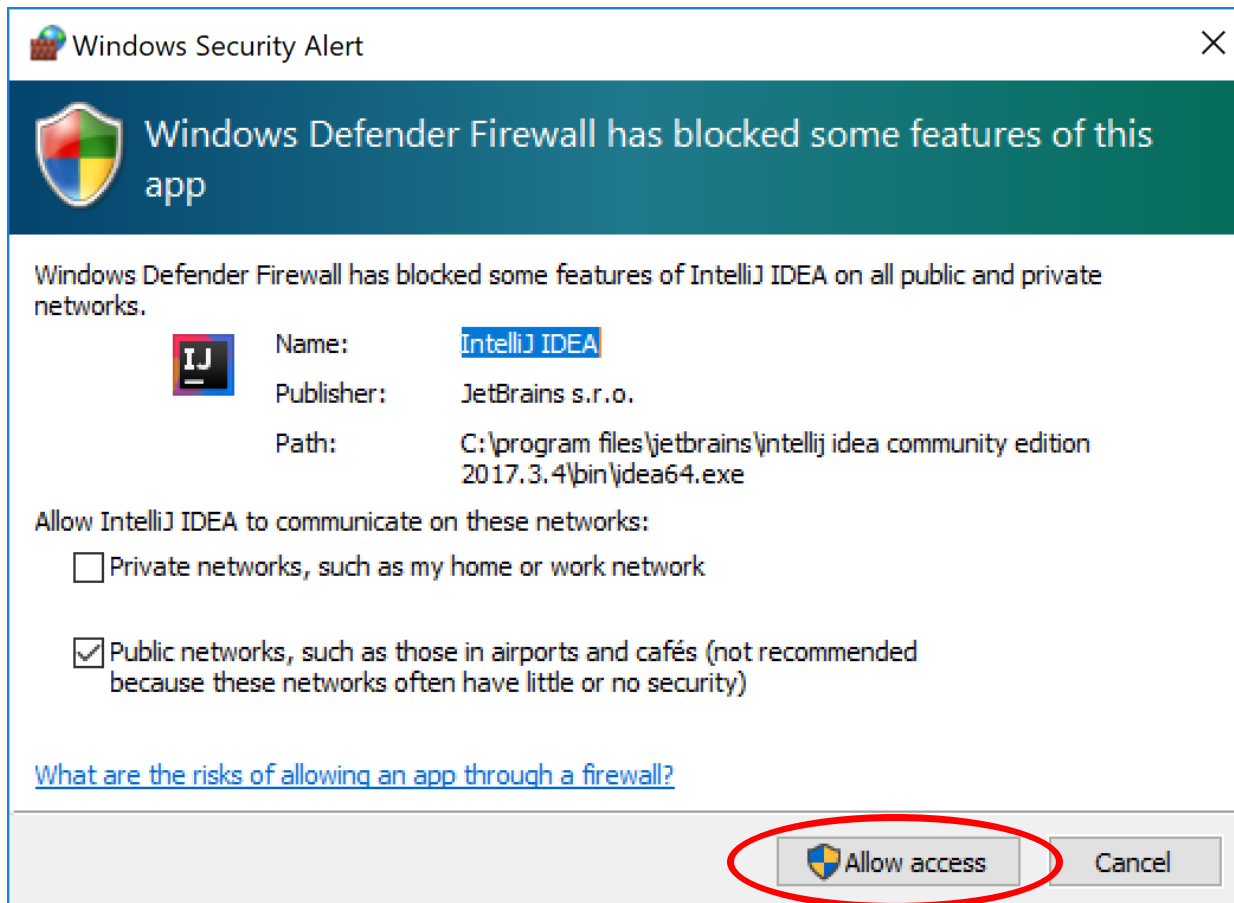
1

Click in the grey margin beside line 7. This will set up a **breakpoint** on this line.



2

From the Run menu, select **Debug** 'Driver'.



3

If this window appears, click on “Allow access”.

DebugLargest [C:\Users\Siobhan\Documents\2017-2018\ict-programming\topic10 - persistence\talk-3-debugging-...]

File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help

DebugLargest > src > Driver >

Project > Driver.java x Largest.java x

```
1 public class Driver {
2
3
4     public static void main(String args[] args: {})
5     {
6         int list[] = {2,5,3,4}; list: {2, 5, 3, 4}
7         int largestNumber = Largest.findLargest(list); list: {2, 5, 3, 4}
8         System.out.println("Largest number is: " + largestNumber);
9     }
10 }
11
12
```

Driver > main()

Debug Driver

Debugger Console

Frames

Variables

- args = {String[0]@668}
- list = {int[4]@669}
  - 0 = 2
  - 1 = 5
  - 2 = 3
  - 3 = 4

All files are up-to-date (3 minutes ago) 7:1 CRLF UTF-8

4

You are now in Debug mode...the program has stopped just before executing line 7.



The screenshot shows an IDE window titled "DebugLargest" with a menu bar (File, Edit, View, Navigate, Code, Analyze, Refactor, Build, Run, Tools, VCS, Window, Help) and a toolbar. The project structure on the left includes "DebugLargest" with subfolders ".idea", "out", and "src". The "src" folder contains "Driver" and "Largest". The "Largest" folder is selected, and the "Driver.java" file is open in the editor. The code in "Driver.java" is as follows:

```
1  
2 public class Driver {  
3  
4     public static void main(String args[] args: {}  
5     {  
6         int list[] = {2,5,3,4}; list: {2, 5, 3, 4}  
7         int largestNumber = Largest.findLargest(list); list: {2, 5, 3,  
8         System.out.println("Largest number is: " + largestNumber);  
9     }  
10 }  
11  
12
```

The debugger toolbar at the bottom shows the "Step Into (F7)" button circled in red. The "Frames" pane shows the current frame as "main:7, Driver". The "Variables" pane shows the following variables:

- args = {String[0]@668}
- list = {int[4]@669}
  - 0 = 2
  - 1 = 5
  - 2 = 3
  - 3 = 4

5

'Step Into' the findLargest method...

The screenshot shows an IDE window titled "DebugLargest" with the following components:

- Project View:** Shows the project structure including "src", "Driver", "Largest", and "DebugLargest.iml".
- Code Editor:** Displays the source code for "Largest.java". The code is as follows:

```
1 public class Largest {
2
3
4 @   public static int findLargest (int[] list) { list: {2, 5, 3, 4}
5     int index = 0;
6     int max = Integer.MAX_VALUE;
7
8     for (index = 0; index < list.length; index++) {
9         if (list[index] > max) {
10            max = list[index];
11        }
12    }
13
14    return max;
15 }
16
17 }
```
- Debugger:** Shows the current execution state. The stack trace includes "findLargest:5, Largest" and "main:7, Driver".
- Variables Window:** Shows the state of the "list" array:
  - list = (int[4]@669)
  - 0 = 2
  - 1 = 5
  - 2 = 3
  - 3 = 4
  - list.length = 4
- Status Bar:** Shows "All files are up-to-date (6 minutes ago)", "13:1", "CRLF", "UTF-8", and a "1" notification icon.

6

Now that we are in the findLargest method, we want to execute each line while monitoring the value of Max. This should help us locate the error...

DebugLargest [C:\Users\Siobhan\Documents\2017-2018\ict-programming\topic10 - persistence\talk-3-debugging-...]

File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help

DebugLargest > src > Largest

Project: DebugLargest C:\Users\Siobhan\Documents\2017-2018\ict-programming\topic10 - persistence\talk-3-debugging-...>src

```
1 public class Largest {
2
3
4 @
5 public static int findLargest (int[] list) { list: {2, 5, 3, 4}
6 int index = 0; index: 0
7 int max = Integer.MAX_VALUE;
8
9 for (index = 0; index < list.length; index++) {
10     if (list[index] > max) {
11         max = list[index];
12     }
13 }
14 return max;
15 }
16 }
```

Debug Driver

Debugger Console

Frames: "main"@1 in group "...", findLargest:6, Largest, main:7, Driver

Variables: P list = {int[4]@669}

- 0 = 2
- 1 = 5
- 2 = 3
- 3 = 4
- index = 0
- list[index] = 2
- list.length = 4

All files are up-to-date (9 minutes ago) 6:1 CRLF UTF-8

7

Step → execution now stopped on line 6

The screenshot shows an IDE window titled "DebugLargest" with the following code in "Largest.java":

```
1 public class Largest {
2
3
4 @   public static int findLargest (int[] list) { list: {2, 5, 3, 4}
5     int index = 0; index: 0
6     int max = Integer.MAX_VALUE; max: 2147483647
7
8     for (index = 0; index < list.length; index++) { index: 0 list: {
9         if (list[index] > max) {
10            max = list[index];
11        }
12    }
13
14    return max;
15 }
16 }
```

The debugger is paused at line 8. The "Variables" window shows the following state:

- list = {int[4]@669}
- 0 = 2
- 1 = 5
- 2 = 3
- 3 = 4
- index = 0
- max = 2147483647
- list[index] = 2
- list.length = 4

8

**Step** → execution now stopped on line 8...note the value of max.

The screenshot shows an IDE window titled "DebugLargest" with the following components:

- Project View:** Shows the project structure with folders for ".idea", "out", "src", and "External Libraries". The "src" folder contains "Driver" and "Largest" files.
- Code Editor:** Displays the source code for "Largest.java". The code is as follows:

```
1 public class Largest {  
2  
3  
4 @   public static int findLargest (int[] list) { list: {2, 5, 3, 4}  
5     int index = 0; index: 0  
6     int max = Integer.MAX_VALUE; max: 2147483647  
7  
8     for (index = 0; index < list.length; index++) {  
9         if (list[index] > max) { list: {2, 5, 3, 4} index: 0 max: 2147483647  
10            max = list[index];  
11        }  
12    }  
13  
14    return max;  
15 }  
16 }
```

Line 9 is highlighted in blue, and a red circle is drawn around the line number "9".
- Debugger:** Shows the current state of the program. The "Frames" pane shows the call stack with "findLargest:9, Largest" selected. The "Variables" pane shows the following values:
  - list = (int[4]@669)
    - 0 = 2
    - 1 = 5
    - 2 = 3
    - 3 = 4
  - index = 0
  - max = 2147483647
  - list[index] = 2
  - list.length = 4

9

Step → execution now stopped on line 9...

The screenshot shows an IDE window titled "DebugLargest" with a project named "DebugLargest". The source code in "Largest.java" is as follows:

```
1 public class Largest {
2
3
4     @
5     public static int findLargest (int[] list) { list: {2, 5, 3, 4}
6         int index = 0; index: 0
7         int max = Integer.MAX_VALUE; max: 2147483647
8         for (index = 0; index < list.length; index++) { index: 0 list: {2, 5, 3, 4}
9             if (list[index] > max) {
10                 max = list[index];
11             }
12         }
13
14         return max;
15     }
16 }
```

The debugger is stopped at line 8. The "Variables" window shows the following state:

- list = {int[4]@669}
- 0 = 2
- 1 = 5
- 2 = 3
- 3 = 4
- index = 0
- max = 2147483647
- list[index] = 2
- list.length = 4

The "Frames" window shows the call stack:

- "main"@1 in group "..."
- findLargest:8, Largest
- main:7, Driver

The status bar at the bottom indicates "All files are up-to-date (14 minutes ago)" and "8:1 CRLF UTF-8".

10

**Step** → execution now stopped back on line 8...  
can you see the problem?

DebugLargest [C:\Users\Siobhan\Documents\2017-2018\ict-programming\topic10 - persistence\talk-3-debugging-resources\c-resou... - □ ×

File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help

DebugLargest src Largest

Project Driver.java Largest.java

```
1
2 public class Largest {
3
4 @   public static int findLargest (int[] list) { list: {2, 5, 3, 4}
5     int index = 0; index: 0
6     int max = Integer.MAX_VALUE; max: 2147483647
7
8     for (index = 0; index < list.length; index++) { index: 0 list: {2, 5, 3, 4}
9         if (list[index] > max) {
10            max = list[index];
11        }
12    }
13
14    return max;
15 }
16 }
```

Debug Driver

Debugger Console

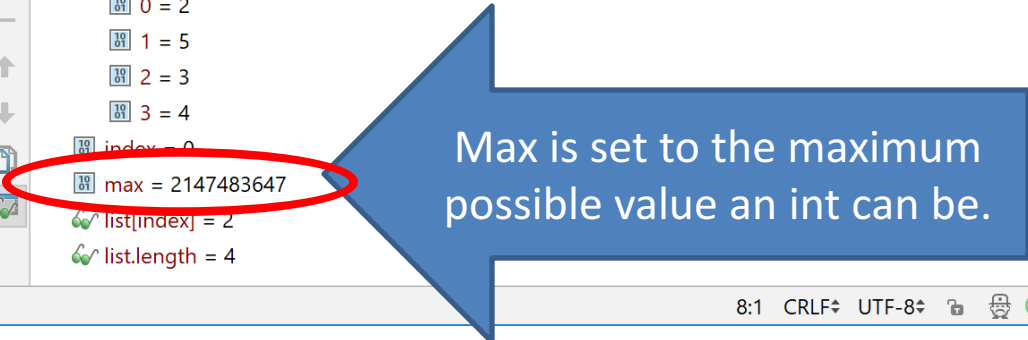
Frames

- "main"@1 in group "..."
- findLargest:8, Largest
- main:7, Driver

Variables

- list = {int[4]@669}
  - 0 = 2
  - 1 = 5
  - 2 = 3
  - 3 = 4
  - index = 0
  - max = 2147483647
  - list[index] = 2
  - list.length = 4

All files are up-to-date (14 minutes ago) 8:1 CRLF UTF-8



DebugLargest [C:\Users\Siobhan\Documents\2017-2018\ict-programming\topic10 - persistence\talk-3-debugging-resources\c-resou... - □ ×

File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help

DebugLargest src Largest Driver Largest

```
1 public class Largest {
2
3
4 @   public static int findLargest (int[] list) { list: {2, 5, 3, 4}
5     int index = 0; index: 0
6     int max = Integer.MAX_VALUE; max: 2147483647
7
8     for (index = 0; index < list.length; index++) { index: 0 list: {2, 5, 3, 4}
9         if (list[index] > max) {
10            max = list[index];
11        }
12    }
13
14    return max;
15 }
16 }
```

Debug Driver

Debugger Console Frames Variables

"main"@1 in group "...

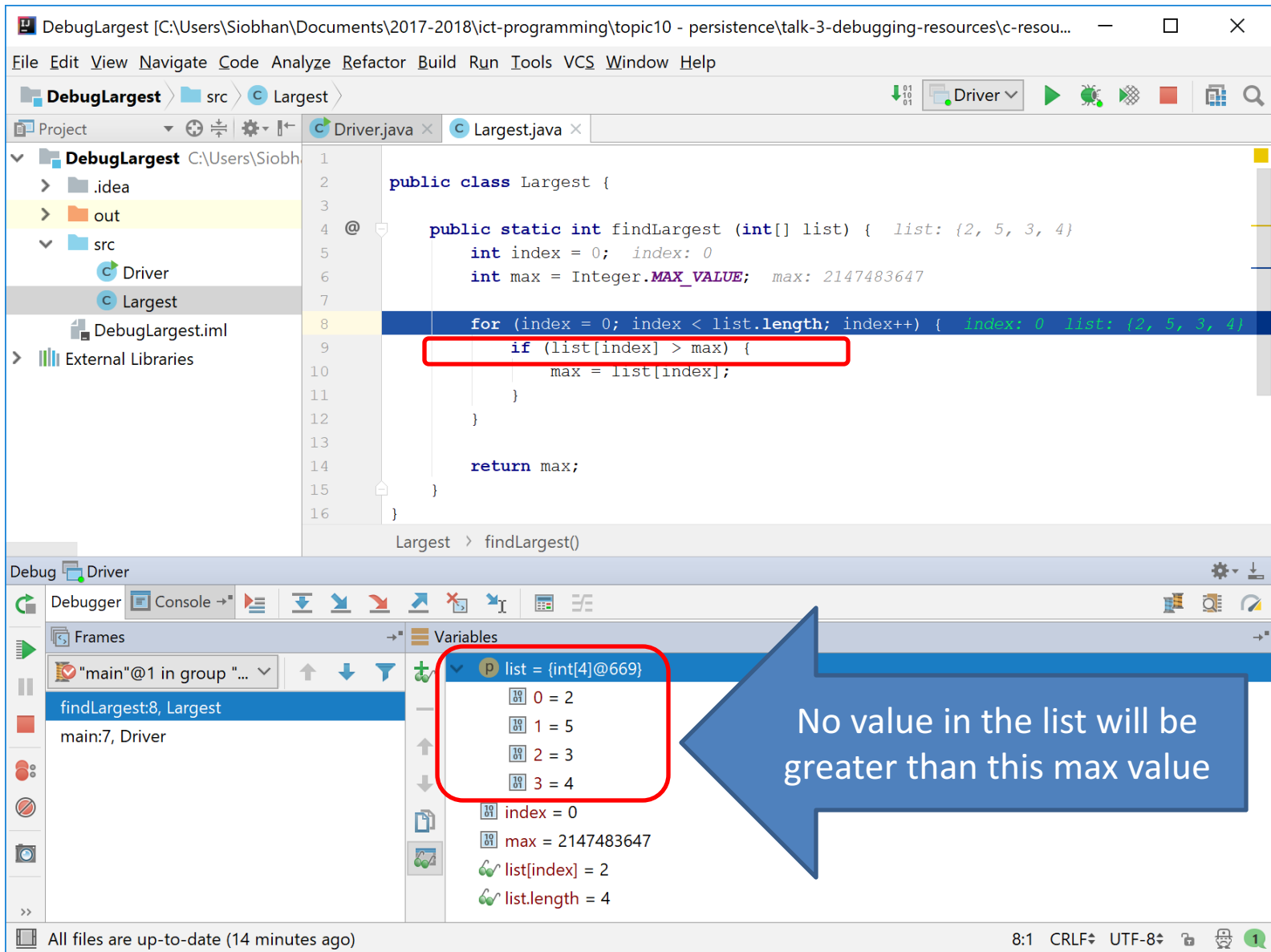
findLargest:8, Largest  
main:7, Driver

list = {int[4]@669}

- 0 = 2
- 1 = 5
- 2 = 3
- 3 = 4

index = 0  
max = 2147483647  
list[index] = 2  
list.length = 4

All files are up-to-date (14 minutes ago) 8:1 CRLF UTF-8



No value in the list will be greater than this max value



DebugLargest [C:\Users\Siobhan\Documents\2017-2018\ict-programming\topic10 - persistence\talk-3-debugging-resources\c-resou... - □ ×

File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help

DebugLargest > src > Largest >

Project > Driver.java × Largest.java ×

```
1 public class Largest {
2
3
4 @   public static int findLargest (int[] list) {
5     int index = 0; index: 0
6     int max = Integer.MAX_VALUE; max: 2147483647
7
8     for (index = 0; index < list.length; index++) {
9         if (list[index] > max) {
10            max = list[index];
11        }
12    }
13
14    return max;
15 }
16 }
```

Debug Driver

Debugger Console →

Frames

- "main"@1 in group "..."
- findLargest:8, Largest
- main:7, Driver

Variables

- list = {int[4]@669}
  - 0 = 2
  - 1 = 5
  - 2 = 3
  - 3 = 4
- index = 0
- max = 2147483647
- list[index] = 2
- list.length = 4

All files are up-to-date (14 minutes ago) 8:1 CRLF UTF-8 1

This is the **bug**...  
we should have set  
the max value  
to the first value in the list.

# Fixing the bug

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- Instead of the line of code:

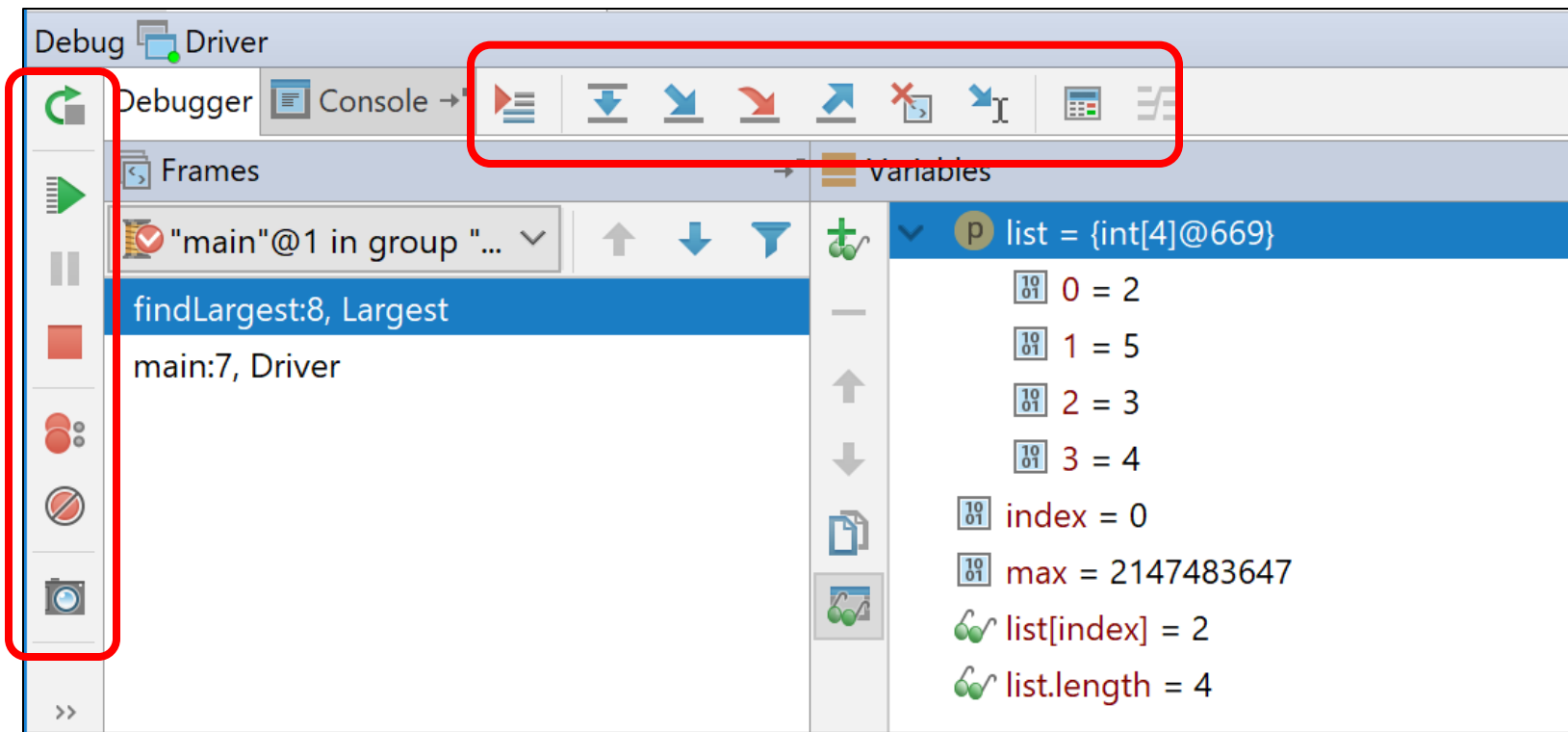
```
int max = Integer.MAX_VALUE;
```

- We need:

```
int max = list[0];
```



# Some IntelliJ debugger buttons...

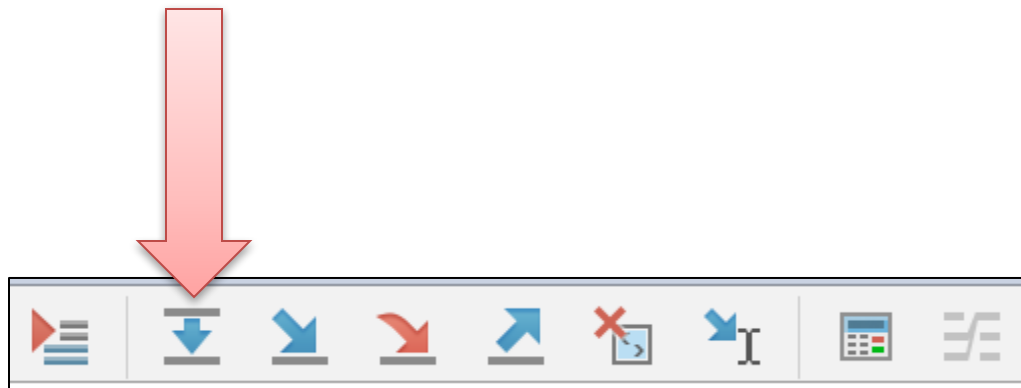


# Some Debugger buttons...



- **Step Over** 

to step over the next method call (without entering it) at the currently executing line of code.

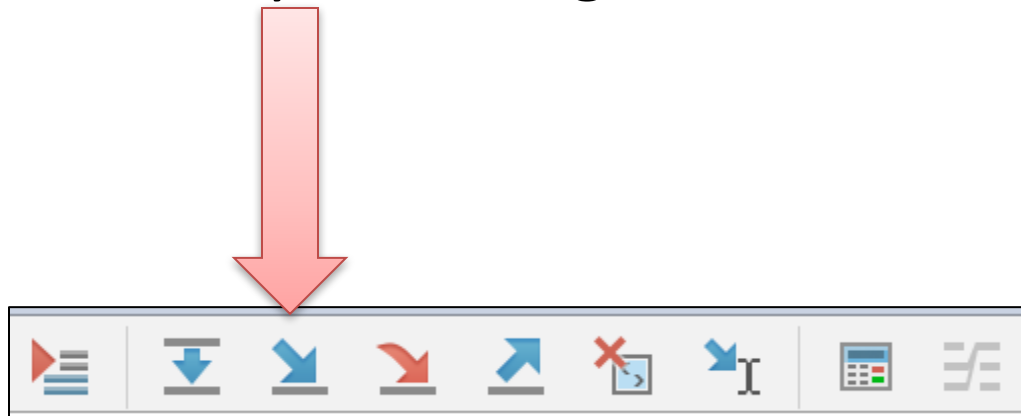


# Some Debugger buttons...



- **Step Into** 

step into the next method call  
at the currently executing line of code.



# Some Debugger buttons...

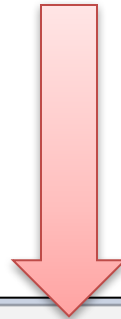


- **Step Out**



executes the remaining lines of a method in which the current execution point lies.

The next statement displayed is the statement following the method call.



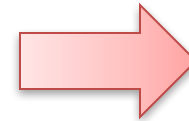
# Some Debugger buttons...



- **Resume Program**



resume the execution of the currently suspended debug target.



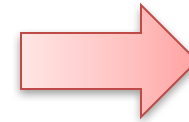
# Some Debugger buttons...



- **Terminate**



to terminate the launch associated with the selected debug target i.e. **stop** the program.



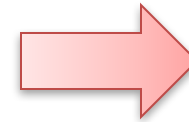


# Some Debugger buttons...



- **Show breakpoints** 

show all the breakpoints  
(in a pop up window)  
in the program.

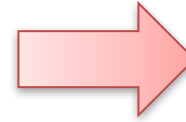


# Some Debugger buttons...



- **Rerun program** 

start the program again.



**Any  
Questions?**

