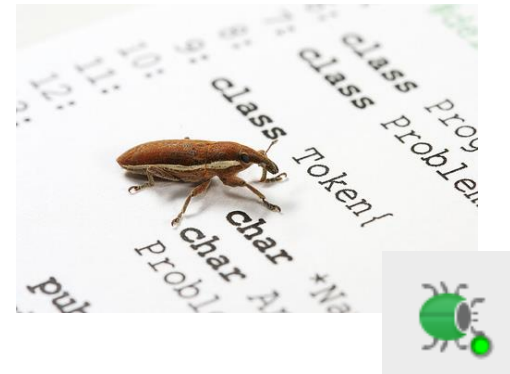


Debugging

Help with finding bugs in your code

Produced by: Dr. Siobhán Drohan
Ms. Mairéad Meagher



Waterford Institute of Technology
INSTITIÚID TEICNEOLAÍOCHTA PHORT LÁIRGE

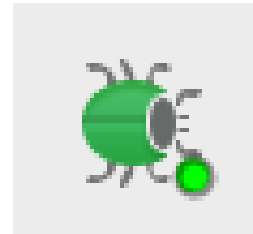
Department of Computing and Mathematics
<http://www.wit.ie/>

Topic List

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

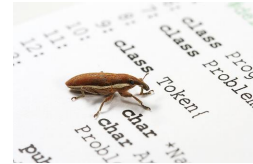
https://en.wikipedia.org/wiki/Software_bug

Bugs can be frustrating to find/fix

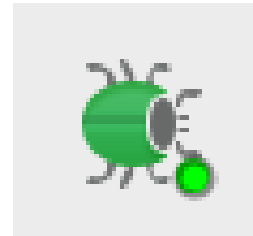


Topic List

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**

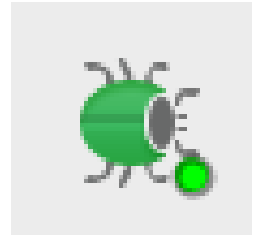
...hence the name debugger!

Debugger



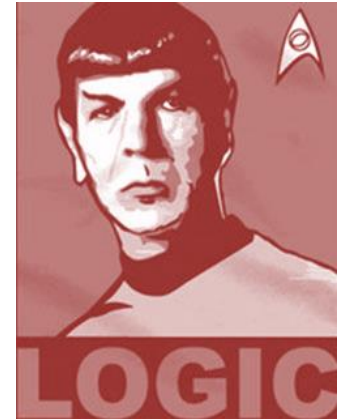
- A **debugger** is a software tool that
 - helps in examining how an application executes
 - lets programmers execute an application one statement at a time. (**Step, step into, step out**)
 - typically provides functions
 - to stop and start a program at selected points in the source code (**breakpoints**)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

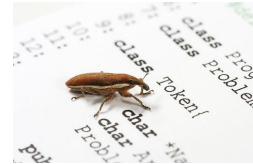
e.g. if your syntax is correct but the logic of your problem solution is faulty.



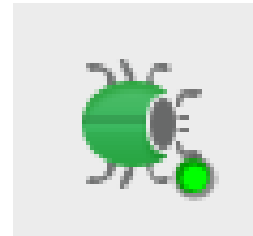
- Using the debugger, you can **trace** how each of the calculations and changes made to fields/variables happen and hopefully **figure out where the error is occurring**.

Topic List

1. What are **bugs**?

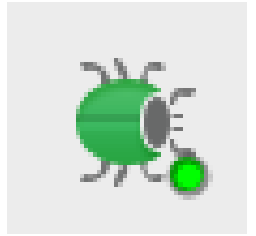


2. What are **debuggers**?



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;

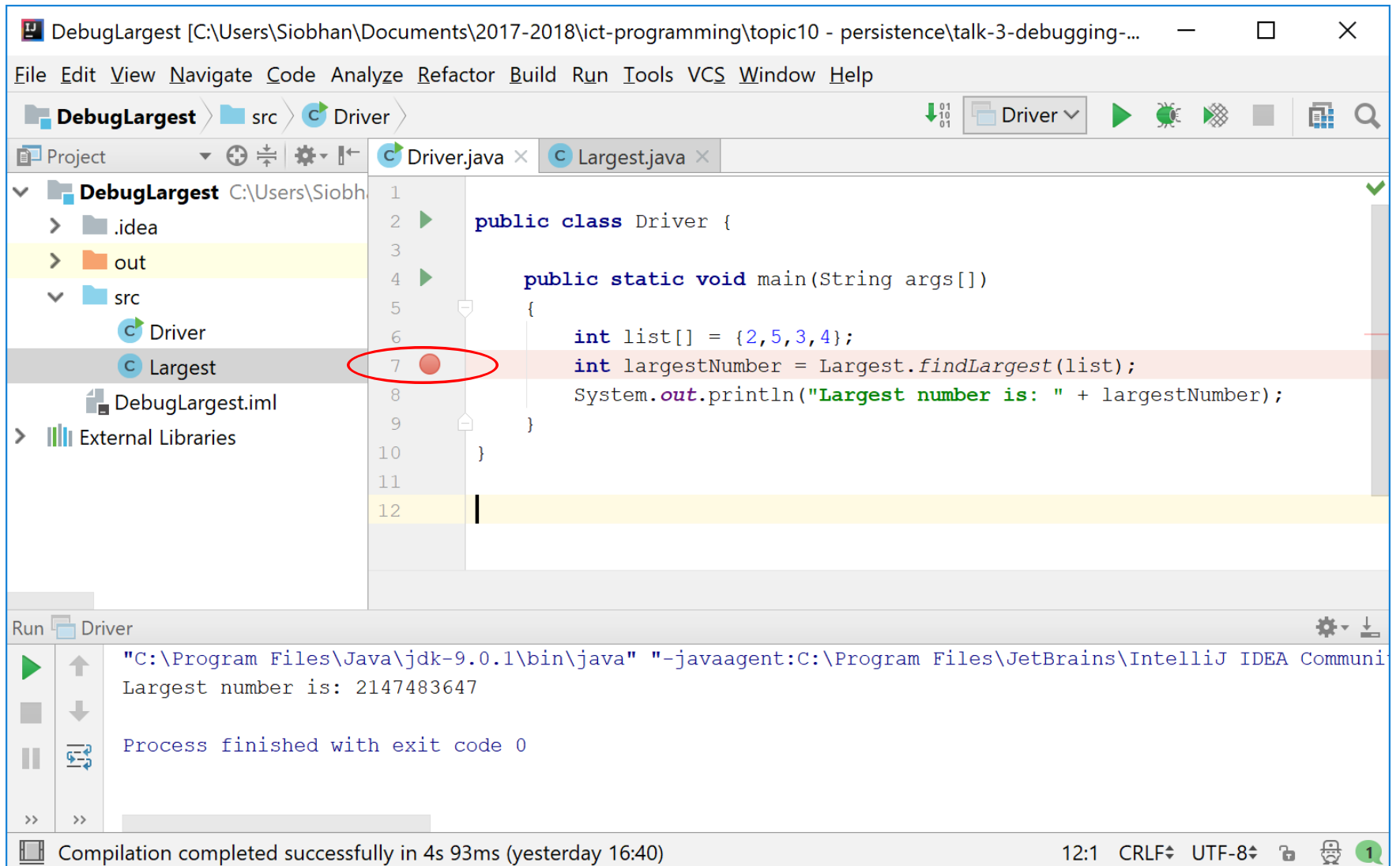
        for (index = 0; index < list.length; index++) {
            if (list[index] > max) {
                max = list[index];
            }
        }

        return max;
    }
}

```

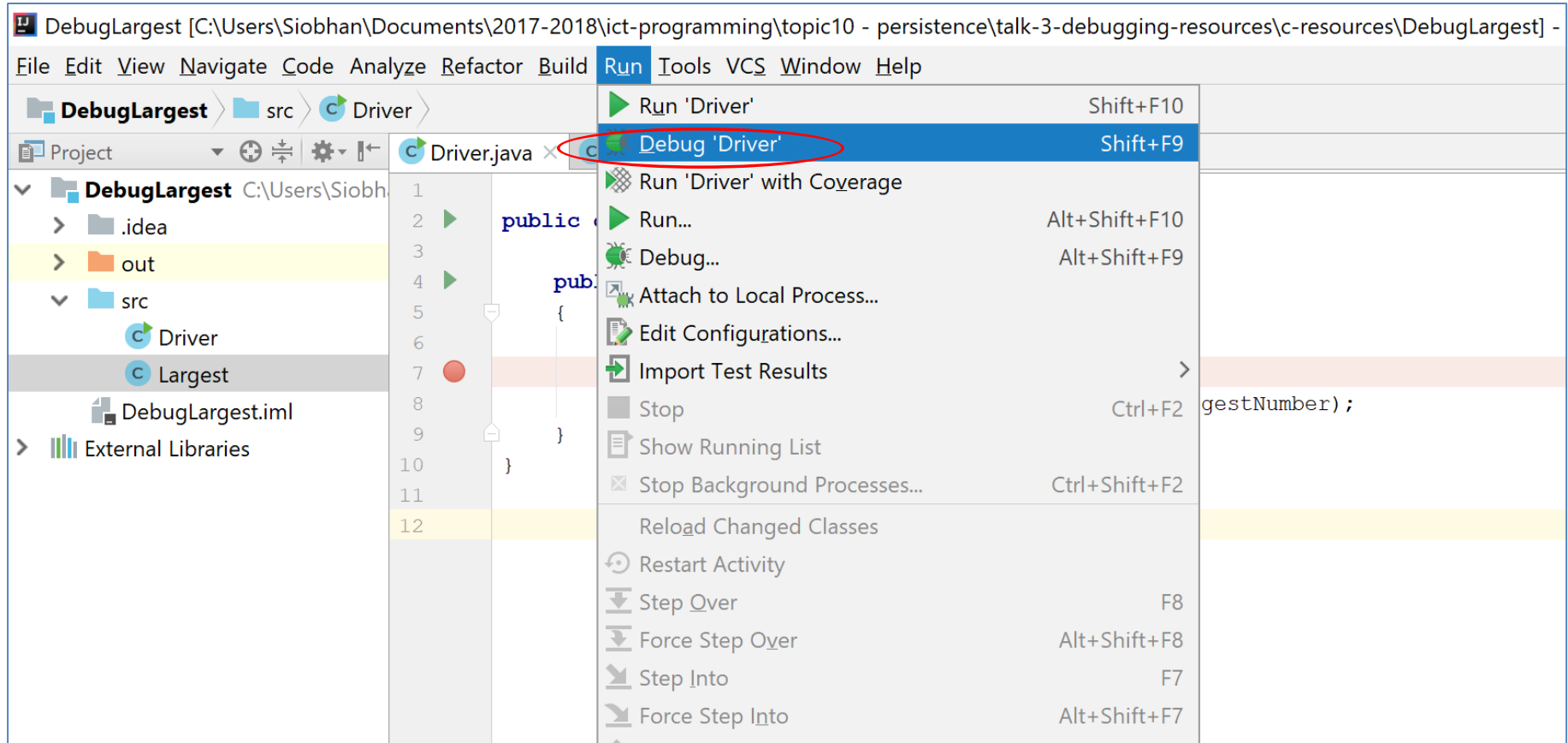


Let's debug the code
in **IntelliJ**
to help us find the error...



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”.

The screenshot shows an IDE window titled "DebugLargest [C:\Users\Siobhan\Documents\2017-2018\ict-programming\topic10 - persistence\talk-3-debugging-...". The menu bar includes File, Edit, View, Navigate, Code, Analyze, Refactor, Build, Run, Tools, VCS, Window, and Help. The project structure on the left shows "DebugLargest" with subfolders ".idea", "out", and "src". The "src" folder contains "Driver" and "Largest" files. The "Driver.java" file is open, showing the following code:

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

Line 7 is highlighted with a red circle. The "Debug" toolbar at the bottom shows the "Debugger" tab selected. The "Frames" panel shows the current frame as "main:7, Driver". The "Variables" panel shows the state of the program at this point:

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

The status bar at the bottom indicates "All files are up-to-date (3 minutes ago)" and "7:1 CRLF UTF-8".

4

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

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: DebugLargest C:\Users\Siobhan\Documents\2017-2018\ict-programming\topic10 - persistence\talk-3-debugging-...> .idea > out > src > Driver > Largest > DebugLargest.iml > External Libraries

```
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,
8         System.out.println("Largest number is: " + largestNumber);
9     }
10 }
11
12
```

Driver > main()

Debug Driver

Debugger Console →

Step Into (F7)

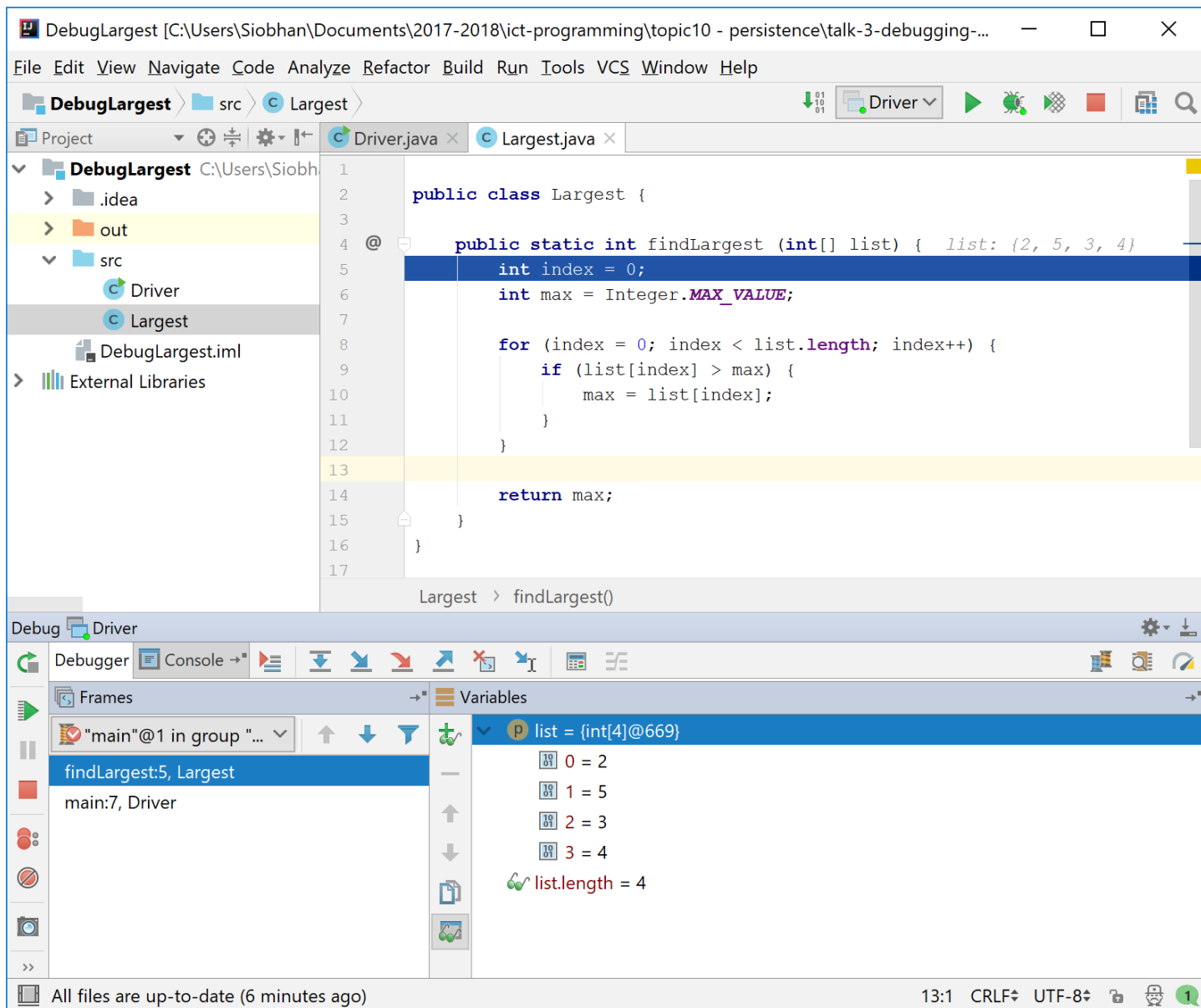
Frames: "main"@1 in group "... main:7, Driver

Variables:

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

5

'Step Into' the findLargest method...



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-...
out
src
Driver
Largest
DebugLargest.iml
External Libraries

```
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 }
```

Largest > findLargest()

Debug Driver

Debugger Console

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

Variables
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

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-...
out
src
Driver
Largest
DebugLargest.iml
External Libraries

```
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 }
```

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 (10 minutes ago) 8:1 CRLF UTF-8

8

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

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: DebugLargest C:\Users\Siobh...
src
Driver
Largest
DebugLargest.iml
External Libraries

```
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 }
```

Debug Driver

Debugger Console →

Frames: findLargest:9, 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 (12 minutes ago) 9:1 CRLF UTF-8

9

Step → execution now stopped on line 9...

The screenshot shows an IDE window titled "DebugLargest" with a project named "DebugLargest". The source code is in "src" and "out" folders. The 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 "Frames" pane shows the call stack: "main" @ 1 in group "...", "findLargest:8, Largest", and "main:7, Driver". The "Variables" pane shows the state of the program:

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

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 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
9         for (index = 0; index < list.length; index++) { index: 0 list: {2, 5, 3, 4}
10             if (list[index] > max) {
11                 max = list[index];
12             }
13
14         return max;
15     }
16 }
```

Debug Driver

Debugger Console

Frames

Variables

list = {int[4]@669}

- 0 = 2
- 1 = 5
- 2 = 3
- 3 = 4
- index = 0
- max = 2147483647
- list[index] = 2
- list.length = 4

findLargest:8, Largest

main:7, Driver

All files are up-to-date (14 minutes ago)

8:1 CRLF UTF-8

Max is set to the maximum possible value an int can be.

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 @
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 }
```

Debug Driver

Debugger Console

Frames

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

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

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

Project DebugLargest C:\Users\Siobhan\Documents\2017-2018\ict-programming\topic10 - persistence\talk-3-debugging-resources\c-resou...
out
src
Driver
Largest
DebugLargest.iml
External Libraries

```
1 public class Largest {  
2  
3  
4 @Override  
5 public static int findLargest (int[] list) {  
6     int index = 0; index: 0  
7     int max = Integer.MAX_VALUE; max: 2147483647  
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: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

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

Fixing the bug

- Instead of the line of code:

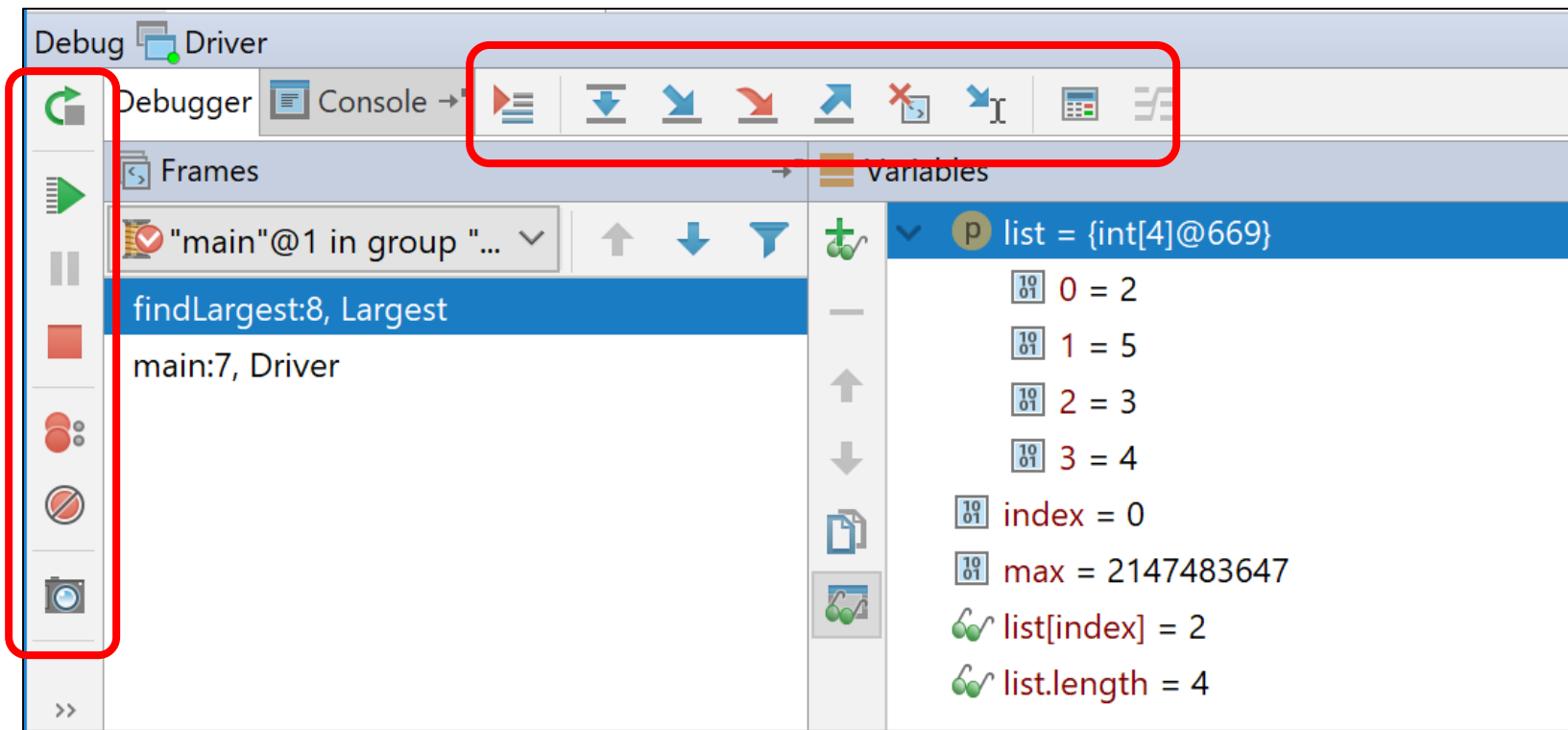
```
int max = Integer.MAX_VALUE;
```

- We need:

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



Some IntelliJ debugger buttons...



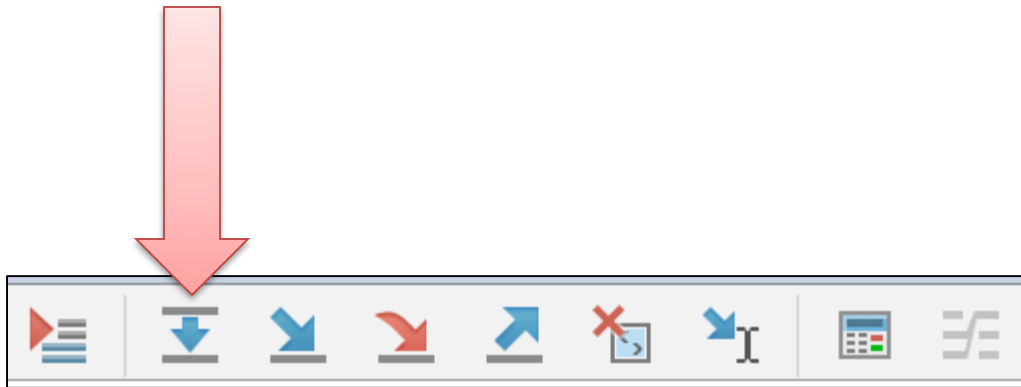
Some Debugger buttons...



- **Step Over**



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



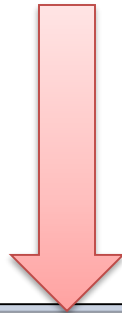
Some Debugger buttons...



- **Step Into**



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



Some Debugger buttons...

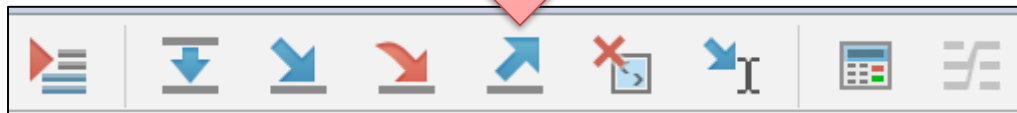
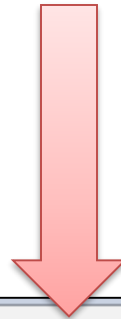


- **Step Out**



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.



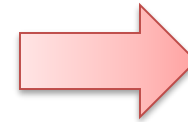
Some Debugger buttons...



- **Resume Program**



resume the execution of
the currently suspended
debug target.



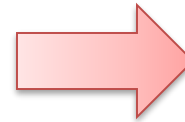
Some Debugger buttons...



- **Terminate**



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



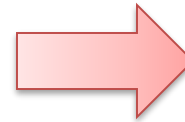
Some Debugger buttons...



- **Show breakpoints**



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



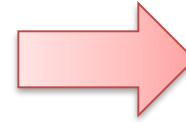
Some Debugger buttons...



- **Rerun program**



start the program again.





Now it's your turn!

- practice using the debugger on this code (there is a step in your labs to provide support).

**Any
Questions?**

