

My Future with Log4j 2 and Log4Shell

WHAT I LEARNED AND HOW I WILL APPLY IT

MARQUIS, ALEX (AMARQUIS2@STUDENT.CCCS.EDU)

Table of Contents

What I did.....	3
What I learned	3
How I Envision I'll Use What I Learned	4
Appendix A: Modified Exercise12_03 Java File	5
Appendix B: Modified pom.xml File	7
Appendix C: Console Output Prior to Logging Implementation	9
Appendix D: Console Output Post-Logging Implementation.....	10
Appendix E: Log Output	11
References	12

How I Envision I'll Use What I Learned

Log4j 2 is a widely used logging framework for the Java language and as such, I envision that there is a good chance that I will use Log4j 2 when working on future Java projects. However, this project has also given me the base knowledge required to use and learn about logging in general which means that regardless of the logging framework, I see logging as being a prevalent part of my future. I also envision myself being able to effectively use the log-level feature prevalent in most logging frameworks, including Log4j 2, to setup meaningful log levels so that information can be communicated efficiently and accurately in log files. I envision that at some point I will be filtering through logs generated by myself and others in order to monitor program activities and to trace down, reproduce, and mitigate bugs. But largely, I envision myself fighting the good fight against the Log4Shell vulnerability that has affected so many. Now, having a base understanding of how the exploit works, how damaging it can be, and how it can be effectively mitigated against, I feel that I am ready to at least begin helping in the fight against this dangerous and prevalent exploit.

Appendix A: Modified Exercise12_03 Java File

```

001 package edu.arapahoe.csc245;
002
003 import org.apache.logging.log4j.LogManager;
004 import org.apache.logging.log4j.Logger;
005
006 import java.io.StringWriter;
007 import java.io.PrintWriter;
008 import java.util.*;
009
010 //////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
011 //
012 // This program was created for Arapahoe Community College's CSC-245 course and
013 // it creates an array holding 100 random numbers between 0-9,999. It then prompts the
014 // user for an index and prints out the random number at that index in the array.
015 //
016 // CSC 245 Secure Software Development
017 //
018 // Change log:
019 //     20220330 AMM: Initially Created
020 //     20220330 AMM: Implemented Logging
021 //     20220401 AMM: Mitigated Log4j 2 Vulnerability (see mitigation tag PR4-Log4j-01
022 //                  in the pom.xml file)
023 //
024 // Dependencies:
025 //     disruptor-3.4.2.jar
026 //     jackson-annotations-2.9.0.jar
027 //     jackson-core-2.9.8.jar
028 //     jackson-databind-2.9.8.jar
029 //     jackson-dataformat-yaml-2.9.8.jar
030 //     log4j-api-2.11.2.jar
031 //     log4j-core-2.11.2.jar
032 //     snakeyaml-1.23.jar
033 //     Oracle JDK 1.8
034 //
035 //////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
036
037 public class Exercise12_03 {
038
039     private static final Logger logger = LogManager.getLogger(Exercise12_03.class);
040
041     // This is the driving method for Exercisel2_03. It will create an array of length 100
042     // filled with random integers between 0-9,999 (inclusive). It will then prompt the user
043     // for an index and print out the random integer at that index.
044     public static void main(String[] args) {
045         logger.info("Program started");
046
047         // Initialize array
048         int[] data = new int[100];
049         for (int i = 0; i < 100; i++) {
050             data[i] = (int) (Math.random() * 10000);
051         }
052         logger.info("Array of length 100 initialized with random integers between 0-9,999 " +
053             "(inclusive)");
054
055         System.out.print("Enter an index: ");
056
057         try {
058             // Get user input (should be an index between 0-99 inclusive)
059             Scanner input = new Scanner(System.in);
060             int index = input.nextInt();
061             logger.info("User input successfully received");
062
063             // Print out the element at the user supplied index
064             System.out.println("The element is " + data[index]);
065             logger.info("Element at user supplied index from random array was successfully " +
066                 "printed to the console");
067         } catch (IndexOutOfBoundsException ex) {

```

```

068 // Inform user that index is out of bounds and log the exception
069 System.out.println("Out of Bounds");
070 logger.warn("User supplied index was out of bounds (0-99) for random array [{}]",
071     ex.toString());
072 if(logger.isTraceEnabled()) {
073     logger.trace("Stack trace for {} throwable {}", "ex.toString()",
074         getStringStackTrace(ex));
075 }
076 } catch (InputMismatchException ex) {
077     // Inform user that their input was invalid and log the exception
078     System.out.println("Invalid Input");
079     logger.warn("User supplied input was not a Java integer [{}]", ex.toString());
080     if(logger.isTraceEnabled()) {
081         logger.trace("Stack trace for {} throwable {}", "ex.toString()",
082             getStringStackTrace(ex));
083     }
084 } finally {
085     logger.info("Program terminated");
086 }
087 }
088
089 // Method to get the stack trace from a throwable object and convert it into
090 // a String.
091 public static String getStringStackTrace(Throwable throwable) {
092     logger.info("Getting stack trace for {} throwable", throwable.toString());
093     StringWriter stringWriter = new StringWriter();
094     throwable.printStackTrace(new PrintWriter(stringWriter));
095     return stringWriter.toString();
096 }
097
098 }
099
100

```

Appendix B: Modified pom.xml File

```

01  <?xml version="1.0" encoding="UTF-8"?>
02  <project xmlns="http://maven.apache.org/POM/4.0.0"
03           xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
04           xsi:schemaLocation="http://maven.apache.org/POM/4.0.0
05                               http://maven.apache.org/xsd/maven-4.0.0.xsd">
06      <modelVersion>4.0.0</modelVersion>
07
08      <groupId>edu.arapahoe.csc245</groupId>
09      <artifactId>log4j2</artifactId>
10      <version>1.0</version>
11
12      <properties>
13          <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
14          <java.version>1.8</java.version>
15          <!-- 20220401 AMM: Upgraded Log4J2 from 2.11.2 to 2.17.1 (PR4-Log4J-
001-M) -->
16          <log4j.version>2.17.1</log4j.version>
17          <disruptor.version>3.4.2</disruptor.version>
18          <jackson.version>2.9.8</jackson.version>
19      </properties>
20
21      <dependencies>
22
23          <dependency>
24              <groupId>org.apache.logging.log4j</groupId>
25              <artifactId>log4j-api</artifactId>
26              <version>${log4j.version}</version>
27          </dependency>
28
29          <dependency>
30              <groupId>org.apache.logging.log4j</groupId>
31              <artifactId>log4j-core</artifactId>
32              <version>${log4j.version}</version>
33          </dependency>
34
35          <!-- https://logging.apache.org/log4j/2.x/manual/async.html -->
36          <dependency>
37              <groupId>com.lmax</groupId>
38              <artifactId>disruptor</artifactId>
39              <version>${disruptor.version}</version>
40          </dependency>
41
42          <!-- https://logging.apache.org/log4j/2.x/runtime-dependencies.html -
->
43          <!-- log4j.yml need this -->
44          <dependency>
45              <groupId>com.fasterxml.jackson.dataformat</groupId>
46              <artifactId>jackson-dataformat-yaml</artifactId>
47              <version>${jackson.version}</version>
48          </dependency>
49
50          <dependency>
51              <groupId>com.fasterxml.jackson.core</groupId>
52              <artifactId>jackson-databind</artifactId>
53              <version>${jackson.version}</version>
54          </dependency>
55

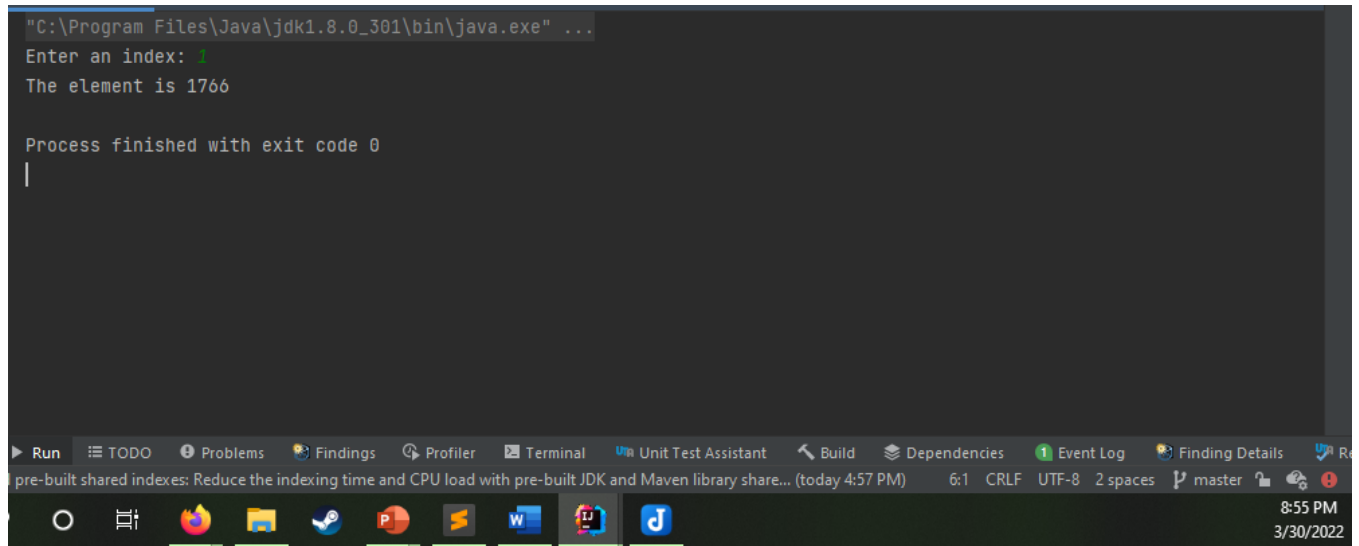
```

```

56     </dependencies>
57
58     <build>
59         <plugins>
60             <plugin>
61                 <groupId>org.apache.maven.plugins</groupId>
62                 <artifactId>maven-compiler-plugin</artifactId>
63                 <version>3.8.0</version>
64                 <configuration>
65                     <source>${java.version}</source>
66                     <target>${java.version}</target>
67                 </configuration>
68             </plugin>
69
70             <plugin>
71                 <groupId>org.apache.maven.plugins</groupId>
72                 <artifactId>maven-shade-plugin</artifactId>
73                 <version>3.2.0</version>
74                 <executions>
75                     <!-- Attach the shade into the package phase -->
76                     <execution>
77                         <phase>package</phase>
78                         <goals>
79                             <goal>shade</goal>
80                         </goals>
81                         <configuration>
82                             <transformers>
83                                 <transformer
84 implementation="org.apache.maven.plugins.shade.resource.ManifestResourceTransformer
">
85
86                 </transformer>
87                 </transformers>
88                 </configuration>
89             </execution>
90         </executions>
91     </plugin>
92
93     </plugins>
94 </build>
95
96 </project>
97

```


Appendix C: Console Output Prior to Logging Implementation



The screenshot shows a terminal window within an IDE. The terminal output is as follows:

```
"C:\Program Files\Java\jdk1.8.0_301\bin\java.exe" ...  
Enter an index: 1  
The element is 1766  
  
Process finished with exit code 0  
|
```

The IDE interface includes a toolbar with icons for Run, TODO, Problems, Findings, Profiler, Terminal, Unit Test Assistant, Build, Dependencies, Event Log, and Finding Details. A status bar at the bottom displays the text "pre-built shared indexes: Reduce the indexing time and CPU load with pre-built JDK and Maven library share... (today 4:57 PM)" along with encoding settings (6:1 CRLF UTF-8 2 spaces) and the file name "master". The system clock in the bottom right corner shows 8:55 PM on 3/30/2022.

Appendix D: Console Output Post-Logging Implementation

```

C:\Program Files\Java\jdk1.8.0_301\bin\java.exe ...
2022-04-01 22:54:07,703 main DEBUG Apache Log4j Core 2.11.2 Initializing configuration XmlConfiguration[location=C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml]
2022-04-01 22:54:07,708 main DEBUG Installed 1 script engine
2022-04-01 22:54:08,038 main DEBUG Oracle Nashorn version: 1.8.0_301, Language: ECMAScript, threading: Not Thread Safe, compile: true, names: [nashorn, Nashorn, js, JS, JavaScript, javascript, ECMAScript, ecmaScript], factory class: jdk.nashorn.api.scripting.NashornScriptEngineFactory
2022-04-01 22:54:08,039 main DEBUG PluginManager 'Core' found 117 plugins
2022-04-01 22:54:08,039 main DEBUG PluginManager 'Level' found 0 plugins
2022-04-01 22:54:08,044 main DEBUG PluginManager 'Lookup' found 13 plugins
2022-04-01 22:54:08,045 main DEBUG Building Plugin[name=layout, class=org.apache.logging.log4j.core.layout.PatternLayout].
2022-04-01 22:54:08,053 main DEBUG PluginManager 'TypeConverter' found 26 plugins
2022-04-01 22:54:08,066 main DEBUG PatternLayout$Builder(pattern="%d{HH:mm:ss.SSS} [%t] %-5level %logger{36} - %msg%n", PatternSelector=null, Configuration(C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml), Replace=null, charset="null", alwaysWriteExceptions="null", disableAnsi="null", noConsoleNoAnsi="null", header="null", footer="null")
2022-04-01 22:54:08,066 main DEBUG PluginManager 'Converter' found 44 plugins
2022-04-01 22:54:08,067 main DEBUG Building Plugin[name=appender, class=org.apache.logging.log4j.core.appender.ConsoleAppender].
2022-04-01 22:54:08,077 main DEBUG ConsoleAppender$Builder(target="SYSTEM_OUT", follow="null", direct="null", bufferedIo="null", bufferSize="null", immediateFlush="null", ignoreExceptions="null", PatternLayout(%d{HH:mm:ss.SSS} [%t] %-5level %logger{36} - %msg%n), name="LogToConsole", Configuration(C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml), Filters=null, {})
2022-04-01 22:54:08,079 main DEBUG Starting OutputStreamManager SYSTEM_OUT.false.false
2022-04-01 22:54:08,079 main DEBUG Building Plugin[name=layout, class=org.apache.logging.log4j.core.layout.PatternLayout].
2022-04-01 22:54:08,081 main DEBUG PatternLayout$Builder(pattern="%d %p %1.} [%t] %M%n", PatternSelector=null, Configuration(C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml), Replace=null, charset="null", alwaysWriteExceptions="null", disableAnsi="null", noConsoleNoAnsi="null", header="null", footer="null")
2022-04-01 22:54:08,094 main DEBUG Building Plugin[name=TimeBasedTriggeringPolicy, class=org.apache.logging.log4j.core.appender.rolling.TimeBasedTriggeringPolicy].
2022-04-01 22:54:08,096 main DEBUG TimeBasedTriggeringPolicy$Builder(interval="null", modulate="null", maxRandomDelay="null")
2022-04-01 22:54:08,097 main DEBUG Building Plugin[name=SizeBasedTriggeringPolicy, class=org.apache.logging.log4j.core.appender.rolling.SizeBasedTriggeringPolicy].
2022-04-01 22:54:08,100 main DEBUG createPolicy(size="1 MB")
2022-04-01 22:54:08,102 main DEBUG Building Plugin[name=Policies, class=org.apache.logging.log4j.core.appender.rolling.CompositeTriggeringPolicy].
2022-04-01 22:54:08,102 main DEBUG createPolicy(TimeBasedTriggeringPolicy(nextRollOverMillis=0, interval=1, modulate=false), SizeBasedTriggeringPolicy(size=1048576))
2022-04-01 22:54:08,103 main DEBUG Building Plugin[name=DefaultRollOverStrategy, class=org.apache.logging.log4j.core.appender.rolling.DefaultRollOverStrategy].
2022-04-01 22:54:08,107 main DEBUG DefaultRollOverStrategy$Builder(max="10", min="null", fileIndex="null", compressionLevel="null", =(), stopCustomActionsOnError="null", tempCompressedFilePattern="null", Configuration(C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml))
2022-04-01 22:54:08,108 main DEBUG Building Plugin[name=appender, class=org.apache.logging.log4j.core.appender.RollingRandomAccessFileAppender].
2022-04-01 22:54:08,110 main DEBUG RollingRandomAccessFileAppender$Builder(fileName="logs/app.log", filePattern="logs/%d{yyyy-MM}/app-%d{HH-dd-yyyy}-%i.log.gz", append="null", Policies(CompositeTriggeringPolicy(policies=[TimeBasedTriggeringPolicy(nextRollOverMillis=0, interval=1, modulate=false), SizeBasedTriggeringPolicy(size=1048576)]), DefaultRollOverStrategy(DefaultRollOverStrategy(min=1, max=10, useMax=true)), advertise="null", advertiseURI="null", filePermissions="null", fileOwner="null", fileGroup="null", bufferedIo="null", bufferSize="null", immediateFlush="null", ignoreExceptions="null", PatternLayout(%d %p %1.} [%t] %M%n), name="LogToRollingRandomAccessFile", Configuration(C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml))
2022-04-01 22:54:08,117 main DEBUG Starting RollingRandomAccessFileManager logs/app.log
2022-04-01 22:54:08,121 main DEBUG PluginManager 'FileConverter' found 2 plugins
2022-04-01 22:54:08,122 main DEBUG Setting prev file time to 2022-04-01T22:54:08.115-0600
2022-04-01 22:54:08,124 main DEBUG Initializing triggering policy CompositeTriggeringPolicy(policies=[TimeBasedTriggeringPolicy(nextRollOverMillis=0, interval=1, modulate=false), SizeBasedTriggeringPolicy(size=1048576)])
2022-04-01 22:54:08,124 main DEBUG Initializing triggering policy TimeBasedTriggeringPolicy(nextRollOverMillis=0, interval=1, modulate=false)
2022-04-01 22:54:08,125 main DEBUG Initializing triggering policy SizeBasedTriggeringPolicy(size=1048576)
2022-04-01 22:54:08,125 main DEBUG Building Plugin[name=appenders, class=org.apache.logging.log4j.core.config.AppendersPlugin].
2022-04-01 22:54:08,129 main DEBUG createAppenders(=([LogToConsole, LogToRollingRandomAccessFile])
2022-04-01 22:54:08,129 main DEBUG Building Plugin[name=AppenderRef, class=org.apache.logging.log4j.core.config.AppenderRef].
2022-04-01 22:54:08,130 main DEBUG createAppenderRef(ref="LogToRollingRandomAccessFile", level="null", Filter=null)
2022-04-01 22:54:08,131 main DEBUG Building Plugin[name=AppenderRef, class=org.apache.logging.log4j.core.config.AppenderRef].
2022-04-01 22:54:08,131 main DEBUG createAppenderRef(ref="LogToConsole", level="null", Filter=null)
2022-04-01 22:54:08,131 main DEBUG Building Plugin[name=logger, class=org.apache.logging.log4j.core.config.LoggerConfig].
2022-04-01 22:54:08,135 main DEBUG createLogger(additivity="false", level="DEBUG", name="edu.arapahoe.csc245", includeLocations="null", =([LogToRollingRandomAccessFile, LogToConsole], =(), Configuration(C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml), Filter=null)
2022-04-01 22:54:08,137 main DEBUG Building Plugin[name=AppenderRef, class=org.apache.logging.log4j.core.config.AppenderRef].
2022-04-01 22:54:08,138 main DEBUG createAppenderRef(ref="LogToConsole", level="null", Filter=null)
2022-04-01 22:54:08,138 main DEBUG Building Plugin[name=root, class=org.apache.logging.log4j.core.config.LoggerConfig$RootLogger].
2022-04-01 22:54:08,139 main DEBUG createLogger(additivity="null", level="ERROR", includeLocations="null", =([LogToConsole], =(), Configuration(C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml), Filter=null)
2022-04-01 22:54:08,140 main DEBUG Building Plugin[name=Loggers, class=org.apache.logging.log4j.core.config.LoggersPlugin].
2022-04-01 22:54:08,141 main DEBUG createLoggers(=([edu.arapahoe.csc245, root])
2022-04-01 22:54:08,143 main DEBUG Configuration XmlConfiguration[location=C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml] initialized
2022-04-01 22:54:08,143 main DEBUG Starting configuration XmlConfiguration[location=C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml]
2022-04-01 22:54:08,143 main DEBUG Started configuration XmlConfiguration[location=C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml] OK.
2022-04-01 22:54:08,144 main DEBUG Shutting down OutputStreamManager SYSTEM_OUT.false.false-1
2022-04-01 22:54:08,144 main DEBUG Shut down OutputStreamManager SYSTEM_OUT.false.false-1, all resources released: true
2022-04-01 22:54:08,144 main DEBUG Appender DefaultConsole-1 stopped with status true
2022-04-01 22:54:08,145 main DEBUG Stopped org.apache.logging.log4j.core.config.DefaultConfiguration@60cd51c3 OK
2022-04-01 22:54:08,190 main DEBUG Registering MBean org.apache.logging.log4j2:type=18b4aac2
2022-04-01 22:54:08,193 main DEBUG Registering MBean org.apache.logging.log4j2:type=18b4aac2,component=StatusLogger
2022-04-01 22:54:08,194 main DEBUG Registering MBean org.apache.logging.log4j2:type=18b4aac2,component=ContextSelector
2022-04-01 22:54:08,196 main DEBUG Registering MBean org.apache.logging.log4j2:type=18b4aac2,component=Loggers,name=
2022-04-01 22:54:08,196 main DEBUG Registering MBean org.apache.logging.log4j2:type=18b4aac2,component=Loggers,name=edu.arapahoe.csc245
2022-04-01 22:54:08,197 main DEBUG Registering MBean org.apache.logging.log4j2:type=18b4aac2,component=Appendors,name=LogToRollingRandomAccessFile
2022-04-01 22:54:08,198 main DEBUG Registering MBean org.apache.logging.log4j2:type=18b4aac2,component=Appendors,name=LogToConsole
2022-04-01 22:54:08,199 main DEBUG org.apache.logging.log4j.core.util.SystemClock does not support precise timestamps.
2022-04-01 22:54:08,199 main DEBUG Reconfiguration complete for context[name=18b4aac2] at URI C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml (org.apache.logging.log4j.core.LoggerContext@60cd51c3)
2022-04-01 22:54:08,200 main DEBUG Shutdown hook enabled. Registering a new one.
2022-04-01 22:54:08,201 main DEBUG LoggerContext[name=18b4aac2, org.apache.logging.log4j.core.LoggerContext@60cd51c3] started OK.
22:54:08.206 [main] INFO edu.arapahoe.csc245.Exercise12_03 - Program started
22:54:08.209 [main] INFO edu.arapahoe.csc245.Exercise12_03 - Array of length 100 initialized with random integers between 0-9,999 (inclusive)
Enter an index:
22:54:11.416 [main] INFO edu.arapahoe.csc245.Exercise12_03 - User input successfully received
The element is 8914
22:54:11.417 [main] INFO edu.arapahoe.csc245.Exercise12_03 - Element at user supplied index from random array was successfully printed to the console
22:54:11.417 [main] INFO edu.arapahoe.csc245.Exercise12_03 - Program terminated
2022-04-01 22:54:11,418 pool-1-thread-1 DEBUG Stopping LoggerContext[name=18b4aac2, org.apache.logging.log4j.core.LoggerContext@60cd51c3]
2022-04-01 22:54:11,418 pool-1-thread-1 DEBUG Stopping LoggerContext[name=18b4aac2, org.apache.logging.log4j.core.LoggerContext@60cd51c3]...
2022-04-01 22:54:11,419 pool-1-thread-1 DEBUG Shutting down OutputStreamManager SYSTEM_OUT.false.false
2022-04-01 22:54:11,419 pool-1-thread-1 DEBUG Shut down OutputStreamManager SYSTEM_OUT.false.false, all resources released: true
2022-04-01 22:54:11,419 pool-1-thread-1 DEBUG Appender LogToConsole stopped with status true
2022-04-01 22:54:11,419 pool-1-thread-1 DEBUG Shutting down RollingRandomAccessFileManager logs/app.log
2022-04-01 22:54:11,420 pool-1-thread-1 DEBUG Shutting down RollingFileManager logs/app.log
2022-04-01 22:54:11,420 pool-1-thread-1 DEBUG All asynchronous threads have terminated
2022-04-01 22:54:11,420 pool-1-thread-1 DEBUG RollingFileManager shutdown completed with status true
2022-04-01 22:54:11,421 pool-1-thread-1 DEBUG Shut down RollingRandomAccessFileManager logs/app.log, all resources released: true
2022-04-01 22:54:11,421 pool-1-thread-1 DEBUG Appender LogToRollingRandomAccessFile stopped with status true
2022-04-01 22:54:11,421 pool-1-thread-1 DEBUG Stopped XmlConfiguration[location=C:\Users\Turno_000\Desktop\School\2022-Spring\CSC245-Sec-Software-Dev\Project-4-Stuff\CSC245-Project-4\log4j2\target\classes\log4j2.xml] OK
2022-04-01 22:54:11,421 pool-1-thread-1 DEBUG Stopped LoggerContext[name=18b4aac2, org.apache.logging.log4j.core.LoggerContext@60cd51c3] with status true

Process finished with exit code 0

```

Appendix E: Log Output

2022-04-01 22:54:08,206 INFO e.a.c.Exercise12_03 [main] Program started

2022-04-01 22:54:08,209 INFO e.a.c.Exercise12_03 [main] Array of length 100 initialized with random integers between 0-9,999 (inclusive)

2022-04-01 22:54:11,416 INFO e.a.c.Exercise12_03 [main] User input successfully received

2022-04-01 22:54:11,417 INFO e.a.c.Exercise12_03 [main] Element at user supplied index from random array was successfully printed to the console

2022-04-01 22:54:11,417 INFO e.a.c.Exercise12_03 [main] Program terminated

2022-04-01 22:56:33,146 INFO e.a.c.Exercise12_03 [main] Program started

2022-04-01 22:56:33,149 INFO e.a.c.Exercise12_03 [main] Array of length 100 initialized with random integers between 0-9,999 (inclusive)

2022-04-01 22:56:37,756 INFO e.a.c.Exercise12_03 [main] User input successfully received

2022-04-01 22:56:37,760 WARN e.a.c.Exercise12_03 [main] User supplied index was out of bounds (0-99) for random array [java.lang.ArrayIndexOutOfBoundsException: -1]

2022-04-01 22:56:37,761 INFO e.a.c.Exercise12_03 [main] Program terminated

2022-04-01 22:56:43,344 INFO e.a.c.Exercise12_03 [main] Program started

2022-04-01 22:56:43,348 INFO e.a.c.Exercise12_03 [main] Array of length 100 initialized with random integers between 0-9,999 (inclusive)

2022-04-01 22:56:54,427 INFO e.a.c.Exercise12_03 [main] User input successfully received

2022-04-01 22:56:54,429 WARN e.a.c.Exercise12_03 [main] User supplied index was out of bounds (0-99) for random array [java.lang.ArrayIndexOutOfBoundsException: 100000]

2022-04-01 22:56:54,429 INFO e.a.c.Exercise12_03 [main] Program terminated

2022-04-01 22:56:59,513 INFO e.a.c.Exercise12_03 [main] Program started

2022-04-01 22:56:59,516 INFO e.a.c.Exercise12_03 [main] Array of length 100 initialized with random integers between 0-9,999 (inclusive)

2022-04-01 22:57:07,006 WARN e.a.c.Exercise12_03 [main] User supplied input was not a Java integer [java.util.InputMismatchException: For input string: "10000000000000000000000000000000"]

2022-04-01 22:57:07,007 INFO e.a.c.Exercise12_03 [main] Program terminated

2022-04-01 22:57:13,122 INFO e.a.c.Exercise12_03 [main] Program started

2022-04-01 22:57:13,125 INFO e.a.c.Exercise12_03 [main] Array of length 100 initialized with random integers between 0-9,999 (inclusive)

2022-04-01 22:57:17,668 WARN e.a.c.Exercise12_03 [main] User supplied input was not a Java integer [java.util.InputMismatchException]

2022-04-01 22:57:17,668 INFO e.a.c.Exercise12_03 [main] Program terminated

References

“Apache LOG4J Vulnerability Guidance.” CISA, <https://www.cisa.gov/uscert/apache-log4j-vulnerability-guidance>.

Liang, Daniel Y. “Exception Handling and Text I/O.” *Intro to Java Programming, Comprehensive Version*, 10th ed., Prentice Hall, Upper Saddle River, NJ, 2014, p. 488.