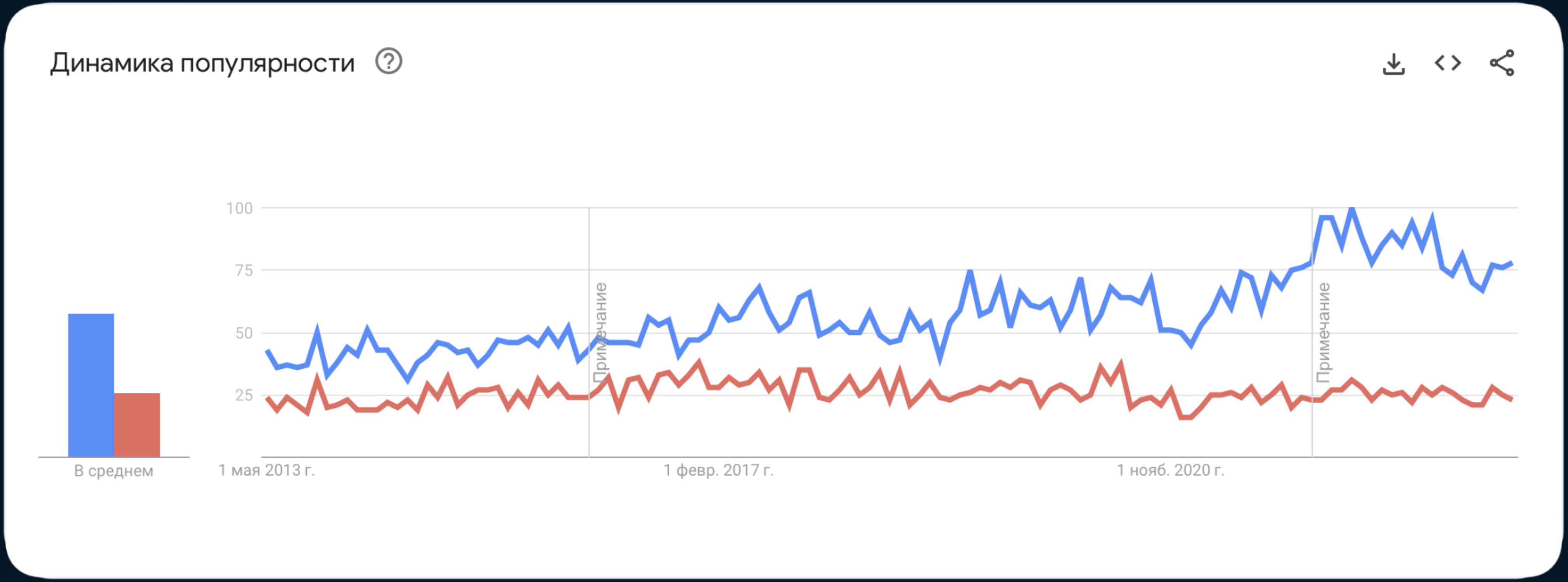
Знакомство с фаззерами

Максим Пелевин

- Разработчик на Java, Kotlin более 10 лет
- **Интересы:** динамический анализ кода
- **Хобби:** преподавание в университете

markoutte

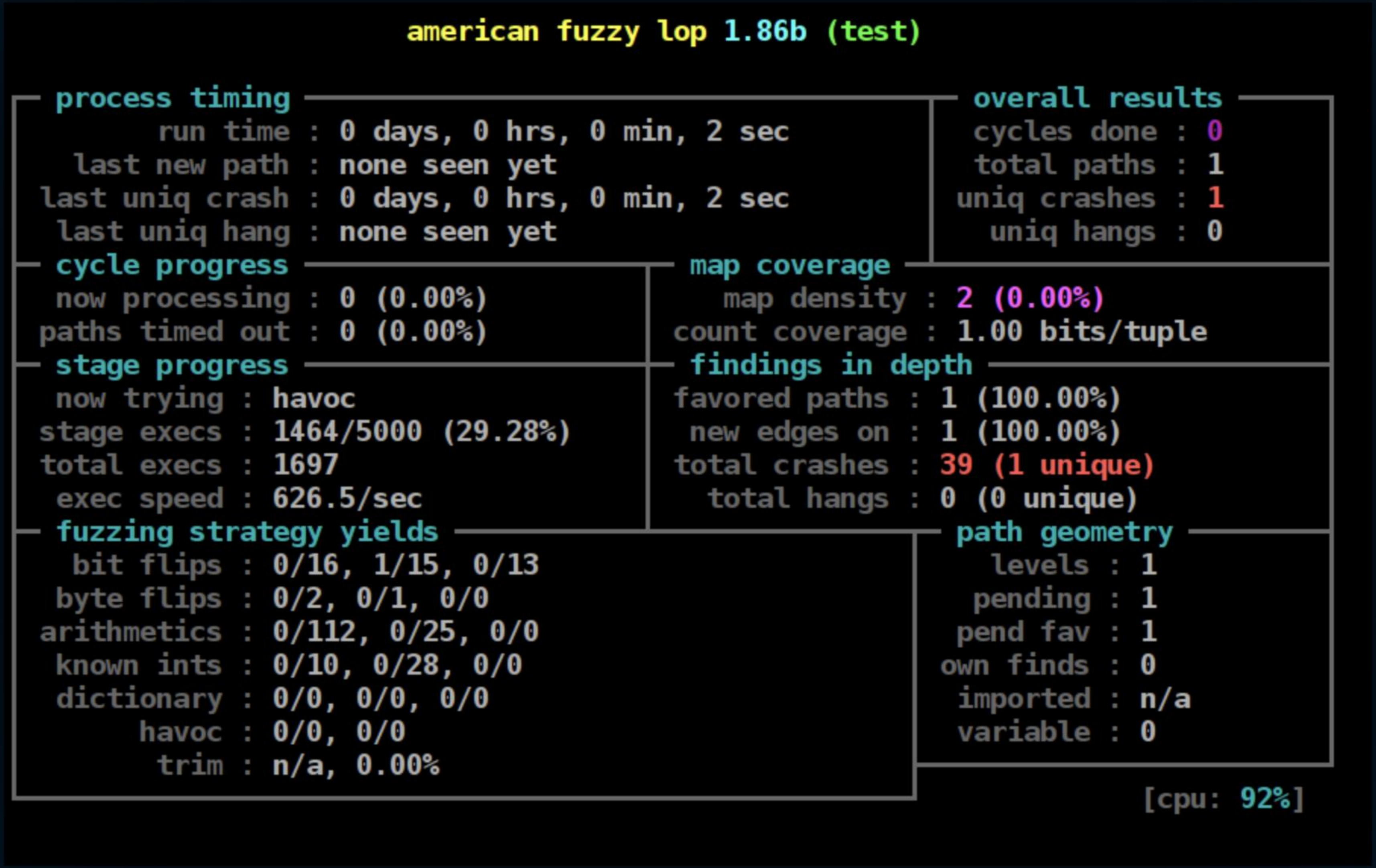
Популярность запросов Fuzzing и Fuzzer



Фаззинг — техника тестирования, когда на вход тестируемой программы подаются неожиданные, неправильные или случайные данные в надежде, что всё сломается

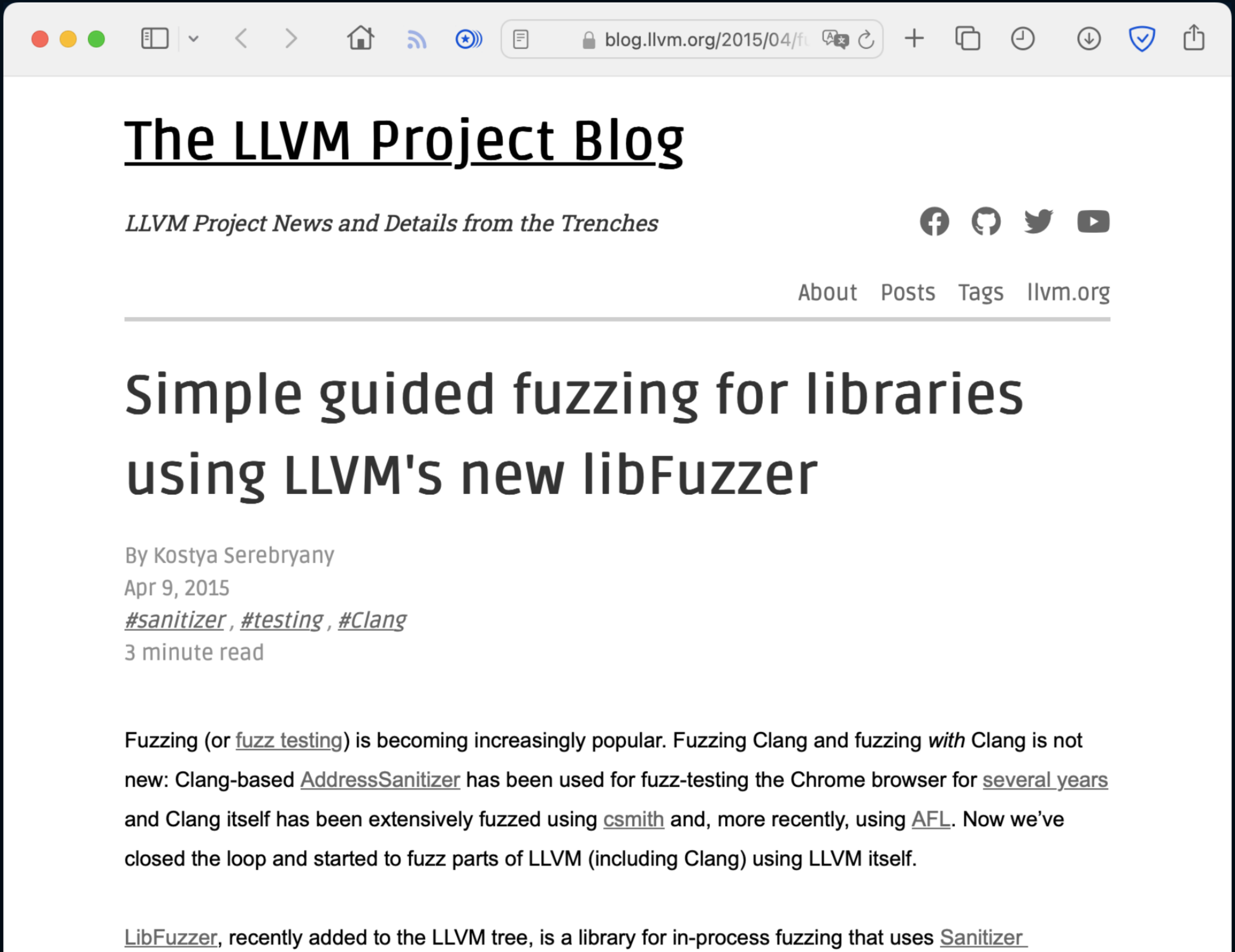
Зачем? Ошибки есть ошибки, а разработчики не так часто тестируют свой код на ошибки несвязанные со спецификацией

Фаззер — программа, которая фаззит



```
                 american fuzzy lop 1.86b (test)

┌─ process timing ─────────────────────────────────────┬─ overall results ────┐
│        run time : 0 days, 0 hrs, 0 min, 2 sec         │  cycles done : 0     │
│   last new path : none seen yet                       │  total paths : 1     │
│ last uniq crash : 0 days, 0 hrs, 0 min, 2 sec         │ uniq crashes : 1     │
│  last uniq hang : none seen yet                       │   uniq hangs : 0     │
├─ cycle progress ──────────────────┬─ map coverage ─┴──────────────────────┤
│  now processing : 0 (0.00%)        │    map density : 2 (0.00%)           │
│ paths timed out : 0 (0.00%)        │ count coverage : 1.00 bits/tuple     │
├─ stage progress ──────────────────┼─ findings in depth ──────────────────┤
│  now trying : havoc                │ favored paths : 1 (100.00%)          │
│ stage execs : 1464/5000 (29.28%)   │  new edges on : 1 (100.00%)          │
│ total execs : 1697                 │ total crashes : 39 (1 unique)        │
│  exec speed : 626.5/sec            │   total hangs : 0 (0 unique)         │
├─ fuzzing strategy yields ─────────┴───────────────┬─ path geometry ────────┤
│   bit flips : 0/16, 1/15, 0/13                     │    levels : 1          │
│  byte flips : 0/2, 0/1, 0/0                        │   pending : 1          │
│ arithmetics : 0/112, 0/25, 0/0                     │  pend fav : 1          │
│  known ints : 0/10, 0/28, 0/0                      │ own finds : 0          │
│  dictionary : 0/0, 0/0, 0/0                        │  imported : n/a        │
│       havoc : 0/0, 0/0                             │  variable : 0          │
│        trim : n/a, 0.00%                           ├────────────────────────┘
└────────────────────────────────────────────────────┘          [cpu: 92%]
```



The LLVM Project Blog

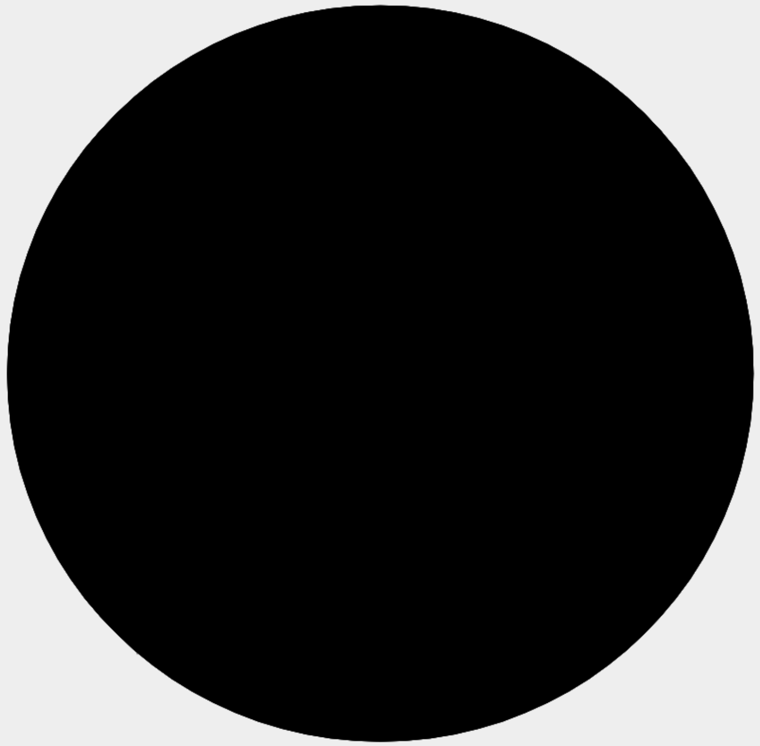
LLVM Project News and Details from the Trenches

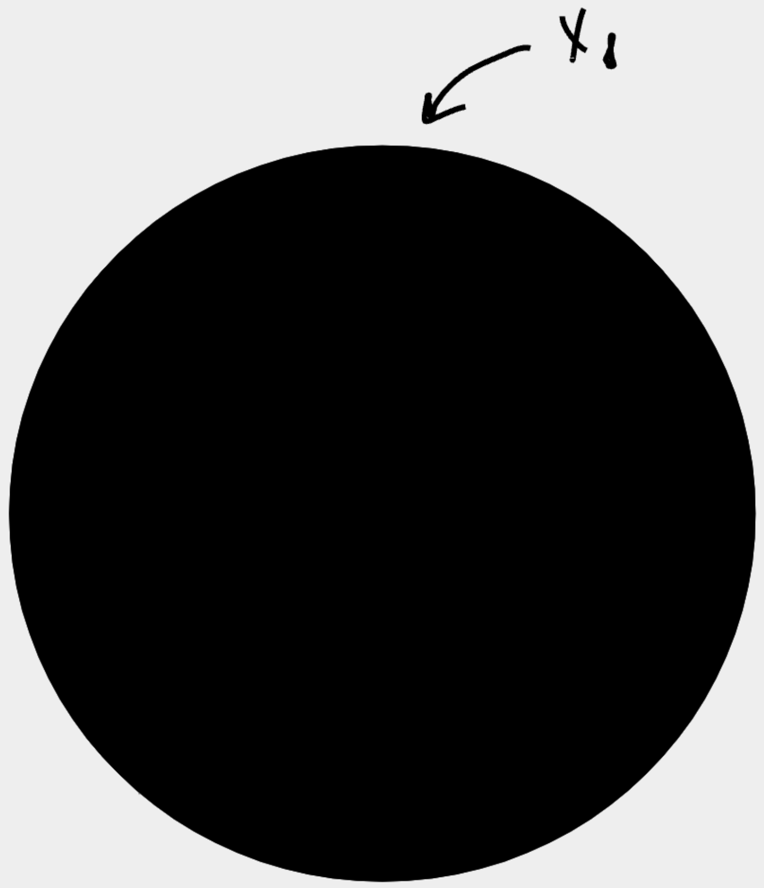
Simple guided fuzzing for libraries using LLVM's new libFuzzer

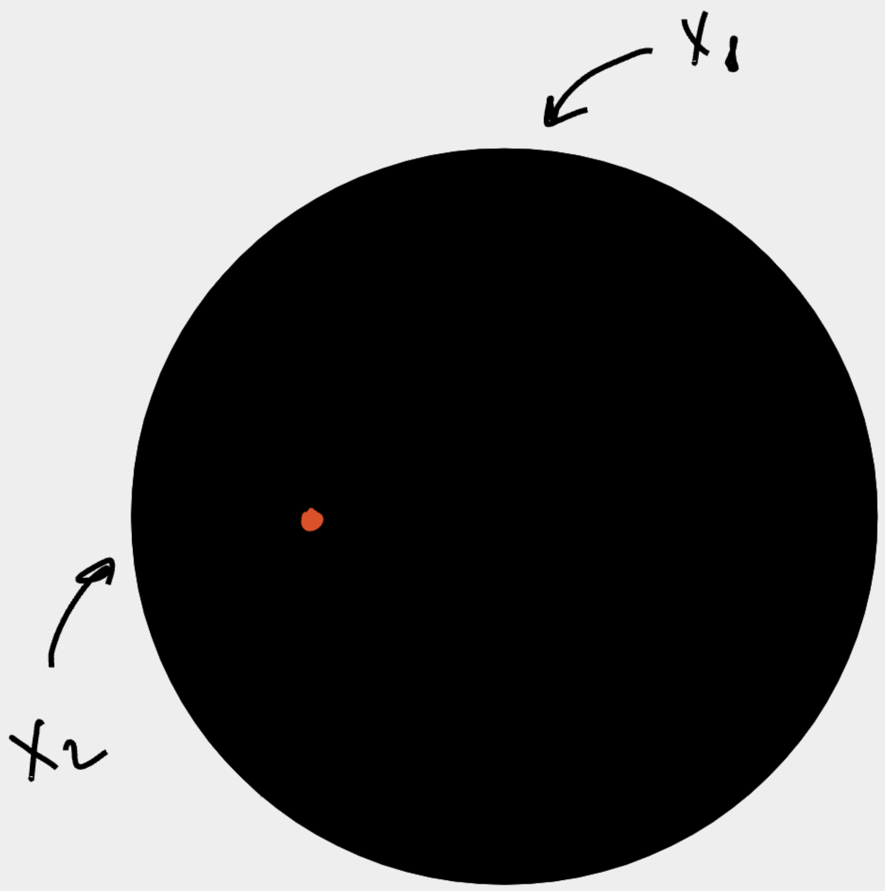
By Kostya Serebryany
Apr 9, 2015
#sanitizer , *#testing* , *#Clang*
3 minute read

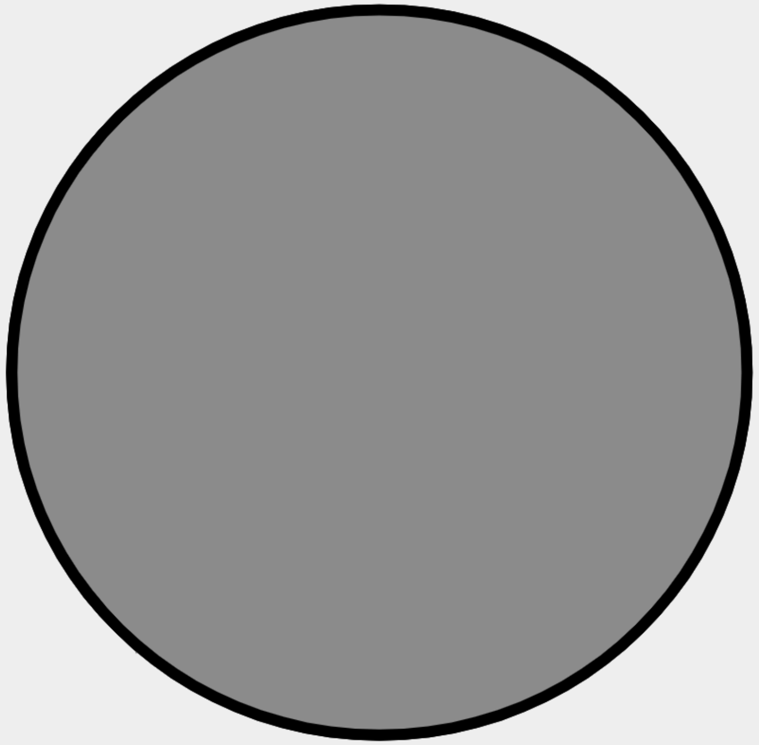
Fuzzing (or fuzz testing) is becoming increasingly popular. Fuzzing Clang and fuzzing *with* Clang is not new: Clang-based AddressSanitizer has been used for fuzz-testing the Chrome browser for several years and Clang itself has been extensively fuzzed using csmith and, more recently, using AFL. Now we've closed the loop and started to fuzz parts of LLVM (including Clang) using LLVM itself.

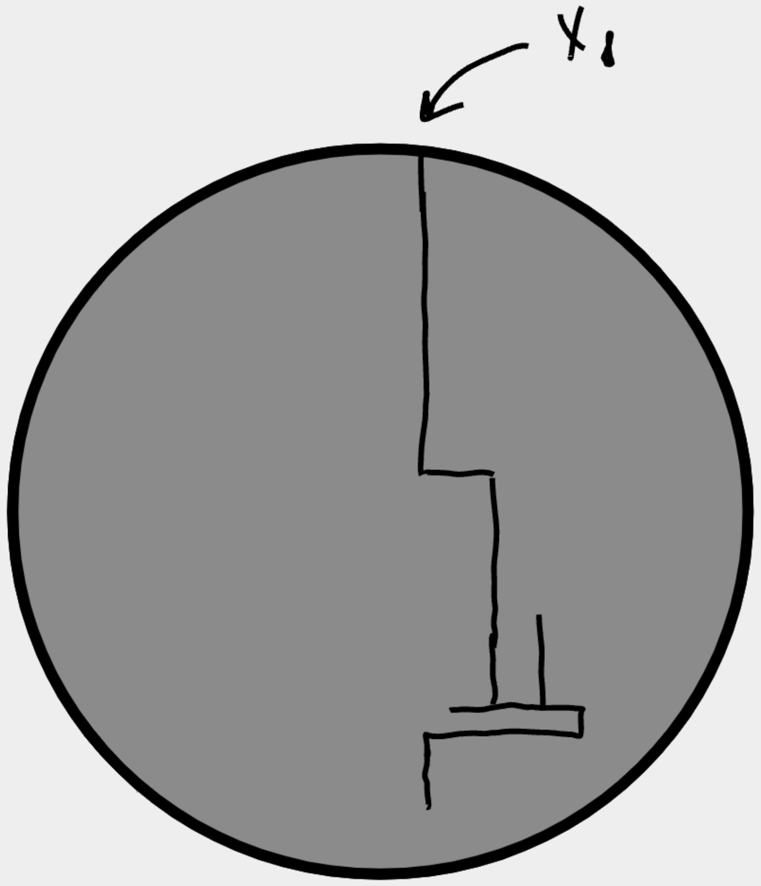
LibFuzzer, recently added to the LLVM tree, is a library for in-process fuzzing that uses Sanitizer

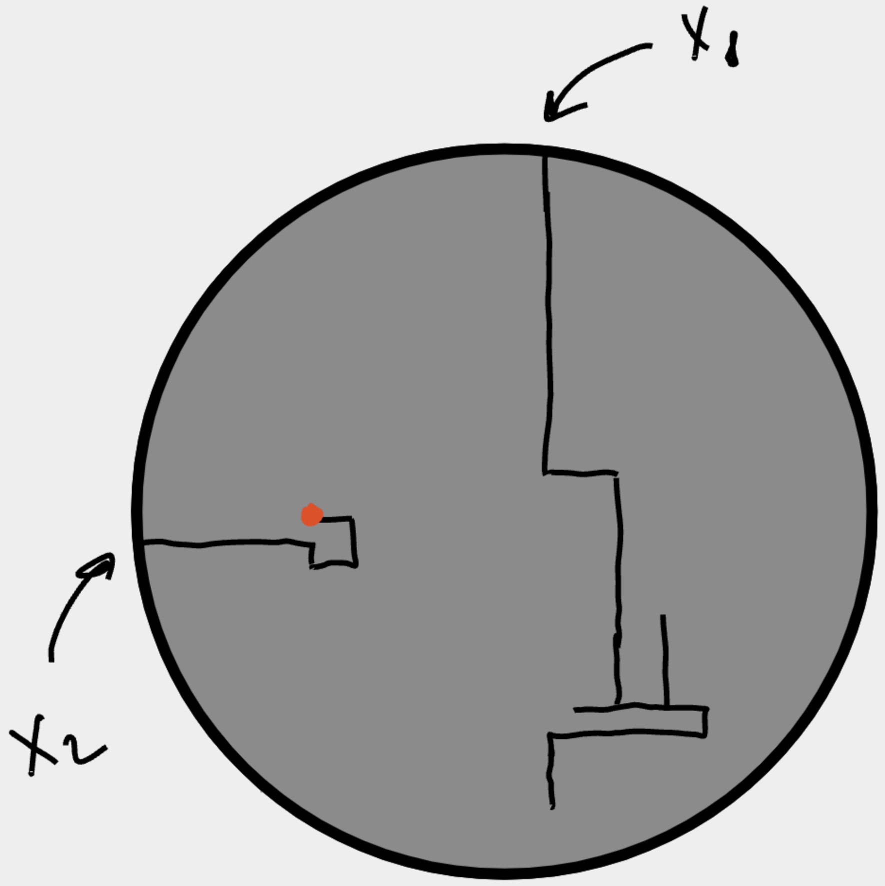


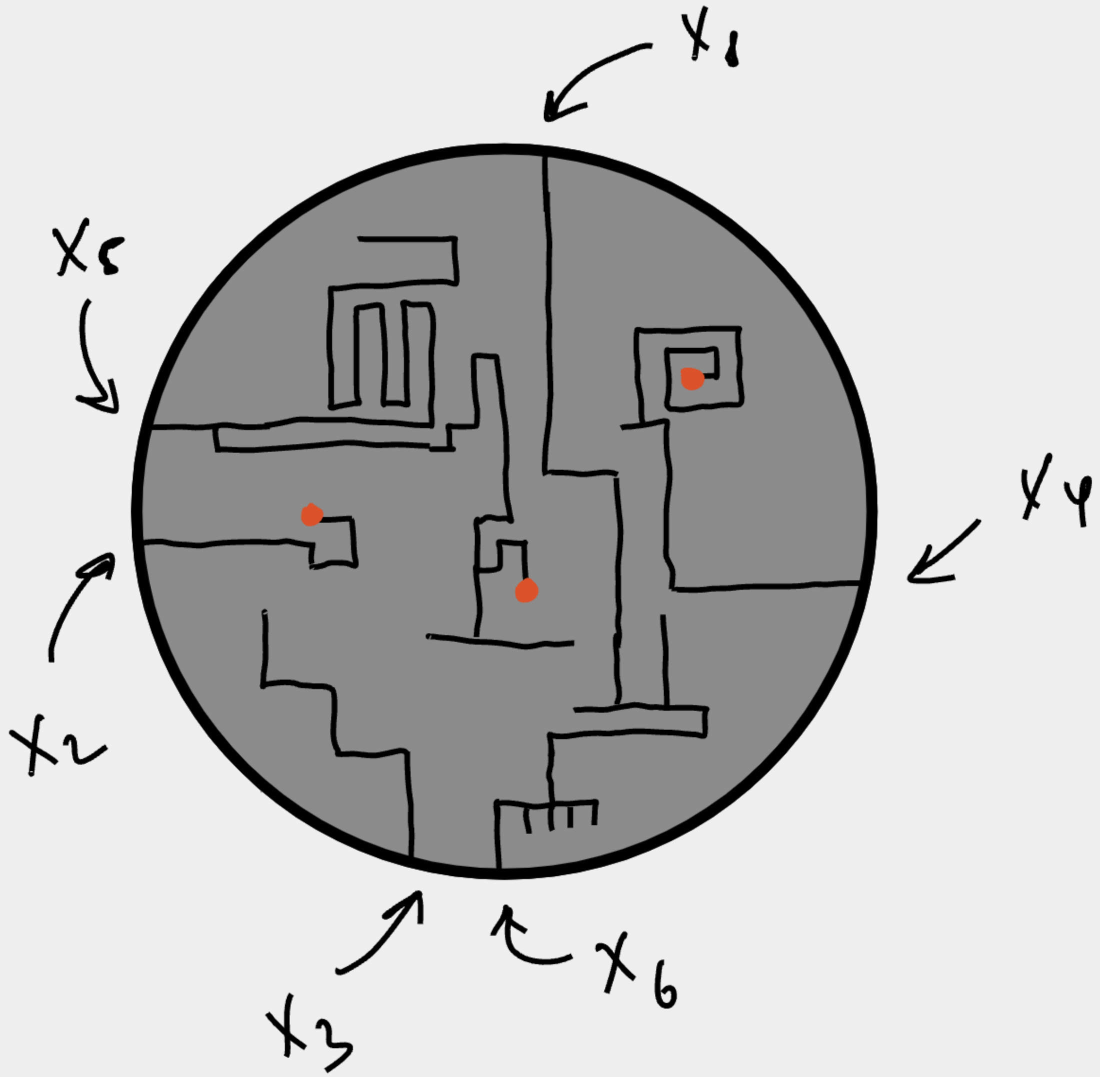

x_1

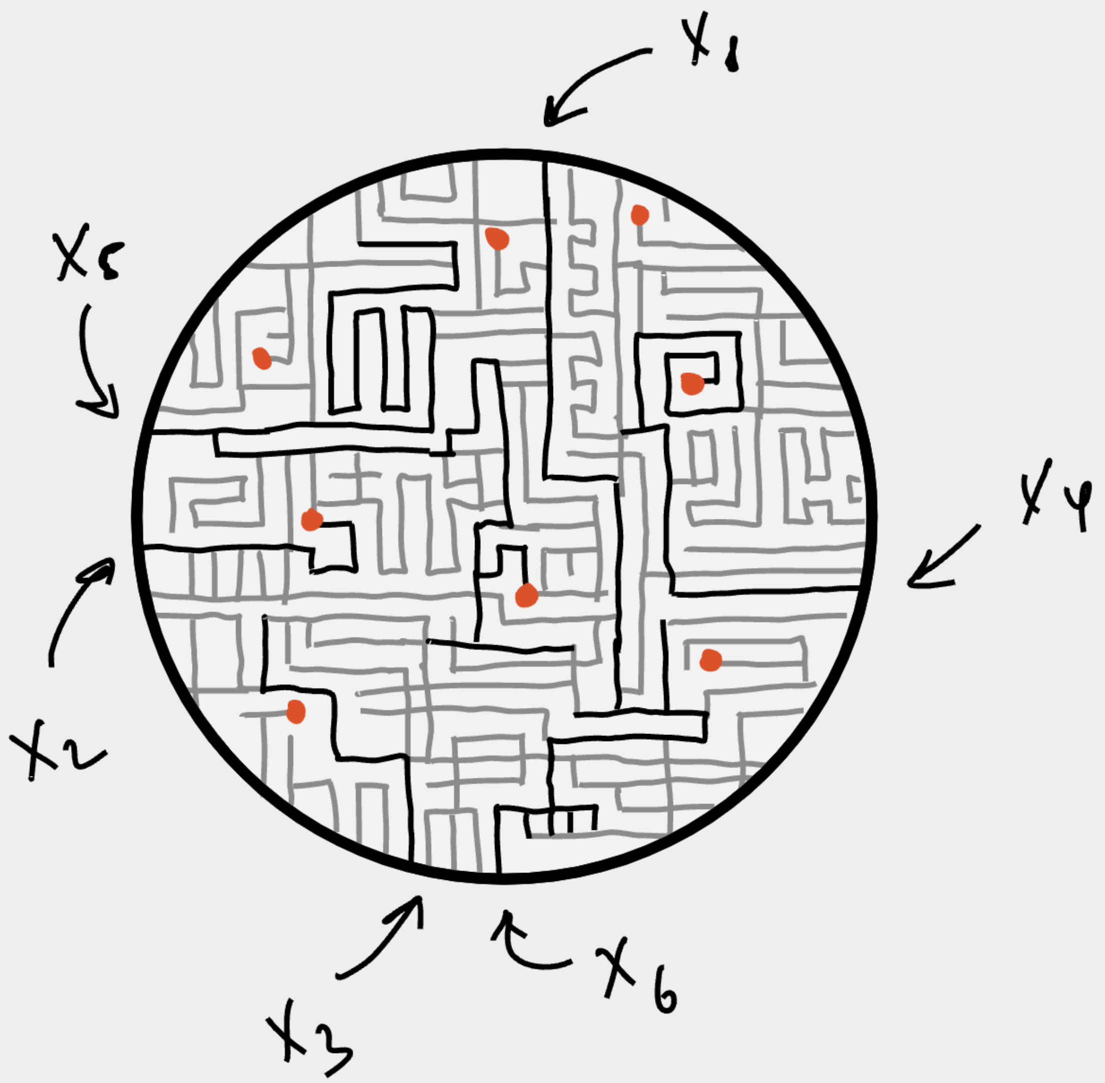

X_1
X_2



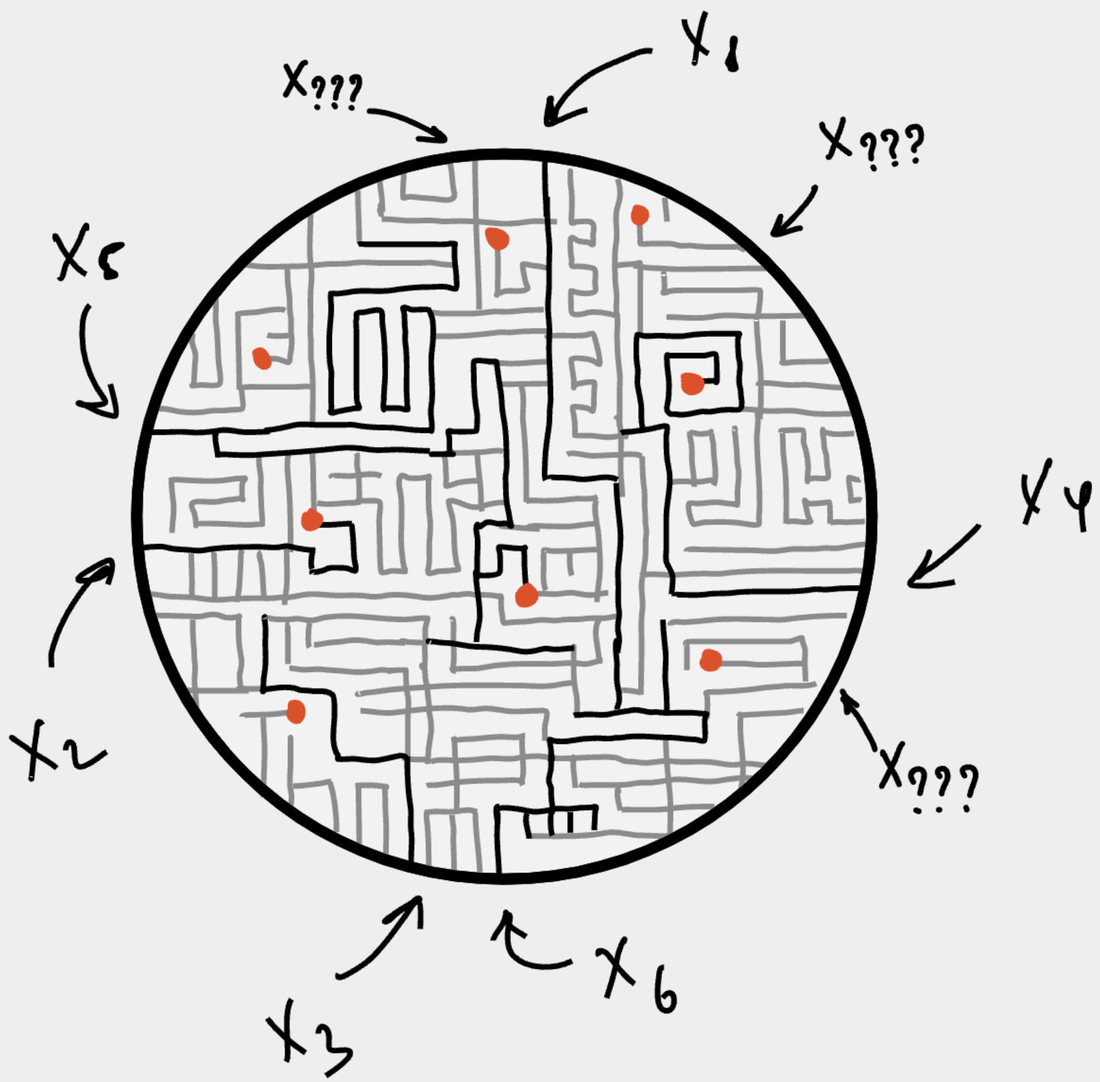

x_1

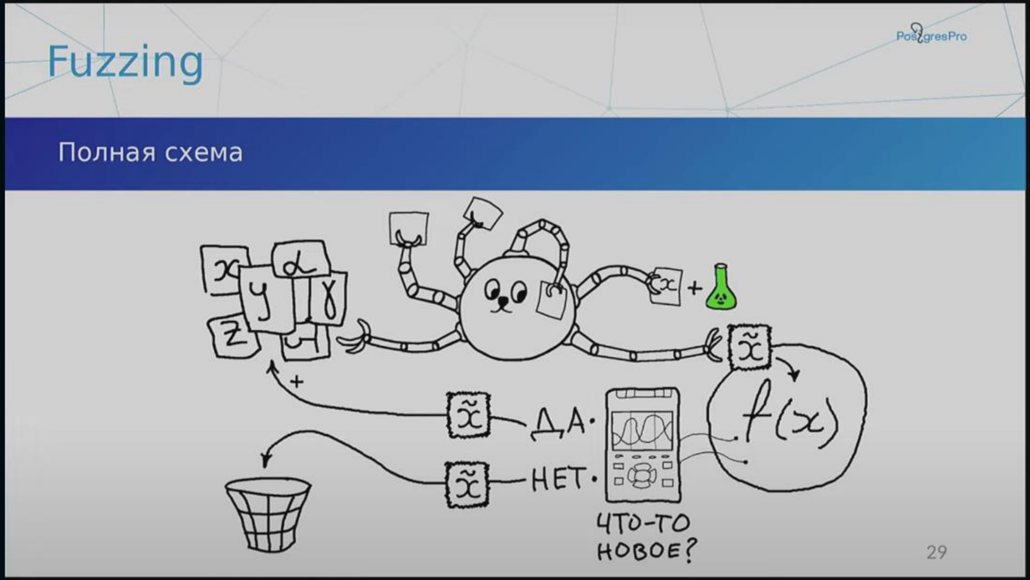

x1
x2


x1
x5
x4
x2
x3
x6



x_1
x_5
x_4
x_2
x_3
x_6

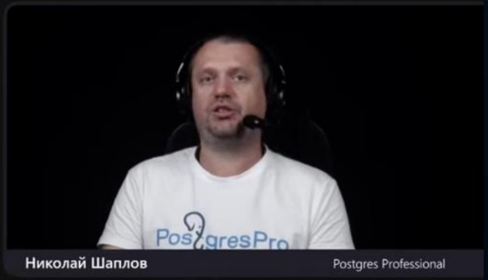

x???
x1
x???
x5
x4
x2
x???
x3
x6

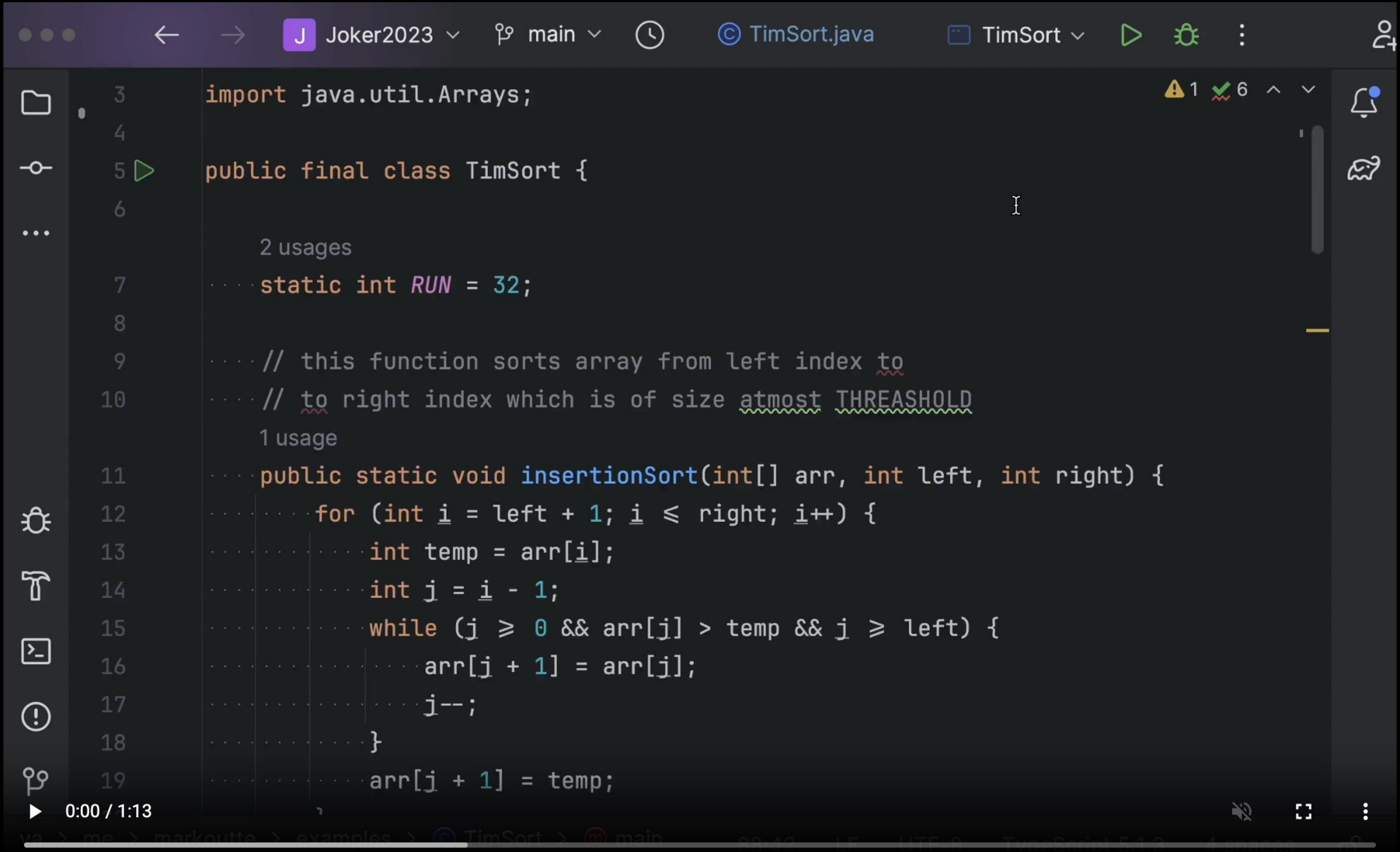


Fuzzing

Полная схема

29





```
import java.util.Arrays;

public final class TimSort {

    2 usages
    static int RUN = 32;

    // this function sorts array from left index to
    // to right index which is of size atmost THREASHOLD
    1 usage
    public static void insertionSort(int[] arr, int left, int right) {
        for (int i = left + 1; i ⩽ right; i++) {
            int temp = arr[i];
            int j = i - 1;
            while (j ⩾ 0 && arr[j] > temp && j ⩾ left) {
                arr[j + 1] = arr[j];
                j--;
            }
            arr[j + 1] = temp;
```

```kotlin
fun main(args: Array<String>) {
    val options = Options().apply {
        addOption("c", "class", true, "Java class fully qualified name")
        addOption("m", "method", true, "Method to be tested")
        addOption("t", "timeout", true, "Maximum time for fuzzing in seconds")
        addOption("s", "seed", true, "The source of randomness")
    }
    val parser = DefaultParser().parse(options, args)
    val className = parser.getOptionValue("class")
    val methodName = parser.getOptionValue("method")
    val timeout = parser.getOptionValue("timeout")?.toLong() ?: 10L
    val seed = parser.getOptionValue("seed")?.toInt() ?: Random.nextInt()
    val random = Random(seed)
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    val seed = parser.getOptionValue("seed")?.toInt() ?: Random.nextInt()
    val random = Random(seed)

    println("Running: $className.$methodName) with seed = $seed")
    val errors = mutableSetOf<String>()
    val b = ByteArray(300)
    val start = System.nanoTime()

    while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
        val buffer = b.apply(random::nextBytes)
    }

    println("Errors found: ${errors.size}")
    println("Time elapsed: ${TimeUnit.NANOSECONDS.toMillis(
        System.nanoTime() - start
    )} ms")
```

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    val b = ByteArray(300)
    val start = System.nanoTime()

    val javaMethod = try {
        loadJavaMethod(className, methodName)
    } catch (t: Throwable) {
        println("Method $className#$methodName is not found")
        return
    }

    while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
        val buffer = b.apply(random::nextBytes)
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        return
    }

    while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
        val buffer = b.apply(random::nextBytes)
        val inputValues = generateInputValues(javaMethod, buffer)
    }

    println("Errors found: ${errors.size}")
    println("Time elapsed: ${TimeUnit.NANOSECONDS.toMillis(
        System.nanoTime() - start
    )} ms")
}

fun loadJavaMethod(className: String, methodName: String): Method {
    val classLoader = ClassLoader.getSystemClassLoader()
    val javaClass = classLoader.loadClass(className)
    val javaMethod = javaClass.declaredMethods.first {
        "${it.name}(${it.parameterTypes.joinToString(",") {
            c -> c.typeName
    val start = System.nanoTime()

    val javaMethod = try {
        loadJavaMethod(className, methodName)
    } catch (t: Throwable) {
        println("Method $className#$methodName is not found")
        return
    }

    while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
        val buffer = b.apply(random::nextBytes)
        val inputValues = generateInputValues(javaMethod, buffer)
        try {
            javaMethod.invoke(null, *inputValues)
        } catch (e: InvocationTargetException) {

        }
    }

    println("Errors found: ${errors.size}")
    println("Time elapsed: ${TimeUnit.NANOSECONDS.toMillis(
        System.nanoTime() - start
    )} ms")
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    val javaClass = classLoader.loadClass(className)
    val javaMethod = javaClass.declaredMethods.first {
    }

    while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
        val buffer = b.apply(random::nextBytes)
        val inputValues = generateInputValues(javaMethod, buffer)
        try {
            javaMethod.invoke(null, *inputValues)
        } catch (e: InvocationTargetException) {
            if (errors.add(e.targetException::class.qualifiedName!!)) {
                val errorName = e.targetException::class.simpleName
                println("New error found: $errorName")
                val path = Paths.get("report$errorName.txt")
                Files.write(path, listOf(
                    "${e.targetException.stackTraceToString()}\n",
                    "${javaMethod.name}${inputValues.contentDeepToString()}\n",
                    "${buffer.contentToString()}\n",
                ))
                Files.write(path, buffer, StandardOpenOption.APPEND)
                println("Saved to: ${path.fileName}")
            }
        }
    }

    println("Errors found: ${errors.size}")
    println("Time elapsed: ${TimeUnit.NANOSECONDS.toMillis(
        System.nanoTime() - start
    )} ms")
}
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}

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    while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
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            }
        }
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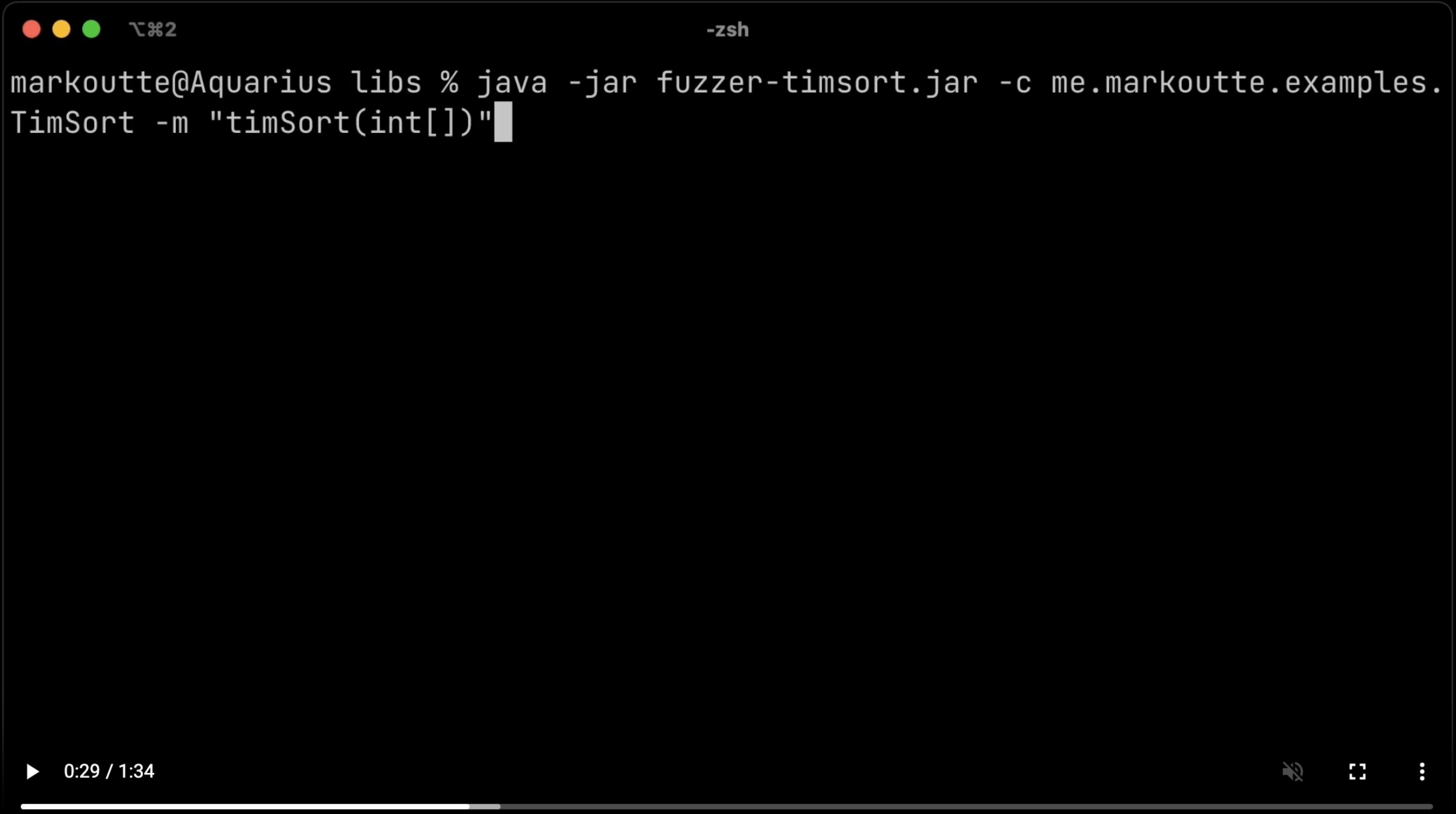
    }

    while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
        val buffer = b.apply(random::nextBytes)
        val inputValues = generateInputValues(javaMethod, buffer)
        val inputValuesString = "${javaMethod.name}: ${inputValues.contentDeepToString()}"
        try {
            javaMethod.invoke(null, *inputValues)
        } catch (e: InvocationTargetException) {
            if (errors.add(e.targetException::class.qualifiedName!!)) {
                val errorName = e.targetException::class.simpleName
                println("New error found: $errorName")
                val path = Paths.get("report$errorName.txt")
                Files.write(path, listOf(
                    "${e.targetException.stackTraceToString()}\n",
                    "$inputValuesString\n",
                    "${buffer.contentToString()}\n",
                ))
                Files.write(path, buffer, StandardOpenOption.APPEND)
                println("Saved to: ${path.fileName}")
            }
        }
    }

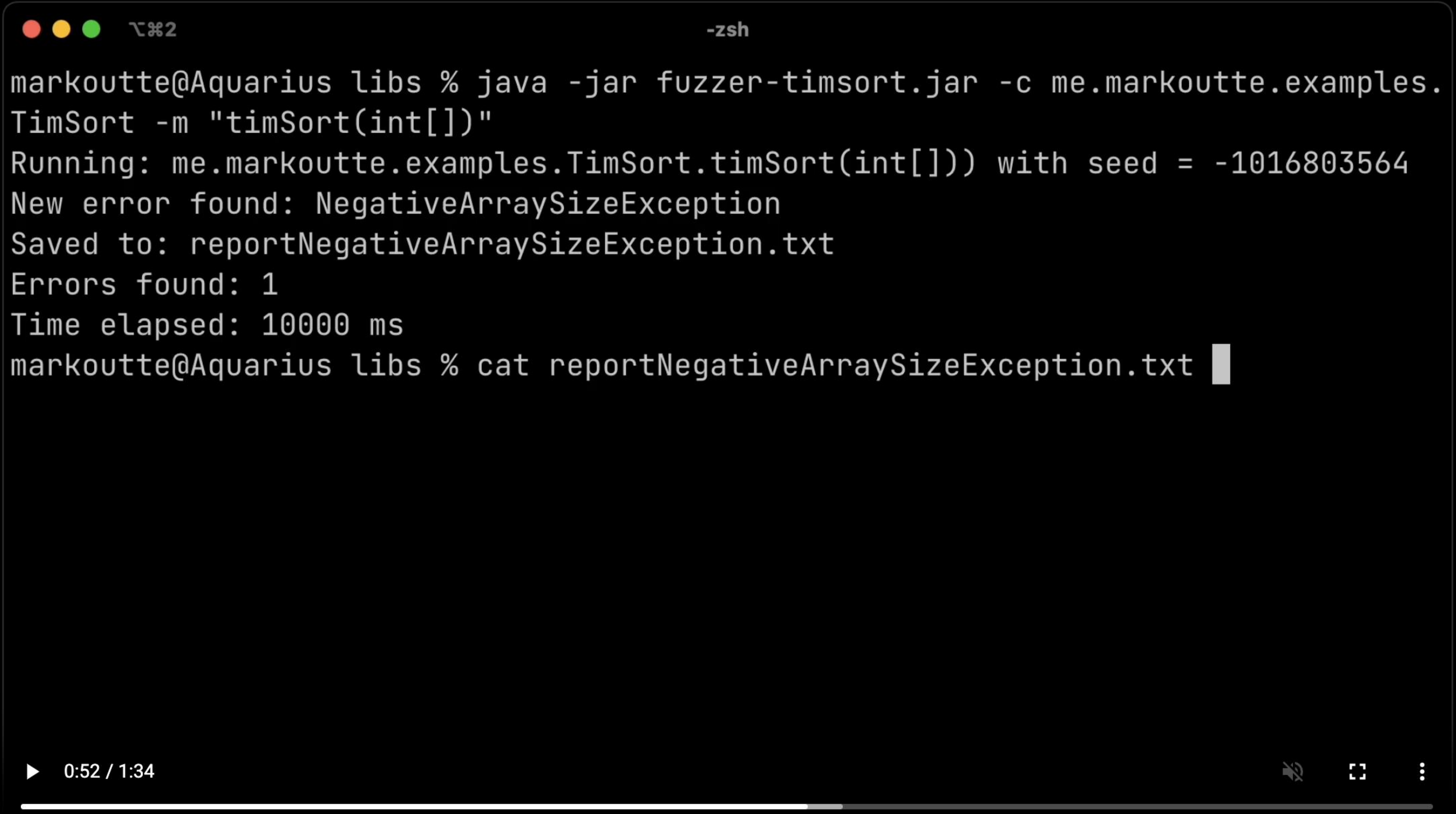
    println("Errors found: ${errors.size}")
    val javaMethod = javaClass.declaredMethods.first {
        "${it.name}(${it.parameterTypes.joinToString(",") {
            c -> c.typeName
        }})" == methodName
    }
    return javaMethod
}

fun generateInputValues(method: Method, data: ByteArray): Array<Any> {
    val buffer = ByteBuffer.wrap(data)
    val parameterTypes = method.parameterTypes
    return Array(parameterTypes.size) {
        when (parameterTypes[it]) {
            IntArray::class.java -> IntArray(buffer.get().toUByte().toInt()) {
                buffer.get().toInt()
            }
            else -> error("Cannot create value of type ${parameterTypes[it]}")
        }
    }
}
```

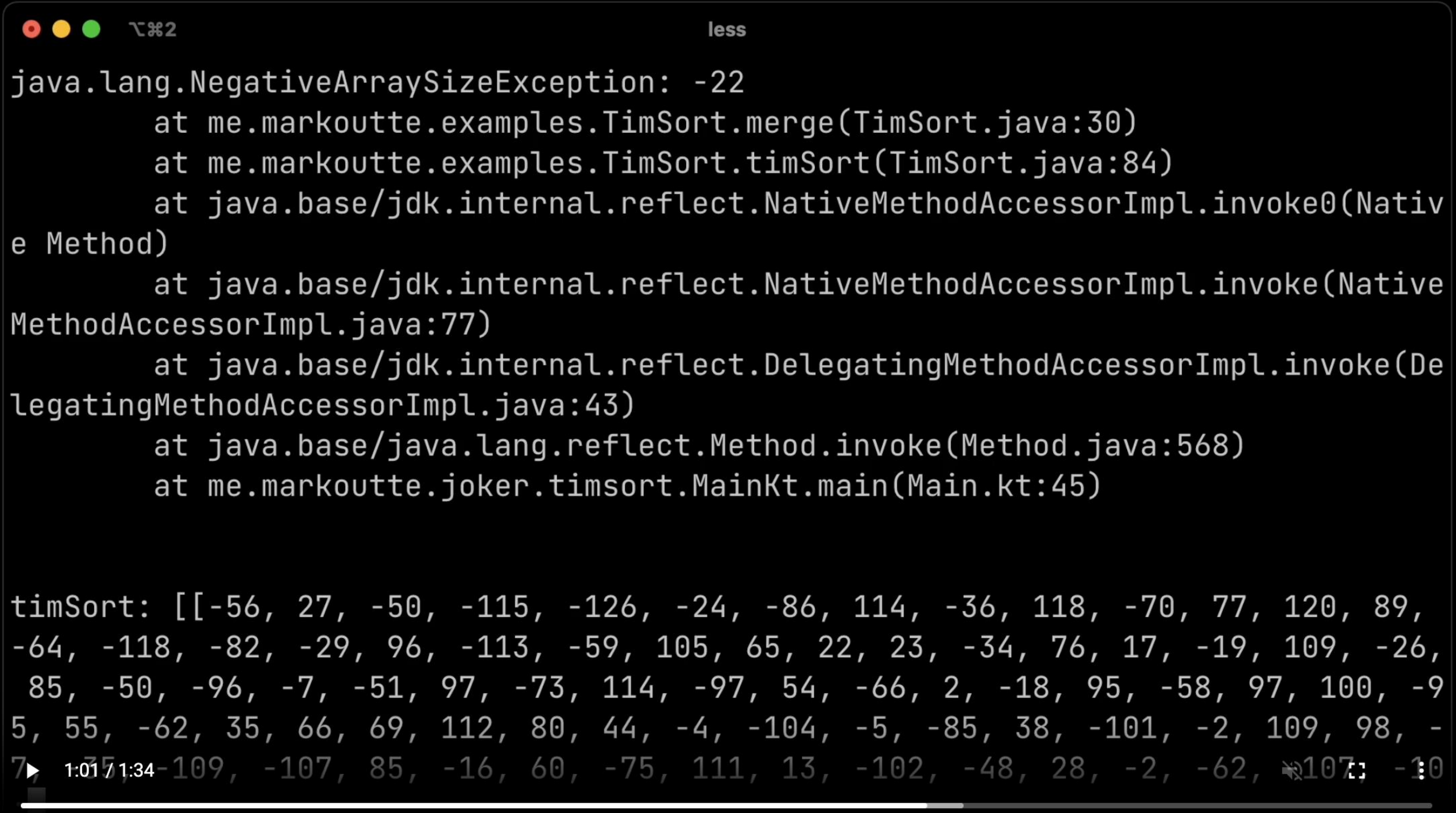
```kotlin
        }
    }

    println("Errors found: ${errors.size}")
    println("Time elapsed: ${TimeUnit.NANOSECONDS.toMillis(
        System.nanoTime() - start
    )} ms")
}

fun loadJavaMethod(className: String, methodName: String): Method {
    val classLoader = ClassLoader.getSystemClassLoader()
    val javaClass = classLoader.loadClass(className)
    val javaMethod = javaClass.declaredMethods.first {
        "${it.name}(${it.parameterTypes.joinToString(",") {
            c -> c.typeName
        }})" == methodName
    }
    return javaMethod
}

fun generateInputValues(method: Method, data: ByteArray): Array<Any> {
    val buffer = ByteBuffer.wrap(data)
    val parameterTypes = method.parameterTypes
    return Array(parameterTypes.size) {
        when (parameterTypes[it]) {
            IntArray::class.java -> IntArray(buffer.get().toUByte().toInt()) {
                buffer.get().toInt()
            }
            else -> error("Cannot create value of type ${parameterTypes[it]}")
```



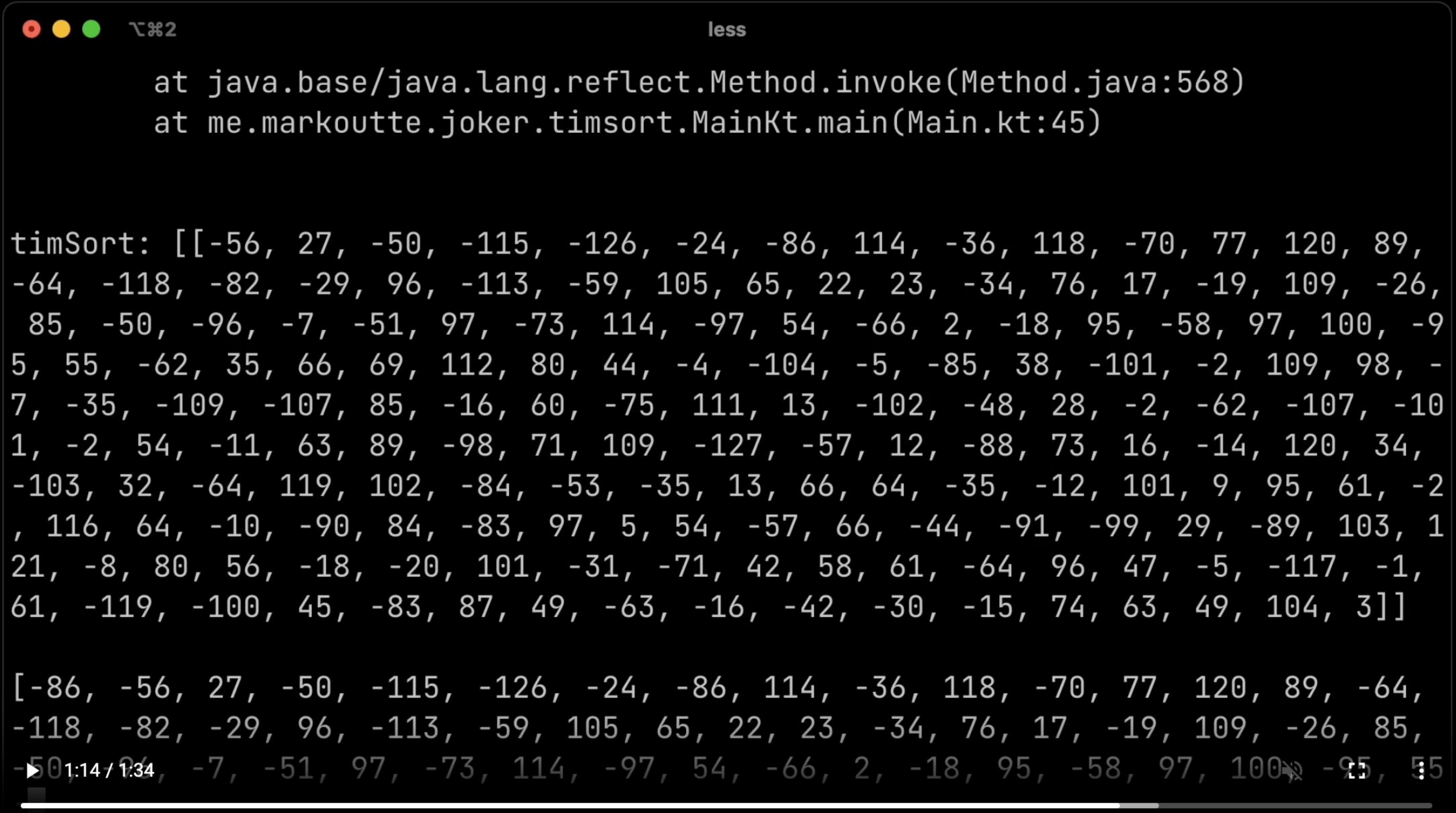
```
markoutte@Aquarius libs % java -jar fuzzer-timsort.jar -c me.markoutte.examples.
TimSort -m "timSort(int[])"
```



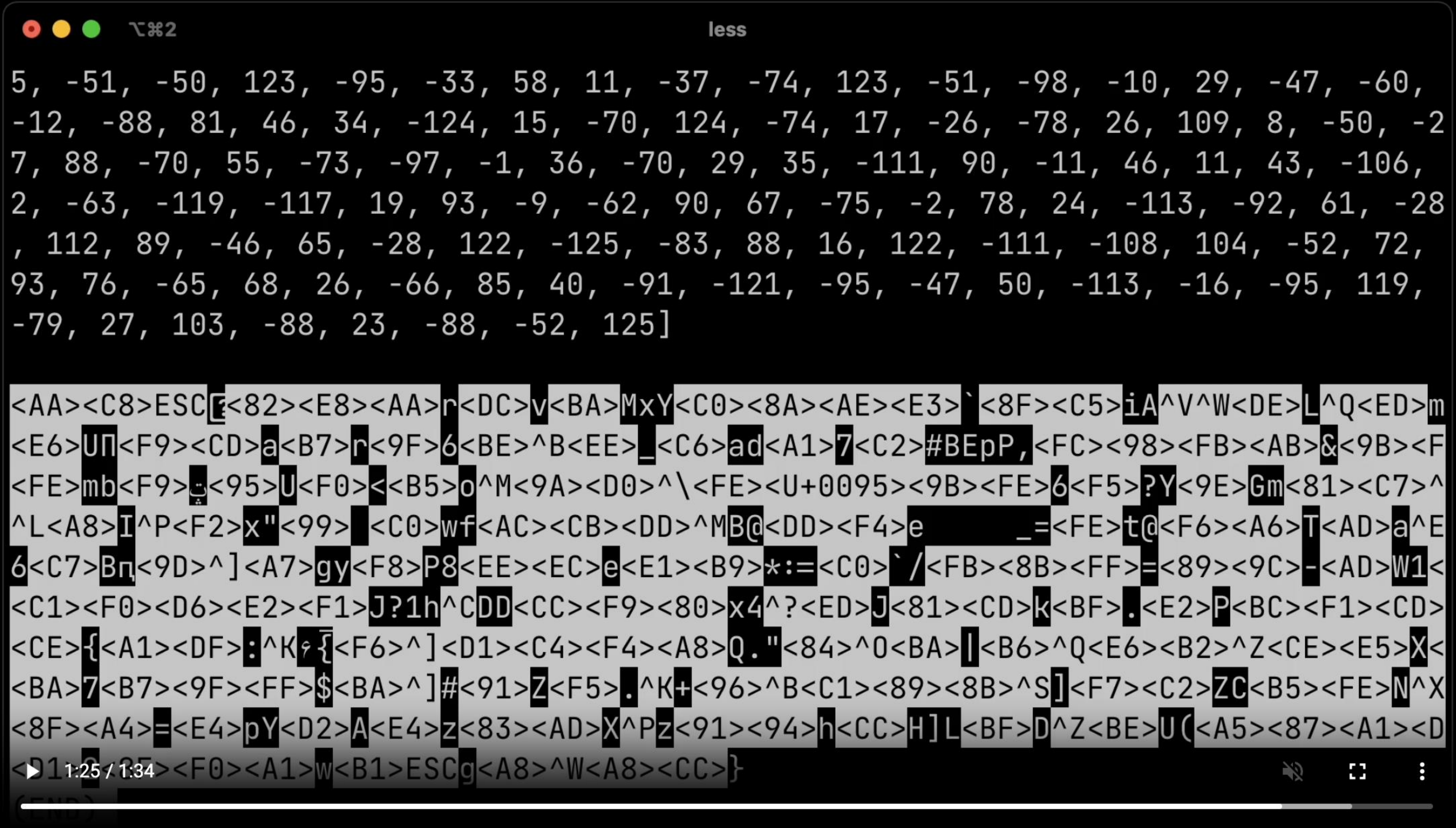
```
markoutte@Aquarius libs % java -jar fuzzer-timsort.jar -c me.markoutte.examples.
TimSort -m "timSort(int[])"
Running: me.markoutte.examples.TimSort.timSort(int[])) with seed = -1016803564
New error found: NegativeArraySizeException
Saved to: reportNegativeArraySizeException.txt
Errors found: 1
Time elapsed: 10000 ms
markoutte@Aquarius libs % cat reportNegativeArraySizeException.txt
```



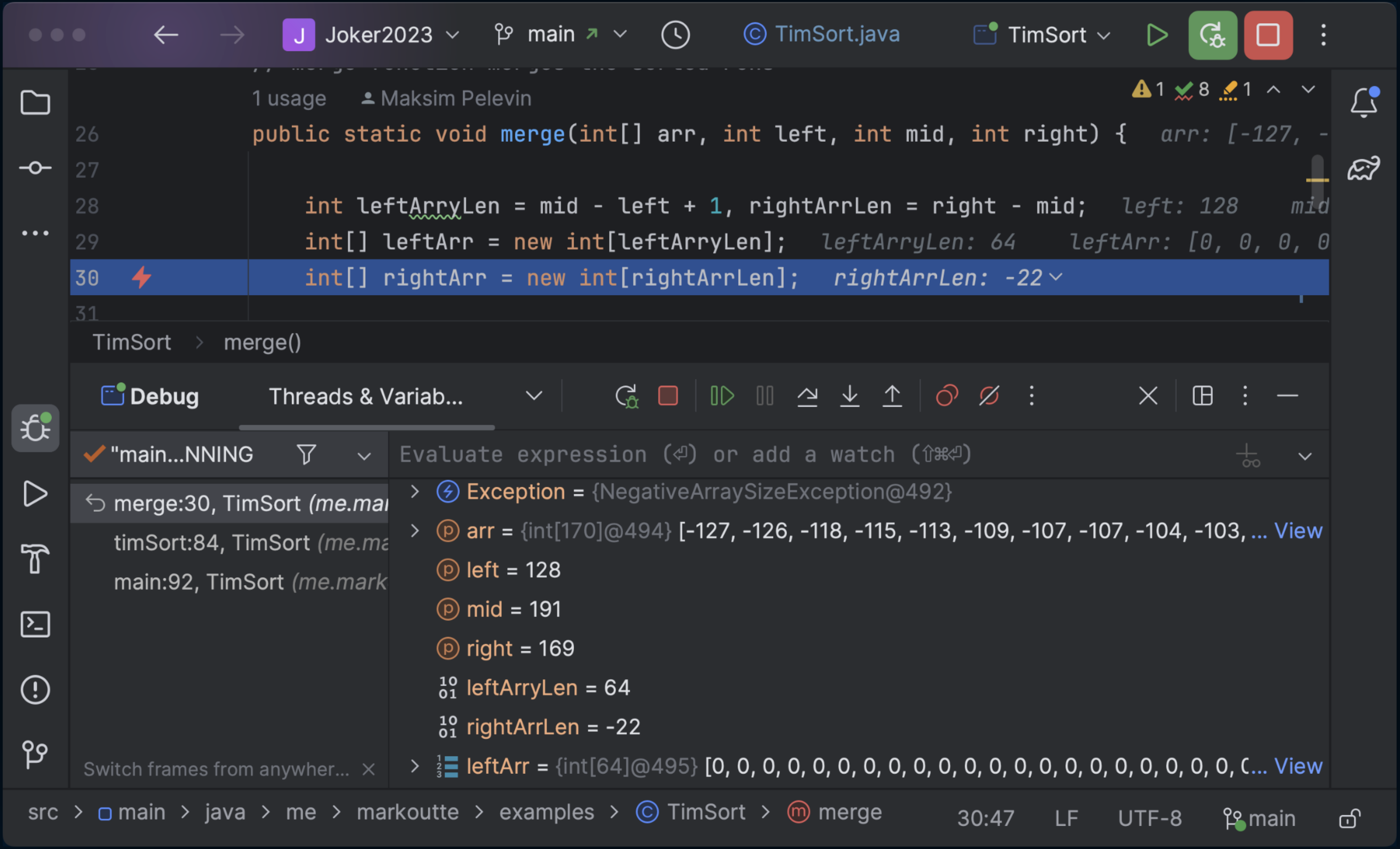
```
java.lang.NegativeArraySizeException: -22
        at me.markoutte.examples.TimSort.merge(TimSort.java:30)
        at me.markoutte.examples.TimSort.timSort(TimSort.java:84)
        at java.base/jdk.internal.reflect.NativeMethodAccessorImpl.invoke0(Nativ
e Method)
        at java.base/jdk.internal.reflect.NativeMethodAccessorImpl.invoke(Native
MethodAccessorImpl.java:77)
        at java.base/jdk.internal.reflect.DelegatingMethodAccessorImpl.invoke(De
legatingMethodAccessorImpl.java:43)
        at java.base/java.lang.reflect.Method.invoke(Method.java:568)
        at me.markoutte.joker.timsort.MainKt.main(Main.kt:45)


timSort: [[-56, 27, -50, -115, -126, -24, -86, 114, -36, 118, -70, 77, 120, 89,
-64, -118, -82, -29, 96, -113, -59, 105, 65, 22, 23, -34, 76, 17, -19, 109, -26,
 85, -50, -96, -7, -51, 97, -73, 114, -97, 54, -66, 2, -18, 95, -58, 97, 100, -9
5, 55, -62, 35, 66, 69, 112, 80, 44, -4, -104, -5, -85, 38, -101, -2, 109, 98, -
7, 35, -109, -107, 85, -16, 60, -75, 111, 13, -102, -48, 28, -2, -62, 107, -10
```



```
        at java.base/java.lang.reflect.Method.invoke(Method.java:568)
        at me.markoutte.joker.timsort.MainKt.main(Main.kt:45)


timSort: [[-56, 27, -50, -115, -126, -24, -86, 114, -36, 118, -70, 77, 120, 89,
-64, -118, -82, -29, 96, -113, -59, 105, 65, 22, 23, -34, 76, 17, -19, 109, -26,
 85, -50, -96, -7, -51, 97, -73, 114, -97, 54, -66, 2, -18, 95, -58, 97, 100, -9
5, 55, -62, 35, 66, 69, 112, 80, 44, -4, -104, -5, -85, 38, -101, -2, 109, 98, -
7, -35, -109, -107, 85, -16, 60, -75, 111, 13, -102, -48, 28, -2, -62, -107, -10
1, -2, 54, -11, 63, 89, -98, 71, 109, -127, -57, 12, -88, 73, 16, -14, 120, 34,
-103, 32, -64, 119, 102, -84, -53, -35, 13, 66, 64, -35, -12, 101, 9, 95, 61, -2
, 116, 64, -10, -90, 84, -83, 97, 5, 54, -57, 66, -44, -91, -99, 29, -89, 103, 1
21, -8, 80, 56, -18, -20, 101, -31, -71, 42, 58, 61, -64, 96, 47, -5, -117, -1,
61, -119, -100, 45, -83, 87, 49, -63, -16, -42, -30, -15, 74, 63, 49, 104, 3]]

[-86, -56, 27, -50, -115, -126, -24, -86, 114, -36, 118, -70, 77, 120, 89, -64,
-118, -82, -29, 96, -113, -59, 105, 65, 22, 23, -34, 76, 17, -19, 109, -26, 85,
-50, -96, -7, -51, 97, -73, 114, -97, 54, -66, 2, -18, 95, -58, 97, 100, -95, 55
```



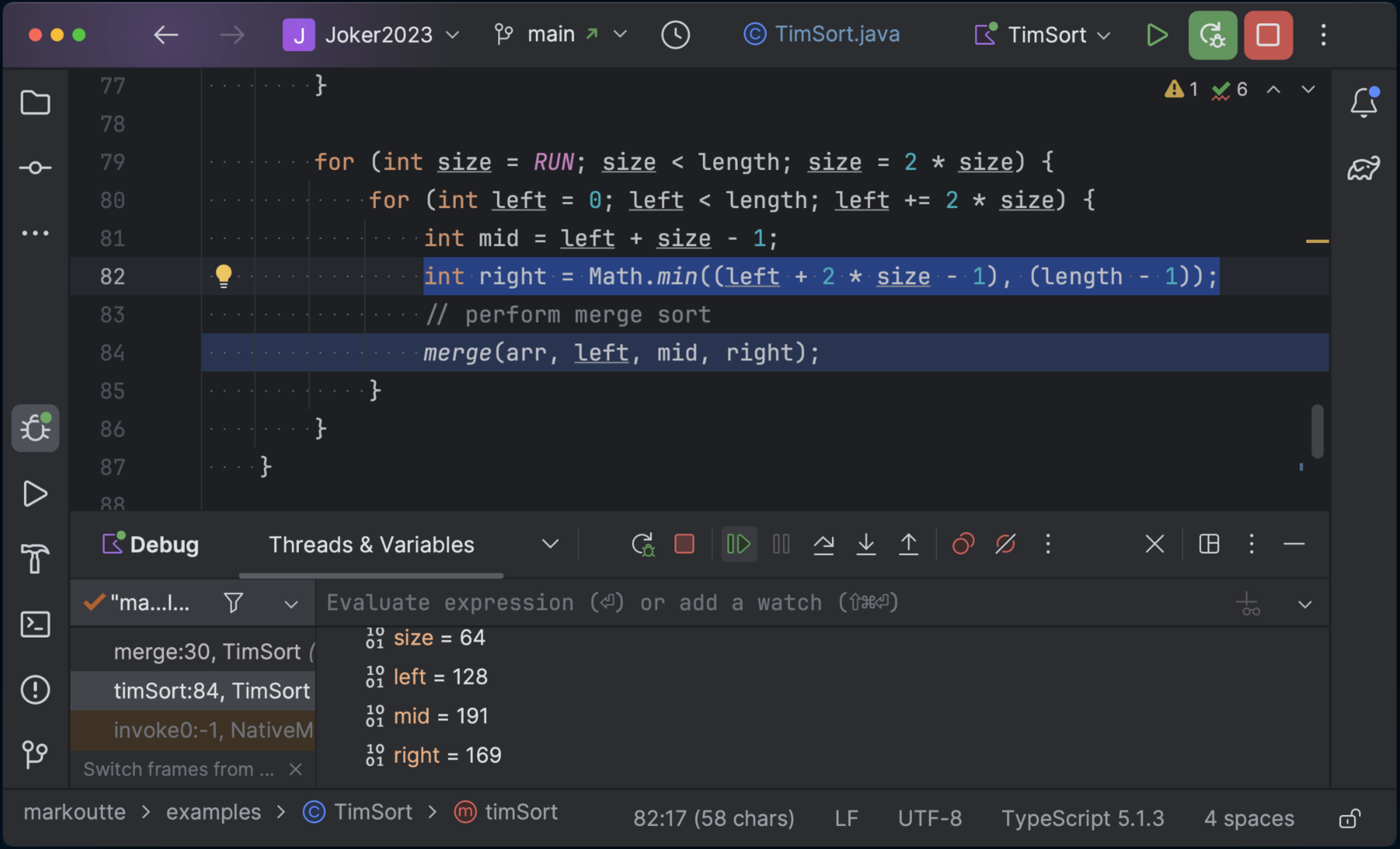
```
5, -51, -50, 123, -95, -33, 58, 11, -37, -74, 123, -51, -98, -10, 29, -47, -60,
-12, -88, 81, 46, 34, -124, 15, -70, 124, -74, 17, -26, -78, 26, 109, 8, -50, -2
7, 88, -70, 55, -73, -97, -1, 36, -70, 29, 35, -111, 90, -11, 46, 11, 43, -106,
2, -63, -119, -117, 19, 93, -9, -62, 90, 67, -75, -2, 78, 24, -113, -92, 61, -28
, 112, 89, -46, 65, -28, 122, -125, -83, 88, 16, 122, -111, -108, 104, -52, 72,
93, 76, -65, 68, 26, -66, 85, 40, -91, -121, -95, -47, 50, -113, -16, -95, 119,
-79, 27, 103, -88, 23, -88, -52, 125]

<AA><C8>ESC[?<82><E8><AA>r<DC>v<BA>MxY<C0><8A><AE><E3>`<8F><C5>iA^V^W<DE>L^Q<ED>m
<E6>UП<F9><CD>a<B7>r<9F>6<BE>^B<EE>_<C6>ad<A1>7<C2>#BEpP,<FC><98><FB><AB>&<9B><F
<FE>mb<F9>ڽ<95>U<F0><<B5>o^M<9A><D0>^\<FE><U+0095><9B><FE>6<F5>?Y<9E>Gm<81><C7>^
^L<A8>I^P<F2>x"<99> <C0>wf<AC><CB><DD>^MB@<DD><F4>e      _=<FE>t@<F6><A6>T<AD>a^E
6<C7>Bп<9D>^]<A7>gy<F8>P8<EE><EC>e<E1><B9>*:=<C0>`/<FB><8B><FF>=<89><9C>-<AD>W1<
<C1><F0><D6><E2><F1>J?1h^CDD<CC><F9><80>x4^?<ED>J<81><CD>k<BF>.<E2>P<BC><F1><CD>
<CE>{<A1><DF>:^K؟{<F6>^]<D1><C4><F4><A8>Q."<84>^O<BA>|<B6>^Q<E6><B2>^Z<CE><E5>X<
<BA>7<B7><9F><FF>$<BA>^]#<91>Z<F5>.^K+<96>^B<C1><89><8B>^S]<F7><C2>ZC<B5><FE>N^X
<8F><A4>=<E4>pY<D2>A<E4>z<83><AD>X^Pz<91><94>h<CC>H]L<BF>D^Z<BE>U(<A5><87><A1><D
<D1>?<2F><F0><A1>w<B1>ESCg<A8>^W<A8><CC>}
(END)
```



```
public static void merge(int[] arr, int left, int mid, int right) {  arr: [-127, -

    int leftArryLen = mid - left + 1, rightArrLen = right - mid;  left: 128    mid
    int[] leftArr = new int[leftArryLen];  leftArryLen: 64    leftArr: [0, 0, 0, 0
    int[] rightArr = new int[rightArrLen];  rightArrLen: -22
```

```
merge:30, TimSort (me.mar
timSort:84, TimSort (me.ma
main:92, TimSort (me.mark
```

```
Evaluate expression (⏎) or add a watch (⇧⌘⏎)
> Exception = {NegativeArraySizeException@492}
> arr = {int[170]@494} [-127, -126, -118, -115, -113, -109, -107, -107, -104, -103, ... View
  left = 128
  mid = 191
  right = 169
  leftArryLen = 64
  rightArrLen = -22
> leftArr = {int[64]@495} [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ... View
```



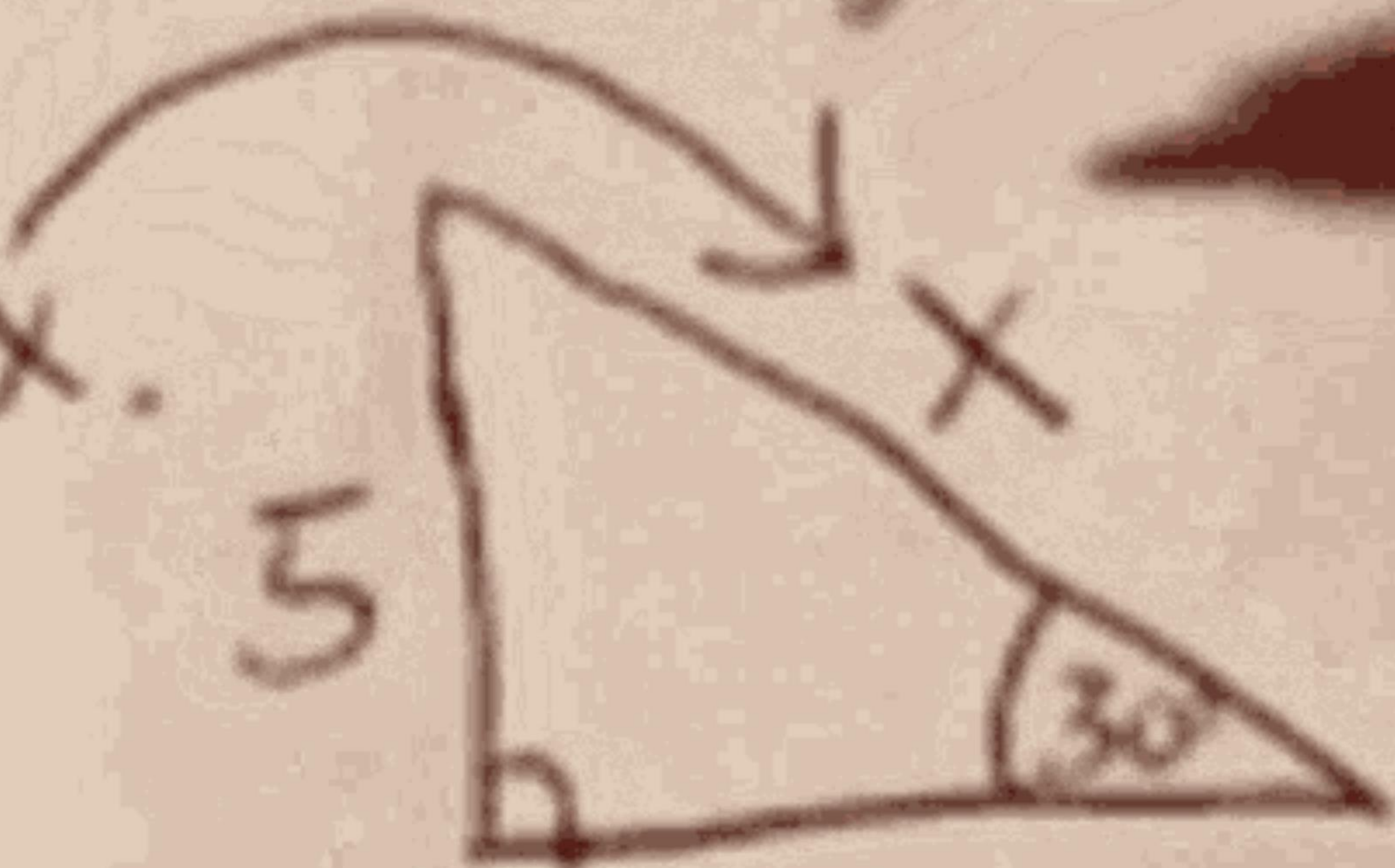
```
        }

        for (int size = RUN; size < length; size = 2 * size) {
            for (int left = 0; left < length; left += 2 * size) {
                int mid = left + size - 1;
                int right = Math.min((left + 2 * size - 1), (length - 1));
                // perform merge sort
                merge(arr, left, mid, right);
            }
        }
    }
```

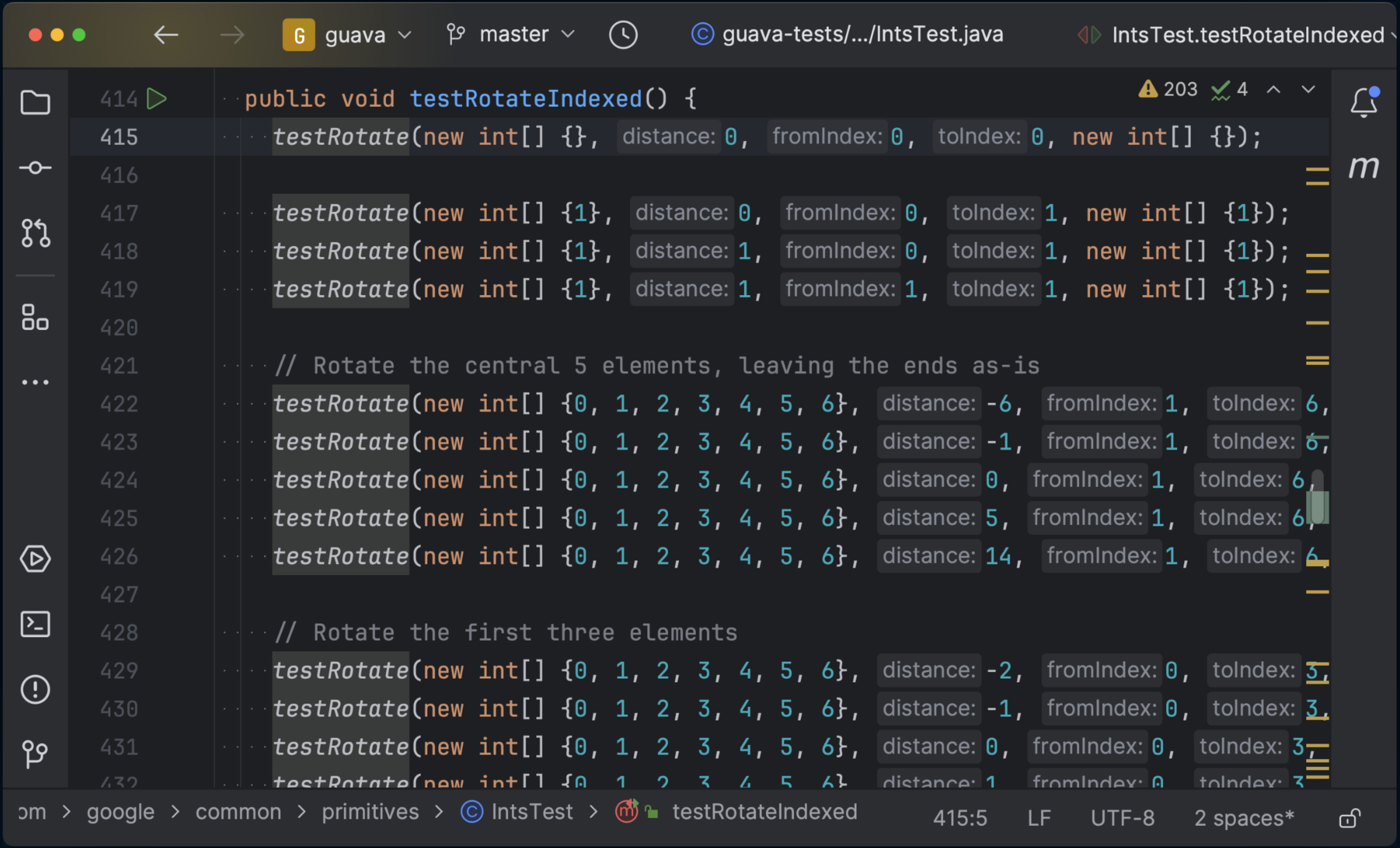
```
"ma...l...
merge:30, TimSort (
timSort:84, TimSort
invoke0:-1, NativeM
Switch frames from ...
```

```
Evaluate expression (⏎) or add a watch (⇧⌘⏎)
size = 64
left = 128
mid = 191
right = 169
```

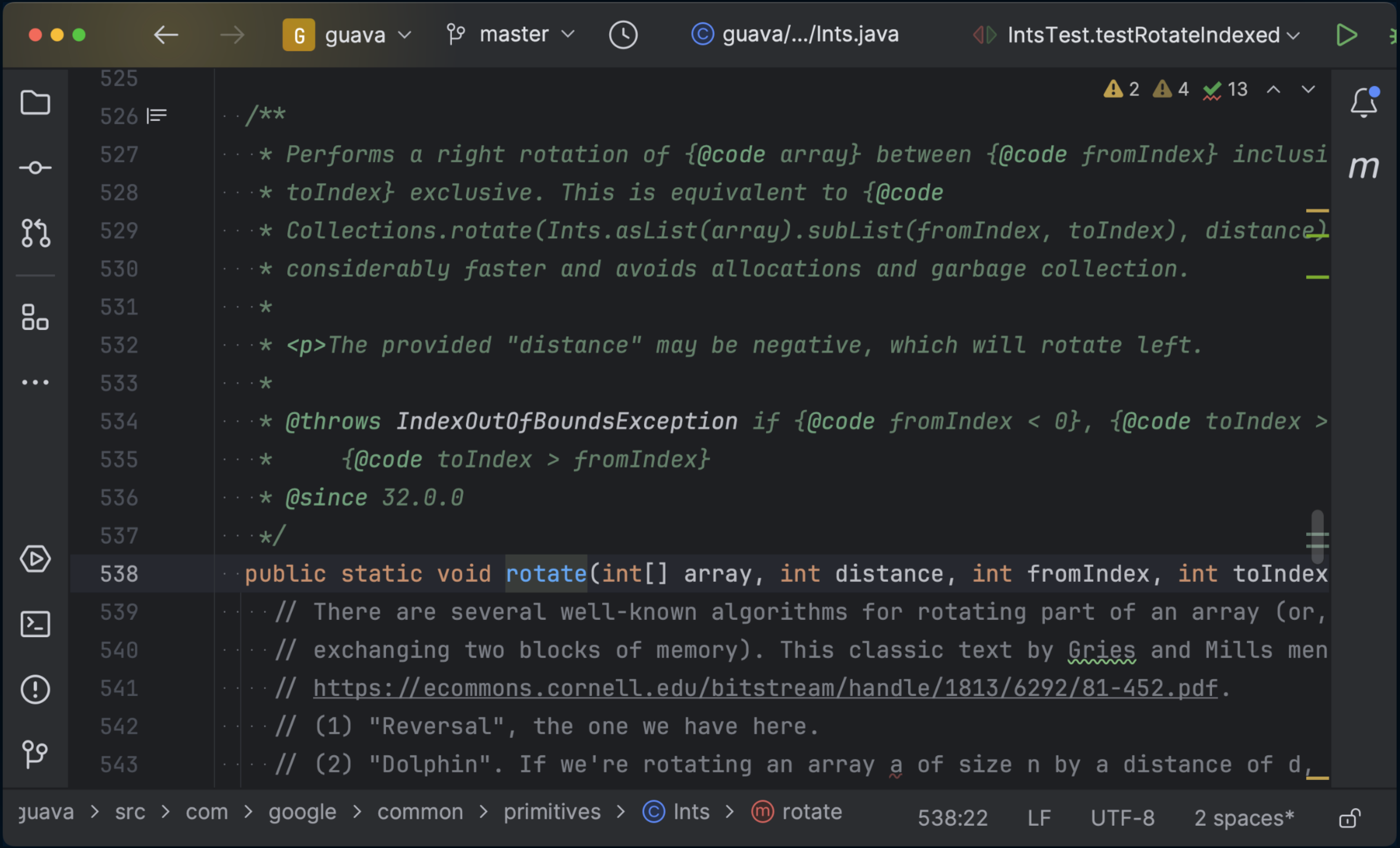
```
markoutte > examples > TimSort > timSort    82:17 (58 chars)   LF   UTF-8   TypeScript 5.1.3   4 spaces
```

. Find x.




guava
master
guava-tests/.../IntsTest.java
IntsTest.testRotateIndexed
203
4
m
om > google > common > primitives > IntsTest > testRotateIndexed
415:5
LF
UTF-8
2 spaces*

```
public void testRotateIndexed() {
  testRotate(new int[] {}, distance: 0, fromIndex: 0, toIndex: 0, new int[] {});

  testRotate(new int[] {1}, distance: 0, fromIndex: 0, toIndex: 1, new int[] {1});
  testRotate(new int[] {1}, distance: 1, fromIndex: 0, toIndex: 1, new int[] {1});
  testRotate(new int[] {1}, distance: 1, fromIndex: 1, toIndex: 1, new int[] {1});

  // Rotate the central 5 elements, leaving the ends as-is
  testRotate(new int[] {0, 1, 2, 3, 4, 5, 6}, distance: -6, fromIndex: 1, toIndex: 6,
  testRotate(new int[] {0, 1, 2, 3, 4, 5, 6}, distance: -1, fromIndex: 1, toIndex: 6,
  testRotate(new int[] {0, 1, 2, 3, 4, 5, 6}, distance: 0, fromIndex: 1, toIndex: 6,
  testRotate(new int[] {0, 1, 2, 3, 4, 5, 6}, distance: 5, fromIndex: 1, toIndex: 6,
  testRotate(new int[] {0, 1, 2, 3, 4, 5, 6}, distance: 14, fromIndex: 1, toIndex: 6,

  // Rotate the first three elements
  testRotate(new int[] {0, 1, 2, 3, 4, 5, 6}, distance: -2, fromIndex: 0, toIndex: 3,
  testRotate(new int[] {0, 1, 2, 3, 4, 5, 6}, distance: -1, fromIndex: 0, toIndex: 3,
  testRotate(new int[] {0, 1, 2, 3, 4, 5, 6}, distance: 0, fromIndex: 0, toIndex: 3,
  testRotate(new int[] {0, 1, 2, 3, 4, 5, 6}, distance: 1, fromIndex: 0, toIndex: 3
```


guava
master
guava/.../Ints.java
IntsTest.testRotateIndexed
2 4 13
guava > src > com > google > common > primitives > Ints > rotate
538:22 LF UTF-8 2 spaces*

```java
  /**
   * Performs a right rotation of {@code array} between {@code fromIndex} inclusi
   * toIndex} exclusive. This is equivalent to {@code
   * Collections.rotate(Ints.asList(array).subList(fromIndex, toIndex), distance)
   * considerably faster and avoids allocations and garbage collection.
   *
   * <p>The provided "distance" may be negative, which will rotate left.
   *
   * @throws IndexOutOfBoundsException if {@code fromIndex < 0}, {@code toIndex >
   *     {@code toIndex > fromIndex}
   * @since 32.0.0
   */
  public static void rotate(int[] array, int distance, int fromIndex, int toIndex
    // There are several well-known algorithms for rotating part of an array (or,
    // exchanging two blocks of memory). This classic text by Gries and Mills men
    // https://ecommons.cornell.edu/bitstream/handle/1813/6292/81-452.pdf.
    // (1) "Reversal", the one we have here.
    // (2) "Dolphin". If we're rotating an array a of size n by a distance of d,
/**
 * Performs a right rotation of {@code array} between {@code fromIndex} inclusive and {@code
 * toIndex} exclusive. This is equivalent to {@code
 * Collections.rotate(Ints.asList(array).subList(fromIndex, toIndex), distance)}, but is
 * considerably faster and avoids allocations and garbage collection.
 *
 * The provided "distance" may be negative, which will rotate left.
 *
 * @throws IndexOutOfBoundsException if {@code fromIndex < 0}, {@code toIndex > array.length}, or
 *     {@code toIndex > fromIndex}
 * @since 32.0.0
 */
```

```java
/**
 * Performs a right rotation of {@code array} between {@code fromIndex} inclusive and {@code
 * toIndex} exclusive. This is equivalent to {@code
 * Collections.rotate(Ints.asList(array).subList(fromIndex, toIndex), distance)}, but is
 * considerably faster and avoids allocations and garbage collection.
 *
 * The provided "distance" may be negative, which will rotate left.
 *
 * @throws IndexOutOfBoundsException if {@code fromIndex < 0}, {@code toIndex > array.length}, or
 *     {@code toIndex > fromIndex}
 * @since 32.0.0
 */
```

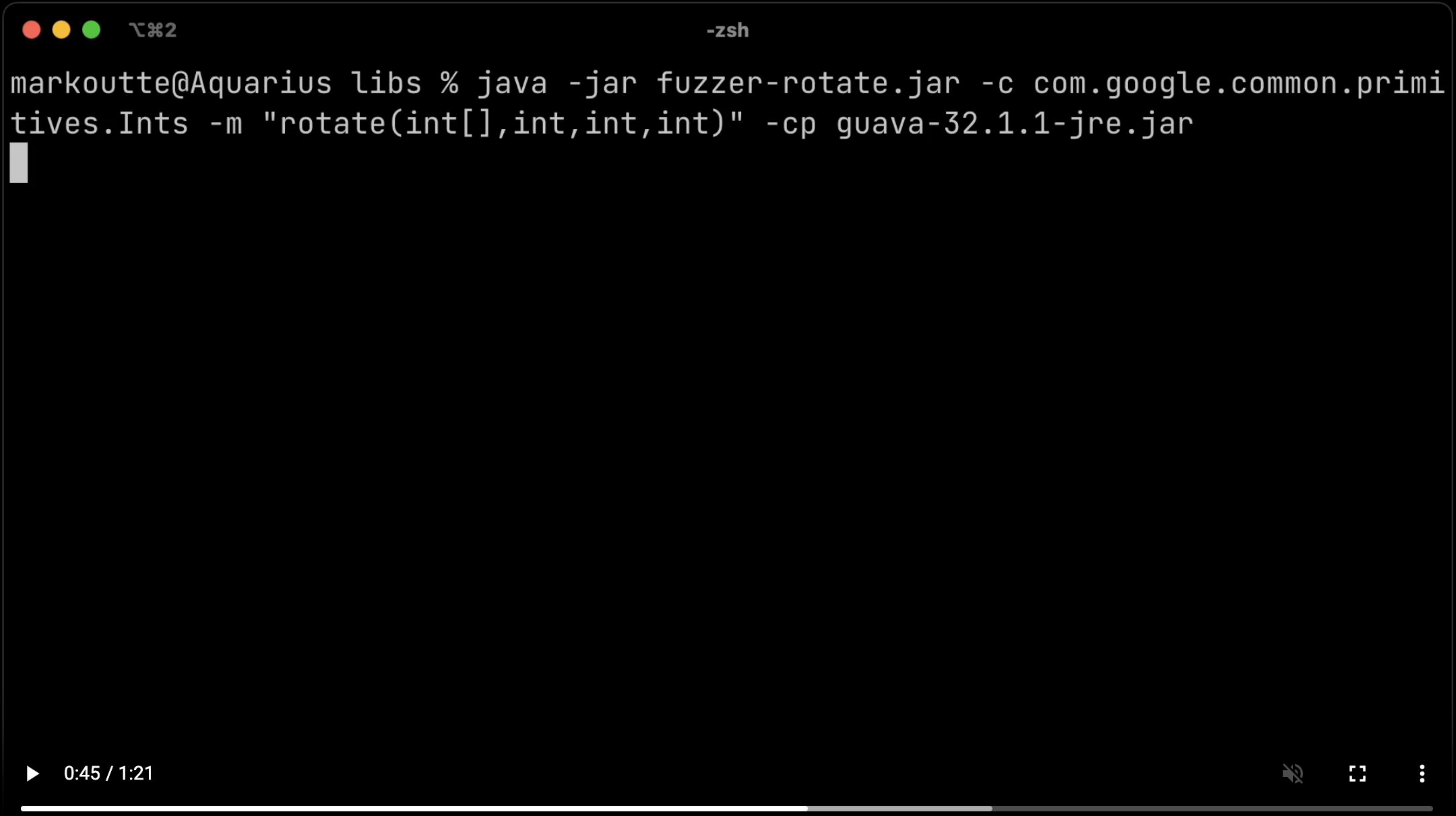
```kotlin
fun main(args: Array<String>) {
    val options = Options().apply {
        addOption("c", "class", true, "Java class fully qualified name")
        addOption("m", "method", true, "Method to be tested")
        addOption("t", "timeout", true, "Maximum time for fuzzing in seconds")
        addOption("s", "seed", true, "The source of randomness")
    }
    val parser = DefaultParser().parse(options, args)
    val className = parser.getOptionValue("class")
    val methodName = parser.getOptionValue("method")
    val timeout = parser.getOptionValue("timeout")?.toLong() ?: 10L
    val seed = parser.getOptionValue("seed")?.toInt() ?: Random.nextInt()
    val random = Random(seed)

    println("Running: $className.$methodName) with seed = $seed")
    val errors = mutableSetOf<String>()
    val b = ByteArray(300)
    val start = System.nanoTime()

    val javaMethod = try {
        loadJavaMethod(className, methodName)
```

```kotlin
fun main(args: Array<String>) {
    val options = Options().apply {
        addOption("c", "class", true, "Java class fully qualified name")
        addOption("m", "method", true, "Method to be tested")
        addOption("cp", "classpath", true, "Classpath with libraries")
        addOption("t", "timeout", true, "Maximum time for fuzzing in seconds")
        addOption("s", "seed", true, "The source of randomness")
    }
    val parser = DefaultParser().parse(options, args)
    val className = parser.getOptionValue("class")
    val methodName = parser.getOptionValue("method")
    val classPath = parser.getOptionValue("classpath")
    val timeout = parser.getOptionValue("timeout")?.toLong() ?: 10L
    val seed = parser.getOptionValue("seed")?.toInt() ?: Random.nextInt()
    val random = Random(seed)

    println("Running: $className.$methodName) with seed = $seed")
    val errors = mutableSetOf<String>()
    val b = ByteArray(300)
    val start = System.nanoTime()

    val javaMethod = try {
```

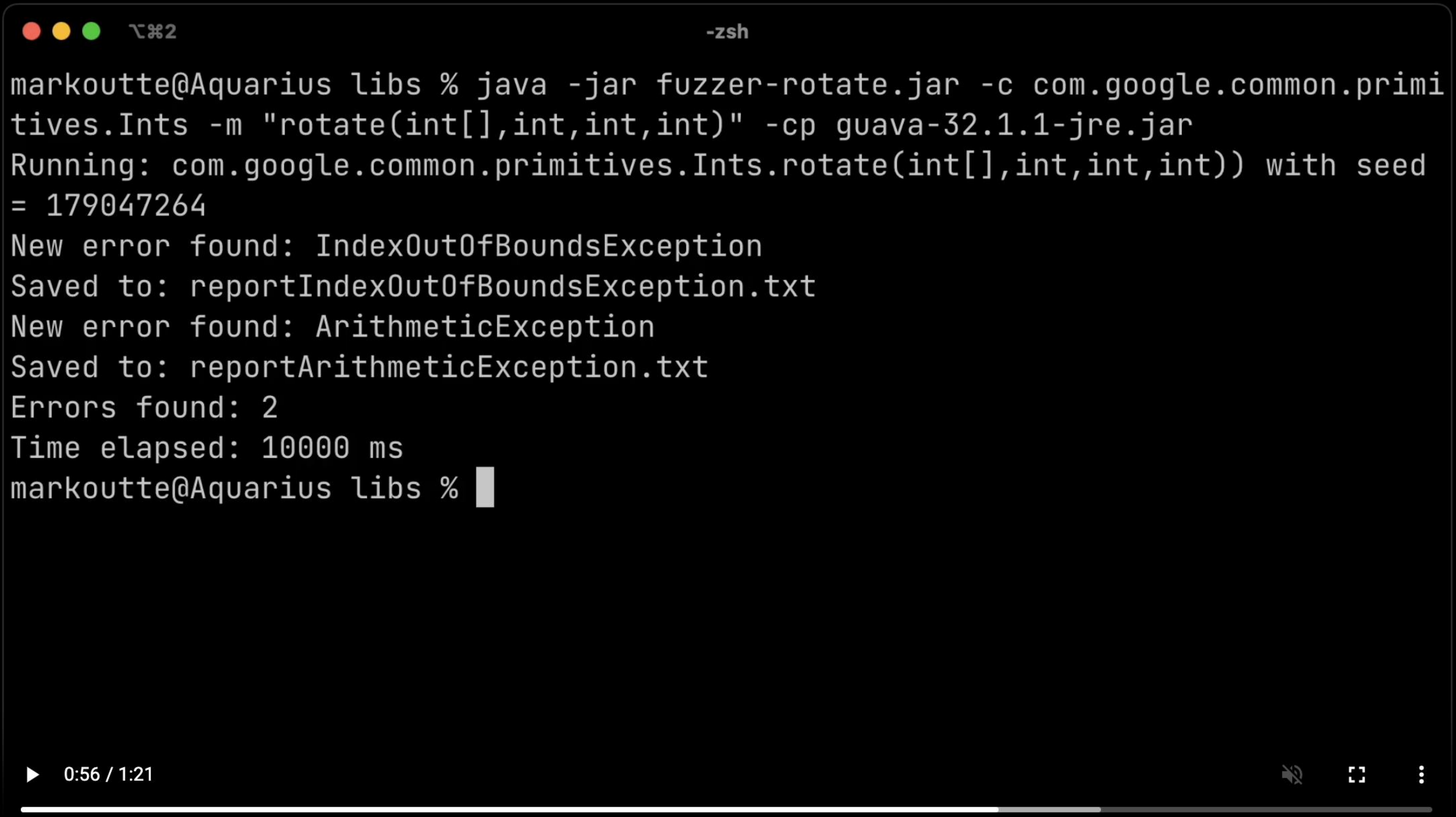
```kotlin
    val parser = DefaultParser().parse(options, args)
    val className = parser.getOptionValue("class")
    val methodName = parser.getOptionValue("method")
    val classPath = parser.getOptionValue("classpath")
    val timeout = parser.getOptionValue("timeout")?.toLong() ?: 10L
    val seed = parser.getOptionValue("seed")?.toInt() ?: Random.nextInt()
    val random = Random(seed)

    println("Running: $className.$methodName) with seed = $seed")
    val errors = mutableSetOf<String>()
    val b = ByteArray(300)
    val start = System.nanoTime()

    val javaMethod = try {
        loadJavaMethod(className, methodName, classPath)
    } catch (t: Throwable) {
        println("Method $className#$methodName is not found")
        return
    }

    while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
        val buffer = b.apply(random::nextBytes)
        val inputValues = generateInputValues(javaMethod, buffer)
        val inputValuesString = "${javaMethod.name}: ${inputValues.contentDeepToString()}"
        try {
            javaMethod.invoke(null, *inputValues)
        } catch (e: InvocationTargetException) {
            if (errors.add(e.targetException::class.qualifiedName!!)) {
                val errorName = e.targetException::class.simpleName
        }
    }

    println("Errors found: ${errors.size}")
    println("Time elapsed: ${TimeUnit.NANOSECONDS.toMillis(
        System.nanoTime() - start
    )} ms")
}

fun loadJavaMethod(className: String, methodName: String): Method {
    val classLoader = ClassLoader.getSystemClassLoader()
    val javaClass = classLoader.loadClass(className)
    val javaMethod = javaClass.declaredMethods.first {
        "${it.name}(${it.parameterTypes.joinToString(",") {
            c -> c.typeName
        }})" == methodName
    }
    return javaMethod
}

fun generateInputValues(method: Method, data: ByteArray): Array<Any> {
    val buffer = ByteBuffer.wrap(data)
    val parameterTypes = method.parameterTypes
    return Array(parameterTypes.size) {
        when (parameterTypes[it]) {
            IntArray::class.java -> IntArray(buffer.get().toUByte().toInt()) {
                buffer.get().toInt()
            }
            else -> error("Cannot create value of type ${parameterTypes[it]}")
```

```kotlin
                println("Saved to: ${path.fileName}")
            }
        }
    }

    println("Errors found: ${errors.size}")
    println("Time elapsed: ${TimeUnit.NANOSECONDS.toMillis(
        System.nanoTime() - start
    )} ms")
}

fun loadJavaMethod(className: String, methodName: String, classPath: String): Method {
    val libraries = classPath
        .split(File.pathSeparatorChar)
        .map { File(it).toURI().toURL() }
        .toTypedArray()
    val classLoader = URLClassLoader(libraries)
    val javaClass = classLoader.loadClass(className)
    val javaMethod = javaClass.declaredMethods.first {
        "${it.name}(${it.parameterTypes.joinToString(",") {
            c -> c.typeName
        }})" == methodName
    }
    return javaMethod
}

fun generateInputValues(method: Method, data: ByteArray): Array<Any> {
    val buffer = ByteBuffer.wrap(data)
    val javaMethod = javaClass.declaredMethods.first {
        "${it.name}(${it.parameterTypes.joinToString(",") {
            c -> c.typeName
        }})" == methodName
    }
    return javaMethod
}

fun generateInputValues(method: Method, data: ByteArray): Array<Any> {
    val buffer = ByteBuffer.wrap(data)
    val parameterTypes = method.parameterTypes
    return Array(parameterTypes.size) {
        when (parameterTypes[it]) {
            IntArray::class.java -> IntArray(buffer.get().toUByte().toInt()) {
                buffer.get().toInt()
            }
            else -> error("Cannot create value of type ${parameterTypes[it]}")
        }
    }
}
```

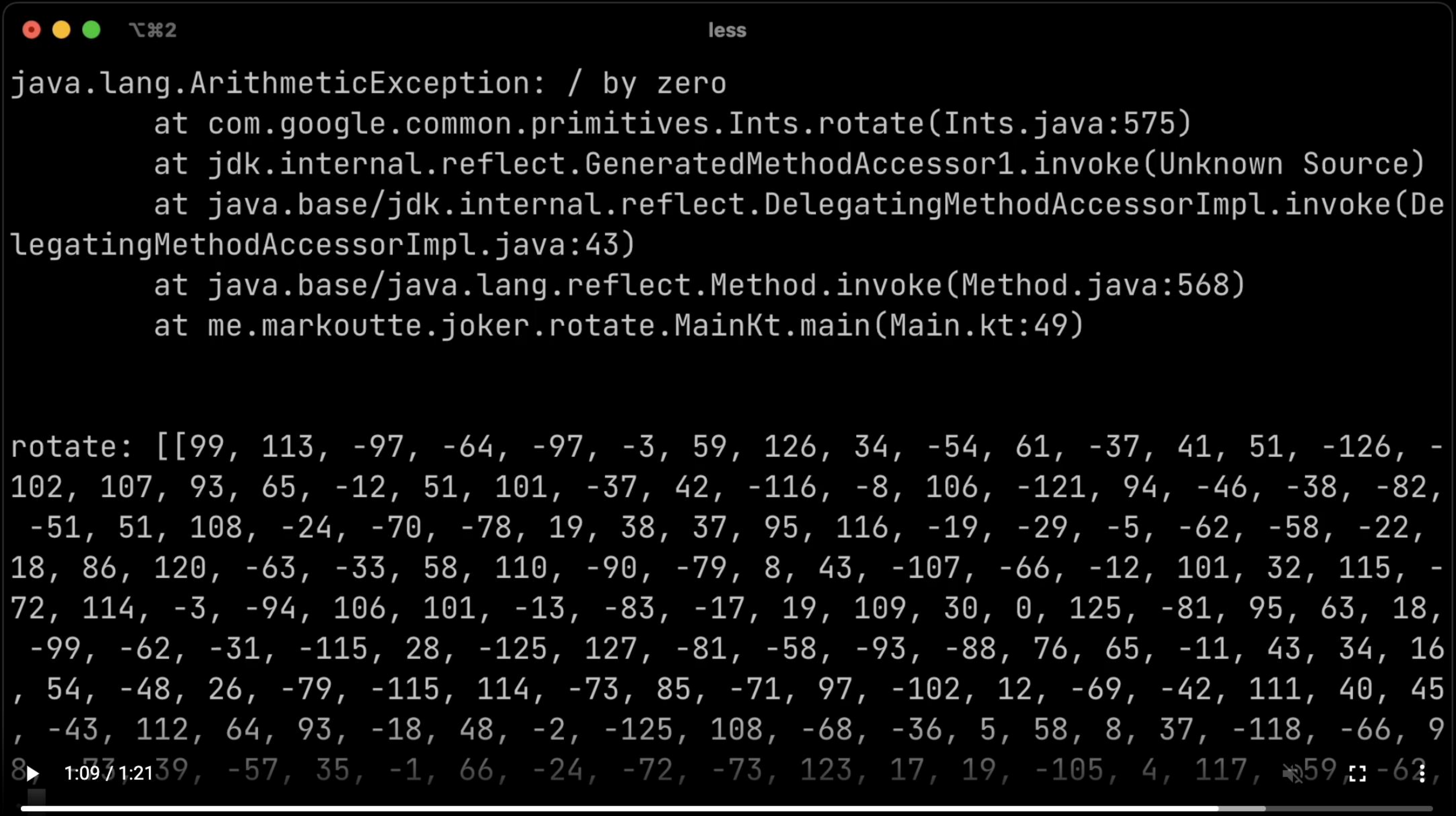
```kotlin
        "${it.name}(${it.parameterTypes.joinToString(",") {
            c -> c.typeName
        }})" == methodName
    }
    return javaMethod
}

fun generateInputValues(method: Method, data: ByteArray): Array<Any> {
    val buffer = ByteBuffer.wrap(data)
    val parameterTypes = method.parameterTypes
    return Array(parameterTypes.size) {
        when (parameterTypes[it]) {
            Int::class.java -> buffer.get().toInt()
            IntArray::class.java -> IntArray(buffer.get().toUByte().toInt()) {
                buffer.get().toInt()
            }
            else -> error("Cannot create value of type ${parameterTypes[it]}")
        }
    }
}
```



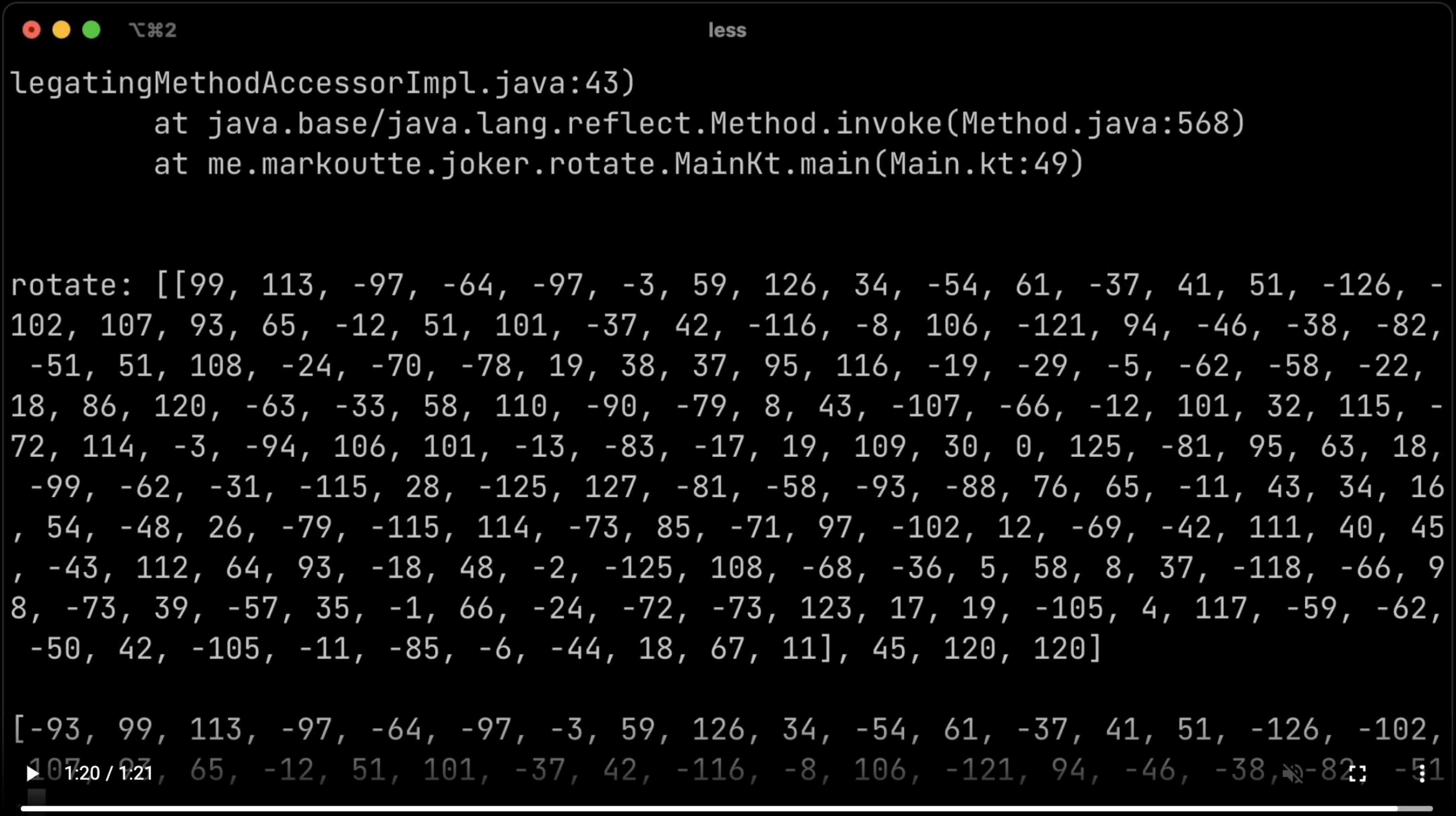
```
markoutte@Aquarius libs % java -jar fuzzer-rotate.jar -c com.google.common.primi
tives.Ints -m "rotate(int[],int,int,int)" -cp guava-32.1.1-jre.jar
```



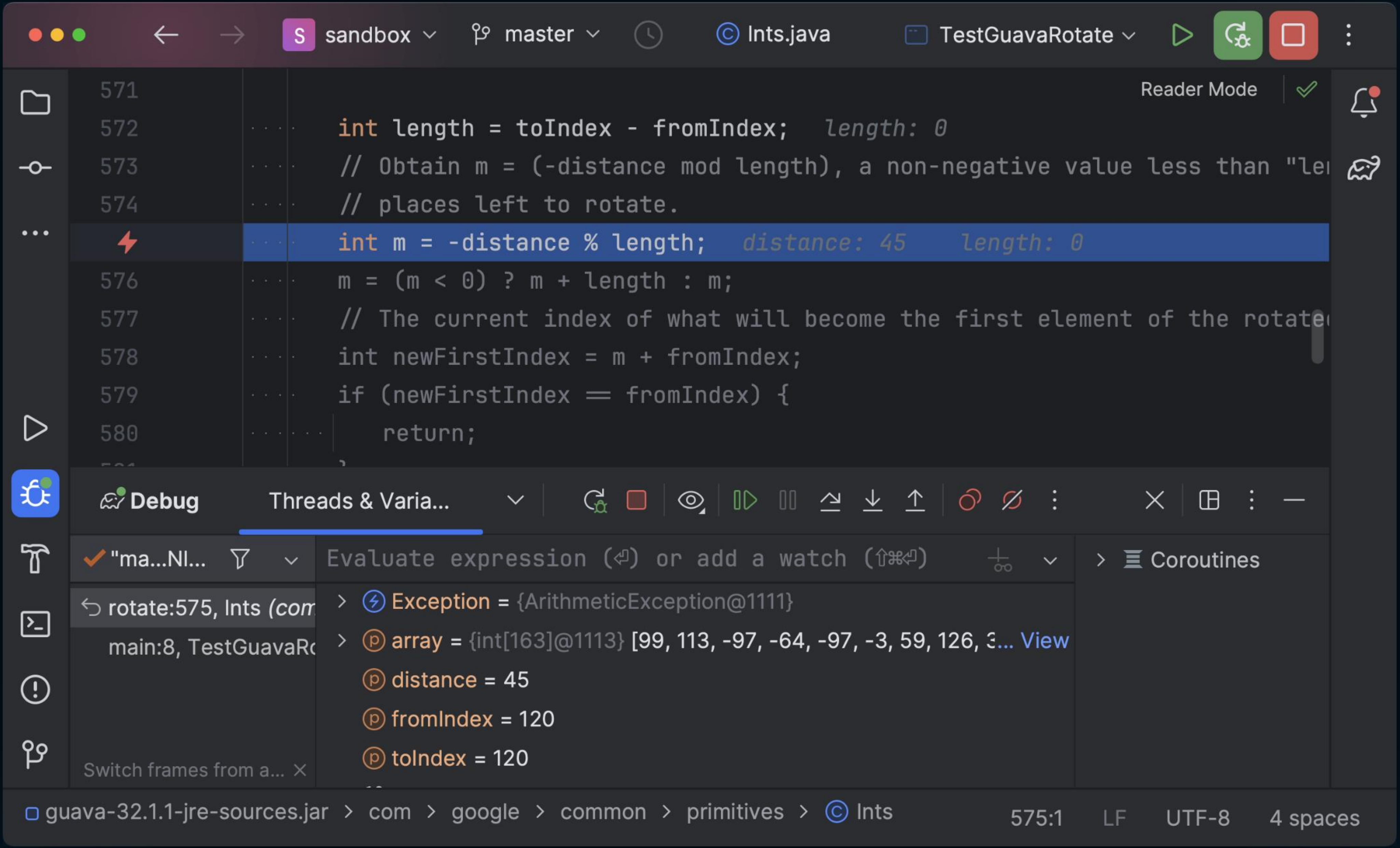
```
markoutte@Aquarius libs % java -jar fuzzer-rotate.jar -c com.google.common.primi
tives.Ints -m "rotate(int[],int,int,int)" -cp guava-32.1.1-jre.jar
Running: com.google.common.primitives.Ints.rotate(int[],int,int,int)) with seed
= 179047264
New error found: IndexOutOfBoundsException
Saved to: reportIndexOutOfBoundsException.txt
New error found: ArithmeticException
Saved to: reportArithmeticException.txt
Errors found: 2
Time elapsed: 10000 ms
markoutte@Aquarius libs %
```



```
java.lang.ArithmeticException: / by zero
        at com.google.common.primitives.Ints.rotate(Ints.java:575)
        at jdk.internal.reflect.GeneratedMethodAccessor1.invoke(Unknown Source)
        at java.base/jdk.internal.reflect.DelegatingMethodAccessorImpl.invoke(De
legatingMethodAccessorImpl.java:43)
        at java.base/java.lang.reflect.Method.invoke(Method.java:568)
        at me.markoutte.joker.rotate.MainKt.main(Main.kt:49)


rotate: [[99, 113, -97, -64, -97, -3, 59, 126, 34, -54, 61, -37, 41, 51, -126, -
102, 107, 93, 65, -12, 51, 101, -37, 42, -116, -8, 106, -121, 94, -46, -38, -82,
 -51, 51, 108, -24, -70, -78, 19, 38, 37, 95, 116, -19, -29, -5, -62, -58, -22,
18, 86, 120, -63, -33, 58, 110, -90, -79, 8, 43, -107, -66, -12, 101, 32, 115, -
72, 114, -3, -94, 106, 101, -13, -83, -17, 19, 109, 30, 0, 125, -81, 95, 63, 18,
 -99, -62, -31, -115, 28, -125, 127, -81, -58, -93, -88, 76, 65, -11, 43, 34, 16
, 54, -48, 26, -79, -115, 114, -73, 85, -71, 97, -102, 12, -69, -42, 111, 40, 45
, -43, 112, 64, 93, -18, 48, -2, -125, 108, -68, -36, 5, 58, 8, 37, -118, -66, 9
8, -73, 39, -57, 35, -1, 66, -24, -72, -73, 123, 17, 19, -105, 4, 117, -59, -62,
```



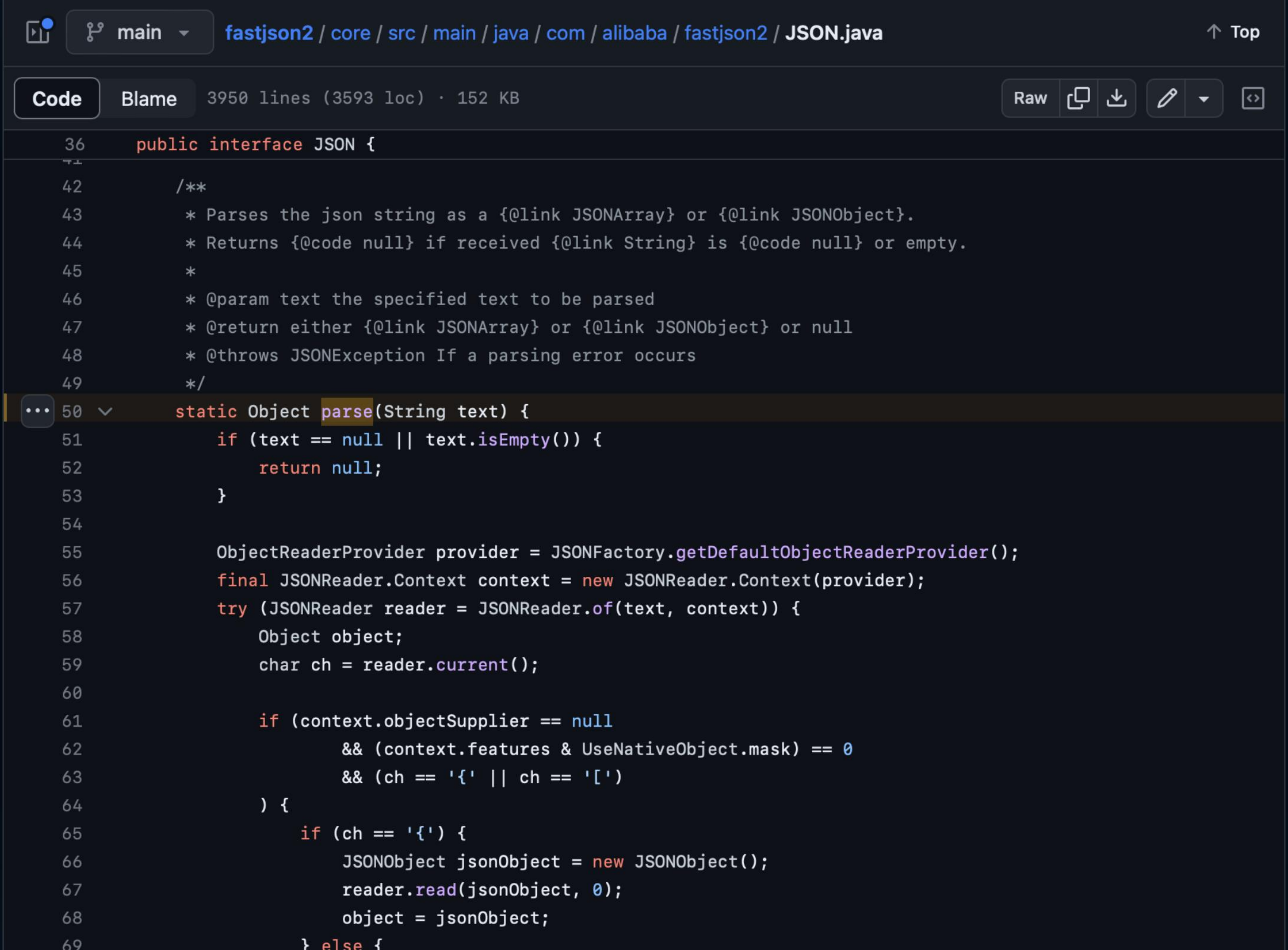
```
legatingMethodAccessorImpl.java:43)
        at java.base/java.lang.reflect.Method.invoke(Method.java:568)
        at me.markoutte.joker.rotate.MainKt.main(Main.kt:49)


rotate: [[99, 113, -97, -64, -97, -3, 59, 126, 34, -54, 61, -37, 41, 51, -126, -
102, 107, 93, 65, -12, 51, 101, -37, 42, -116, -8, 106, -121, 94, -46, -38, -82,
 -51, 51, 108, -24, -70, -78, 19, 38, 37, 95, 116, -19, -29, -5, -62, -58, -22,
18, 86, 120, -63, -33, 58, 110, -90, -79, 8, 43, -107, -66, -12, 101, 32, 115, -
72, 114, -3, -94, 106, 101, -13, -83, -17, 19, 109, 30, 0, 125, -81, 95, 63, 18,
 -99, -62, -31, -115, 28, -125, 127, -81, -58, -93, -88, 76, 65, -11, 43, 34, 16
, 54, -48, 26, -79, -115, 114, -73, 85, -71, 97, -102, 12, -69, -42, 111, 40, 45
, -43, 112, 64, 93, -18, 48, -2, -125, 108, -68, -36, 5, 58, 8, 37, -118, -66, 9
8, -73, 39, -57, 35, -1, 66, -24, -72, -73, 123, 17, 19, -105, 4, 117, -59, -62,
 -50, 42, -105, -11, -85, -6, -44, 18, 67, 11], 45, 120, 120]

[-93, 99, 113, -97, -64, -97, -3, 59, 126, 34, -54, 61, -37, 41, 51, -126, -102,
 107, 93, 65, -12, 51, 101, -37, 42, -116, -8, 106, -121, 94, -46, -38, -82, -51
```



```
    int length = toIndex - fromIndex;   length: 0
    // Obtain m = (-distance mod length), a non-negative value less than "le
    // places left to rotate.
    int m = -distance % length;   distance: 45   length: 0
    m = (m < 0) ? m + length : m;
    // The current index of what will become the first element of the rotate
    int newFirstIndex = m + fromIndex;
    if (newFirstIndex == fromIndex) {
      return;
```

```
rotate:575, Ints (com
main:8, TestGuavaR
```

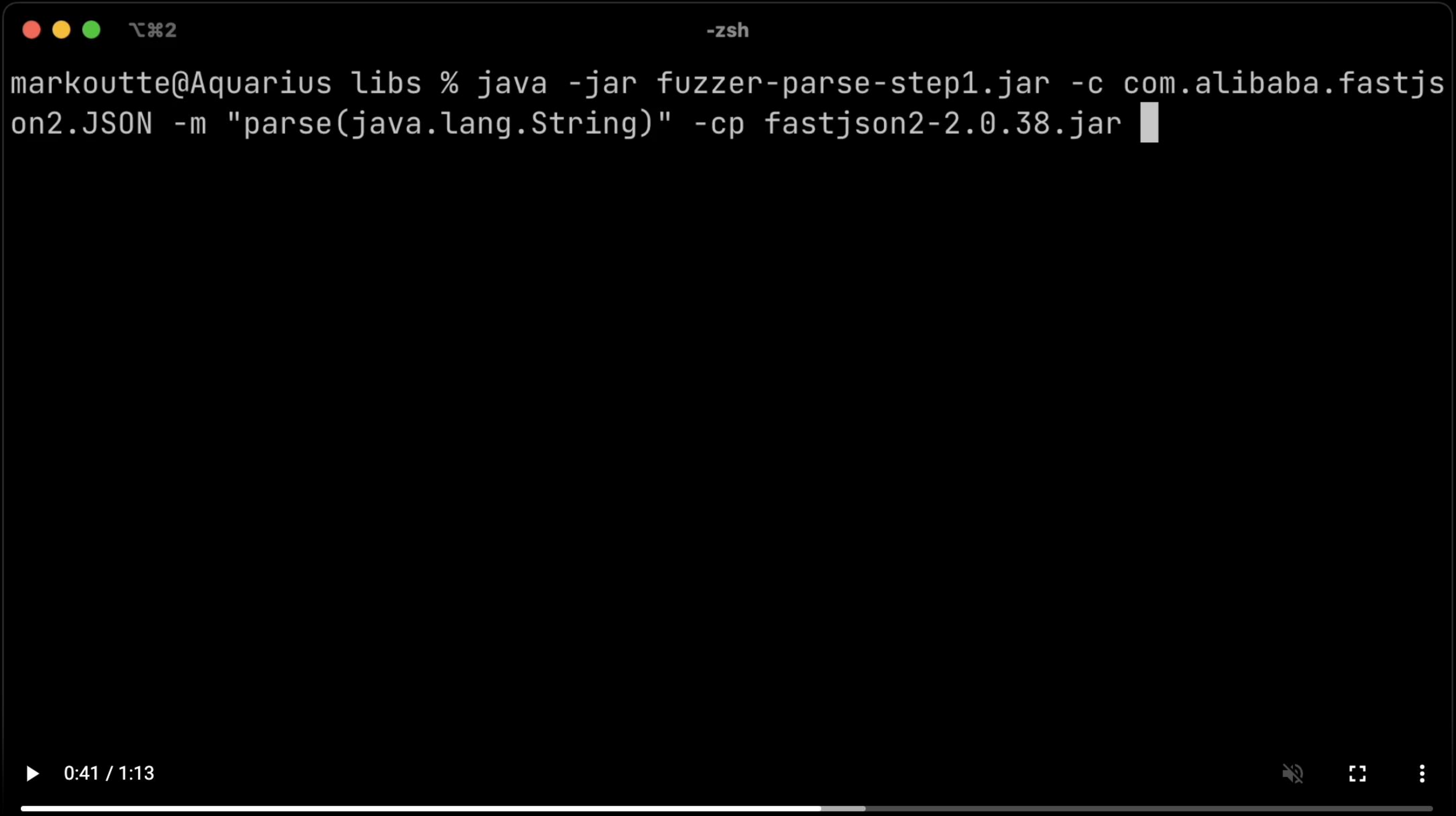
```
> Exception = {ArithmeticException@1111}
> array = {int[163]@1113} [99, 113, -97, -64, -97, -3, 59, 126, 3... View
  distance = 45
  fromIndex = 120
  toIndex = 120
```


main
fastjson2 / core / src / main / java / com / alibaba / fastjson2 / JSON.java
Top
Code
Blame
3950 lines (3593 loc) · 152 KB
Raw

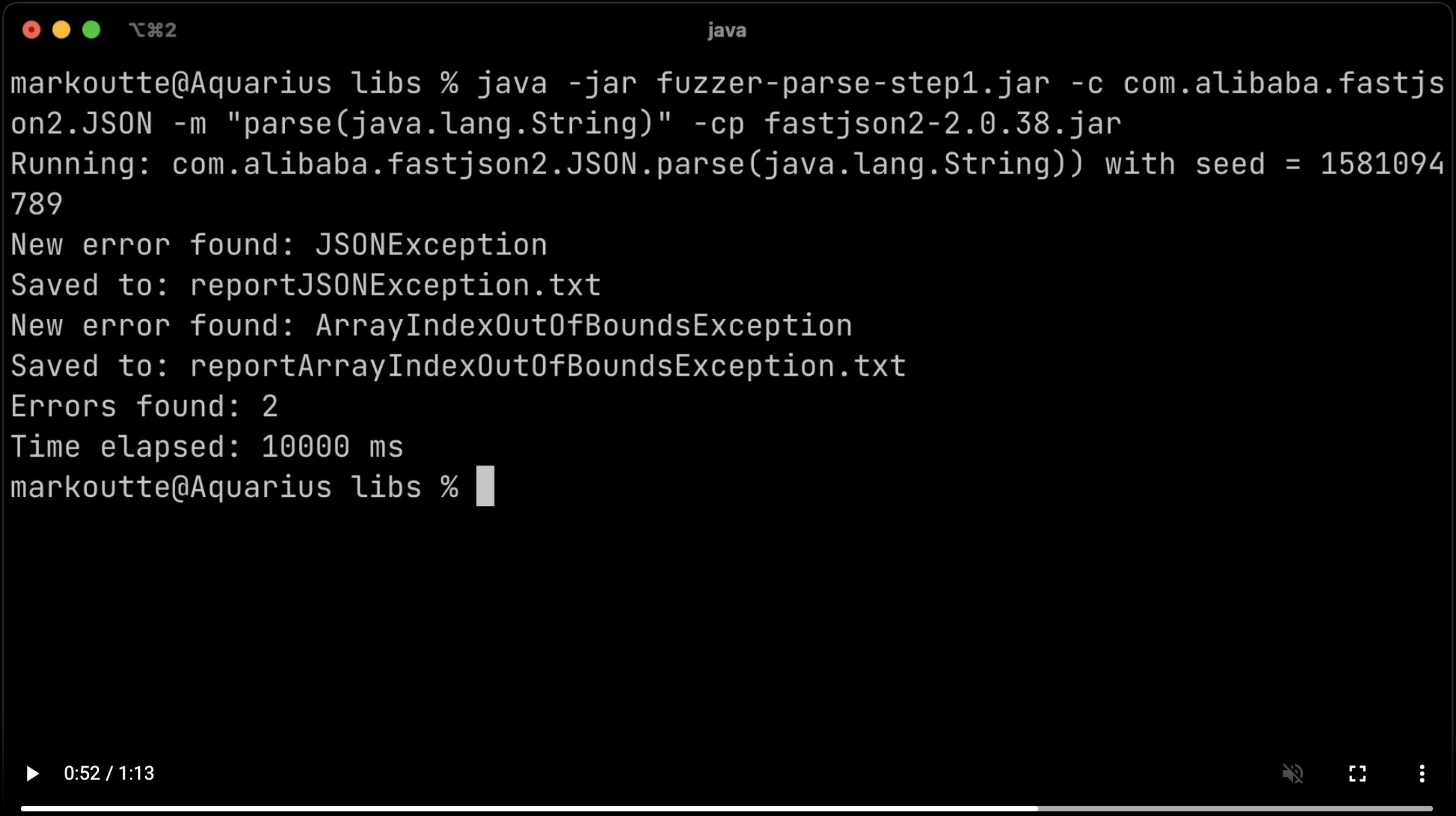
```java
public interface JSON {

    /**
     * Parses the json string as a {@link JSONArray} or {@link JSONObject}.
     * Returns {@code null} if received {@link String} is {@code null} or empty.
     *
     * @param text the specified text to be parsed
     * @return either {@link JSONArray} or {@link JSONObject} or null
     * @throws JSONException If a parsing error occurs
     */
    static Object parse(String text) {
        if (text == null || text.isEmpty()) {
            return null;
        }

        ObjectReaderProvider provider = JSONFactory.getDefaultObjectReaderProvider();
        final JSONReader.Context context = new JSONReader.Context(provider);
        try (JSONReader reader = JSONReader.of(text, context)) {
            Object object;
            char ch = reader.current();

            if (context.objectSupplier == null
                    && (context.features & UseNativeObject.mask) == 0
                    && (ch == '{' || ch == '[')
            ) {
                if (ch == '{') {
                    JSONObject jsonObject = new JSONObject();
                    reader.read(jsonObject, 0);
                    object = jsonObject;
```

```kotlin
    val javaClass = classLoader.loadClass(className)
    val javaMethod = javaClass.declaredMethods.first {
        "${it.name}(${it.parameterTypes.joinToString(",") {
            c -> c.typeName
        }})" == methodName
    }
    return javaMethod
}

fun generateInputValues(method: Method, data: ByteArray): Array<Any> {
    val buffer = ByteBuffer.wrap(data)
    val parameterTypes = method.parameterTypes
    return Array(parameterTypes.size) {
        when (parameterTypes[it]) {
            Int::class.java -> buffer.get().toInt()
            IntArray::class.java -> IntArray(buffer.get().toUByte().toInt()) {
                buffer.get().toInt()
            }
            else -> error("Cannot create value of type ${parameterTypes[it]}")
        }
    }
}
```

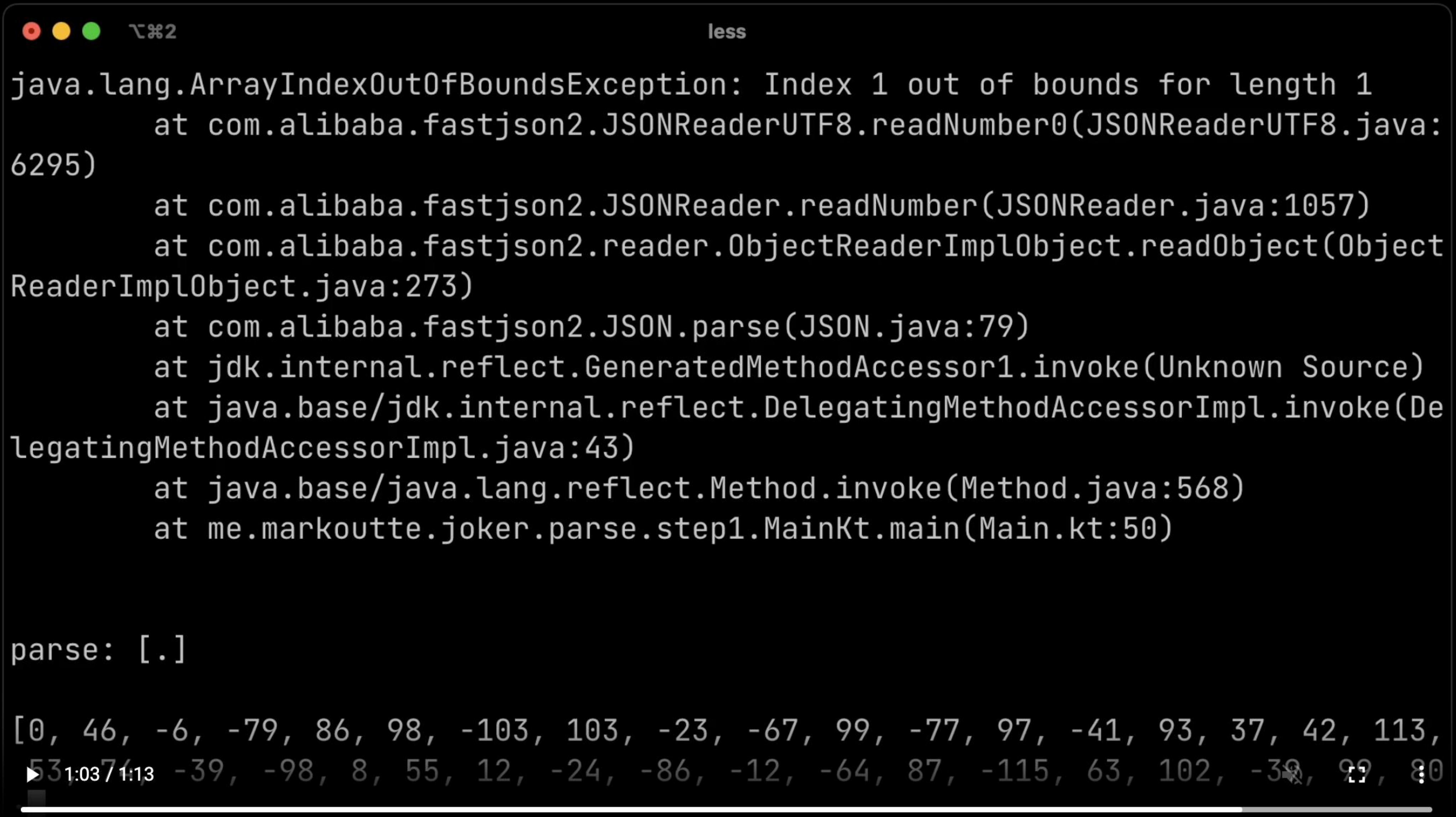
```kotlin
            c -> c.typeName
        }})" == methodName
    }
    return javaMethod
}

fun generateInputValues(method: Method, data: ByteArray): Array<Any> {
    val buffer = ByteBuffer.wrap(data)
    val parameterTypes = method.parameterTypes
    return Array(parameterTypes.size) {
        when (parameterTypes[it]) {
            Int::class.java -> buffer.get().toInt()
            IntArray::class.java -> IntArray(buffer.get().toUByte().toInt()) {
                buffer.get().toInt()
            }
            String::class.java -> String(ByteArray(
                buffer.get().toUByte().toInt() + 1
            ) {
                buffer.get()
            }, Charset.forName("koi8"))
            else -> error("Cannot create value of type ${parameterTypes[it]}")
        }
    }
}
```



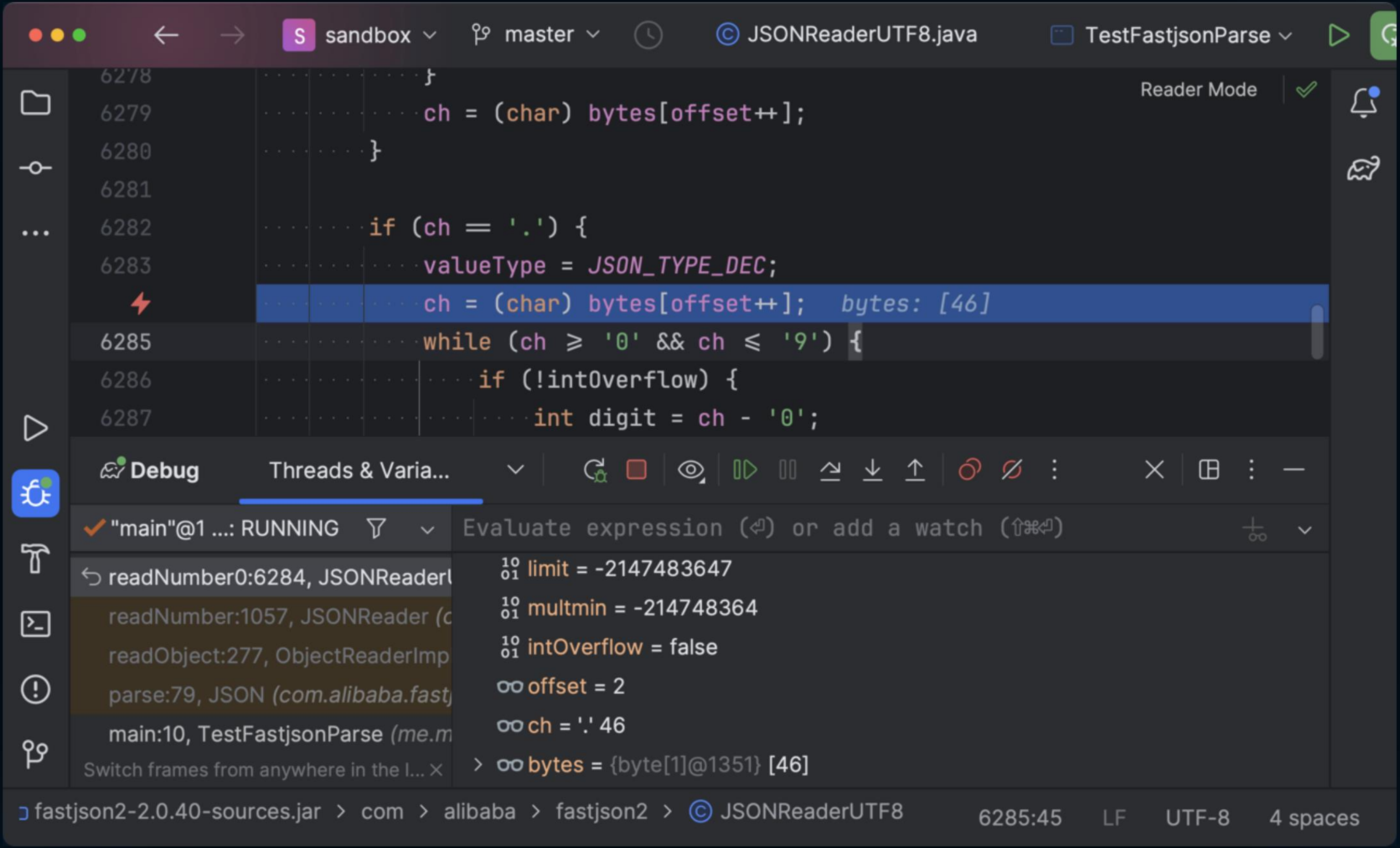
```
markoutte@Aquarius libs % java -jar fuzzer-parse-step1.jar -c com.alibaba.fastjson2.JSON -m "parse(java.lang.String)" -cp fastjson2-2.0.38.jar
```



```
markoutte@Aquarius libs % java -jar fuzzer-parse-step1.jar -c com.alibaba.fastjs
on2.JSON -m "parse(java.lang.String)" -cp fastjson2-2.0.38.jar
Running: com.alibaba.fastjson2.JSON.parse(java.lang.String)) with seed = 1581094
789
New error found: JSONException
Saved to: reportJSONException.txt
New error found: ArrayIndexOutOfBoundsException
Saved to: reportArrayIndexOutOfBoundsException.txt
Errors found: 2
Time elapsed: 10000 ms
markoutte@Aquarius libs %
```



```
java.lang.ArrayIndexOutOfBoundsException: Index 1 out of bounds for length 1
        at com.alibaba.fastjson2.JSONReaderUTF8.readNumber0(JSONReaderUTF8.java:
6295)
        at com.alibaba.fastjson2.JSONReader.readNumber(JSONReader.java:1057)
        at com.alibaba.fastjson2.reader.ObjectReaderImplObject.readObject(Object
ReaderImplObject.java:273)
        at com.alibaba.fastjson2.JSON.parse(JSON.java:79)
        at jdk.internal.reflect.GeneratedMethodAccessor1.invoke(Unknown Source)
        at java.base/jdk.internal.reflect.DelegatingMethodAccessorImpl.invoke(De
legatingMethodAccessorImpl.java:43)
        at java.base/java.lang.reflect.Method.invoke(Method.java:568)
        at me.markoutte.joker.parse.step1.MainKt.main(Main.kt:50)



parse: [.]

[0, 46, -6, -79, 86, 98, -103, 103, -23, -67, 99, -77, 97, -41, 93, 37, 42, 113,
 53, 74, -39, -98, 8, 55, 12, -24, -86, -12, -64, 87, -115, 63, 102, -39, 99, 80
```



```java
        }
        ch = (char) bytes[offset++];
    }

    if (ch == '.') {
        valueType = JSON_TYPE_DEC;
        ch = (char) bytes[offset++];   bytes: [46]
        while (ch >= '0' && ch <= '9') {
            if (!intOverflow) {
                int digit = ch - '0';
```

```
"main"@1 ...: RUNNING
readNumber0:6284, JSONReaderU
readNumber:1057, JSONReader (c
readObject:277, ObjectReaderImp
parse:79, JSON (com.alibaba.fastj
main:10, TestFastjsonParse (me.m
Switch frames from anywhere in the I... ×
```

```
Evaluate expression (⏎) or add a watch (⇧⌘⏎)
limit = -2147483647
multmin = -214748364
intOverflow = false
offset = 2
ch = '.' 46
> bytes = {byte[1]@1351} [46]
```

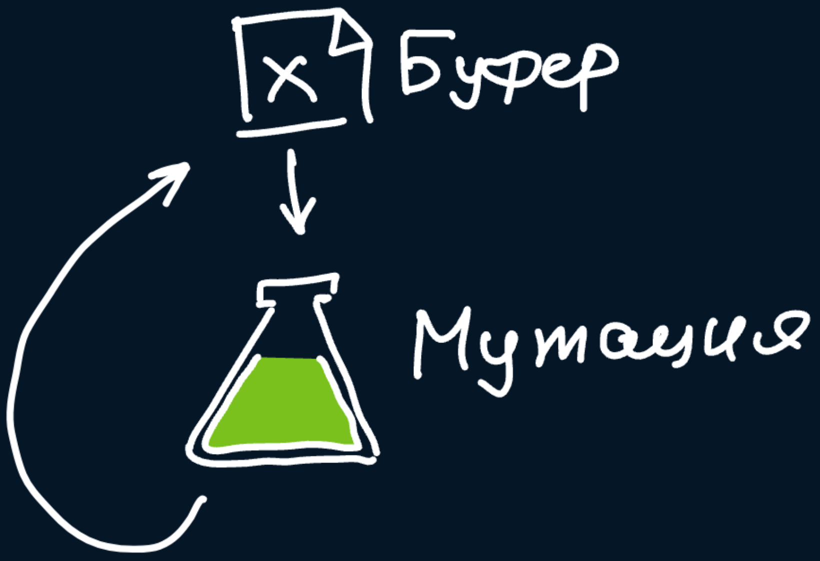
```
fastjson2-2.0.40-sources.jar > com > alibaba > fastjson2 > JSONReaderUTF8     6285:45   LF   UTF-8   4 spaces
```

Mr. F

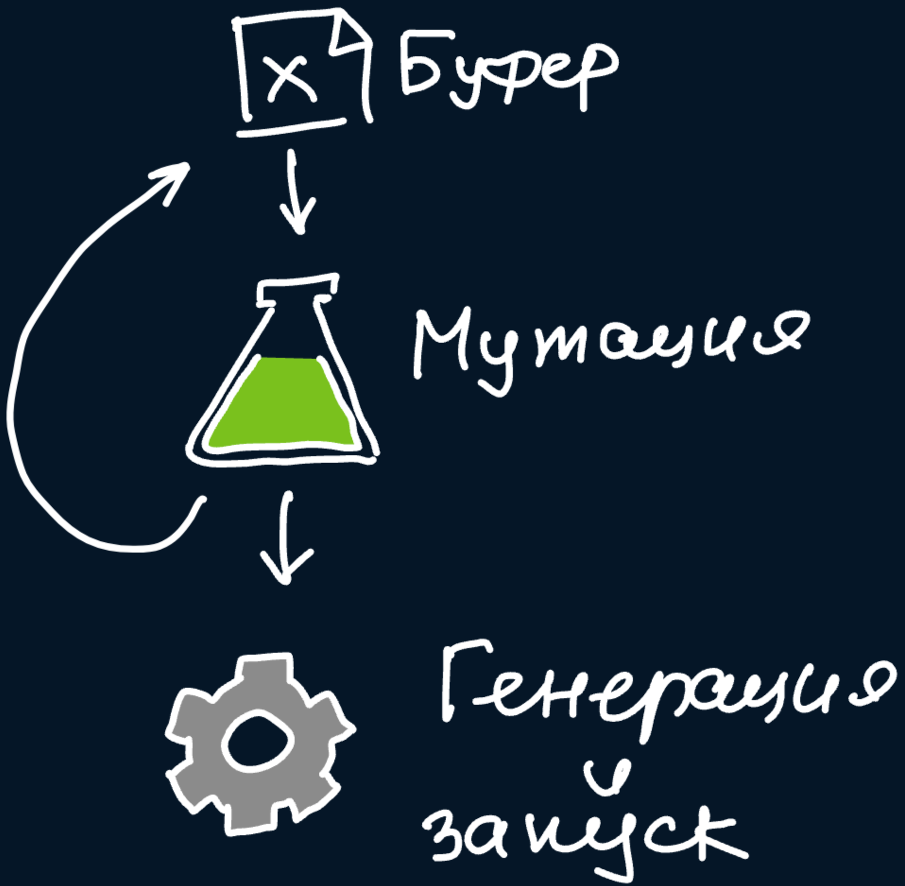
Mr. F

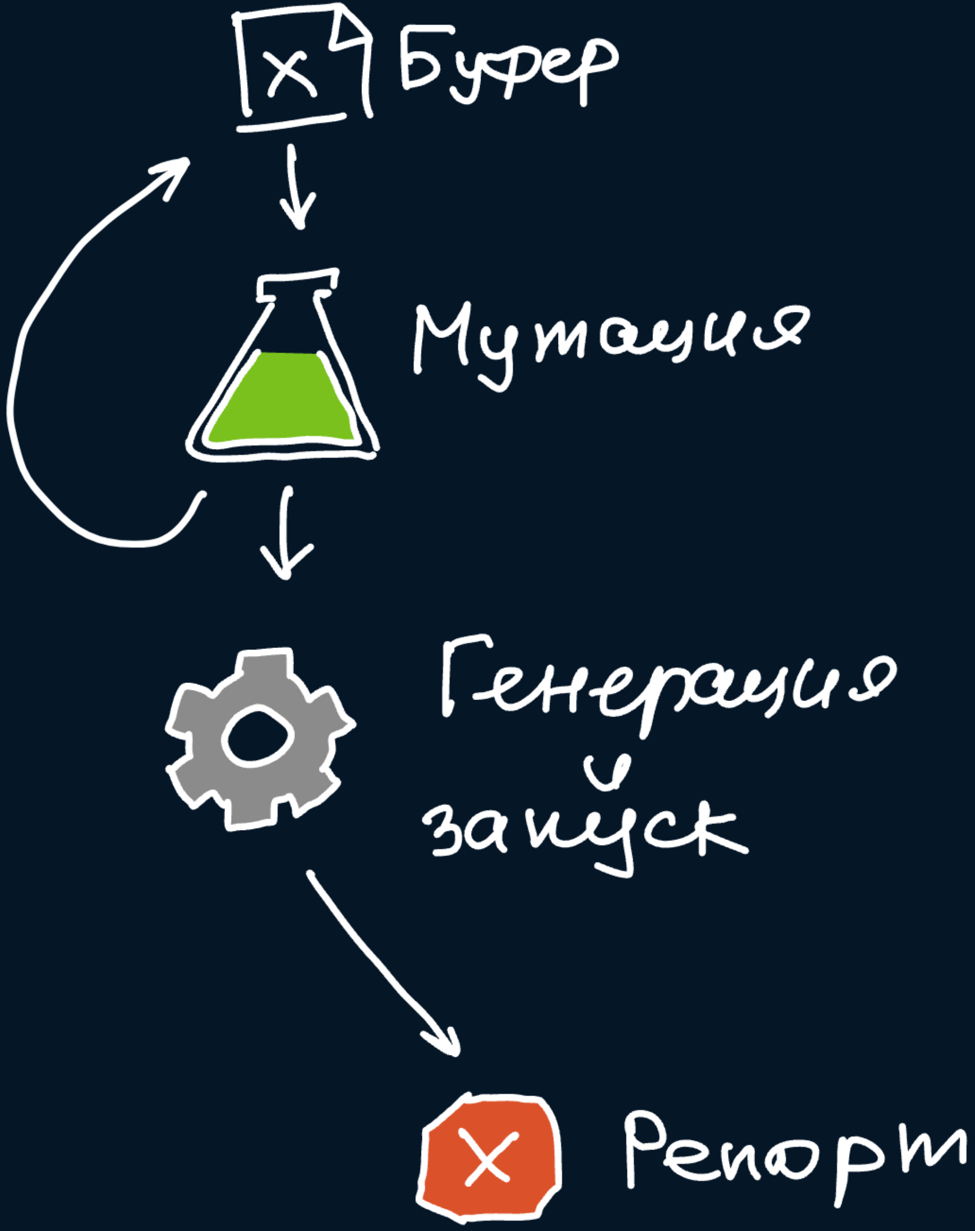
x
Буфер

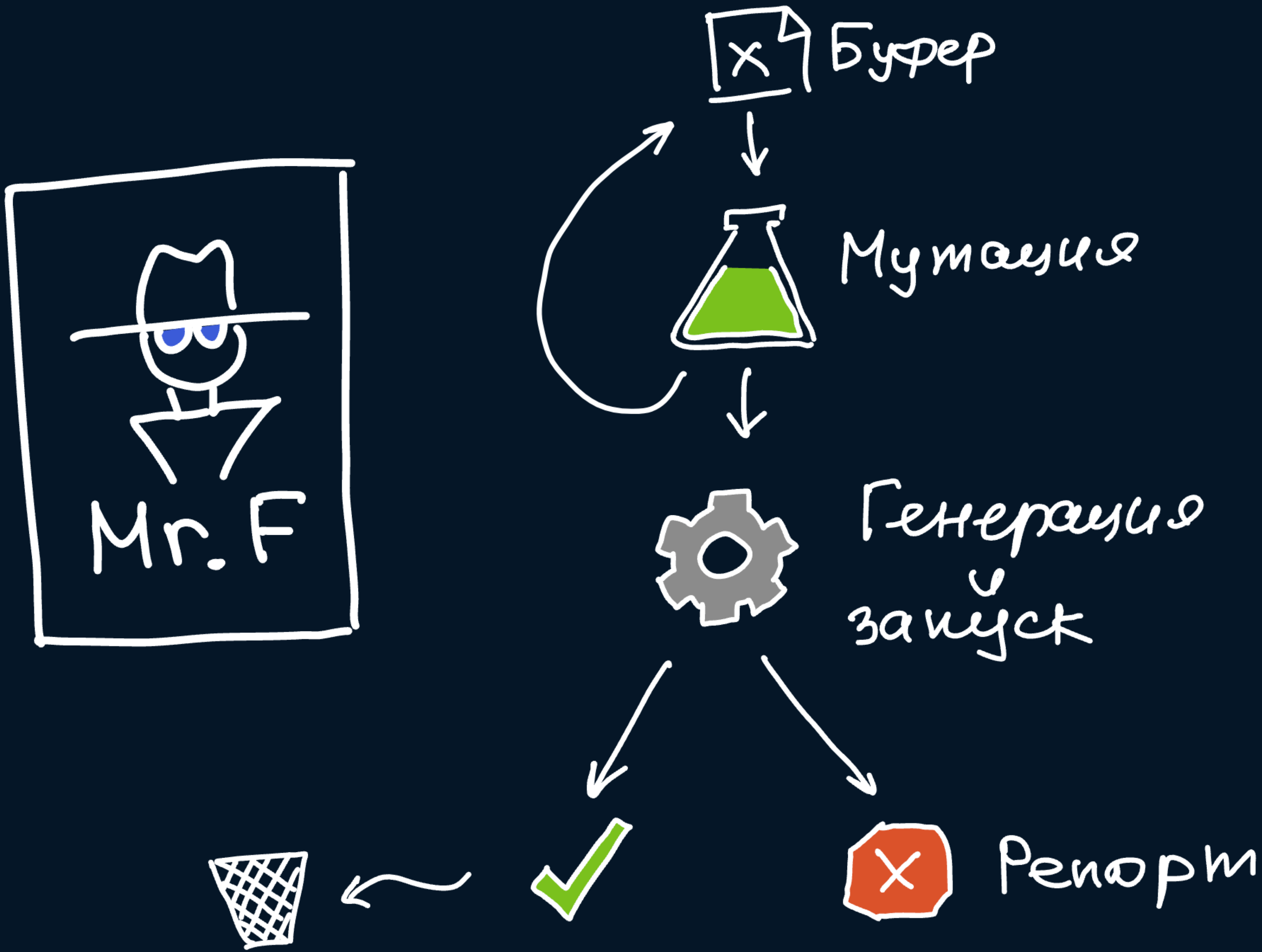
Mr. F

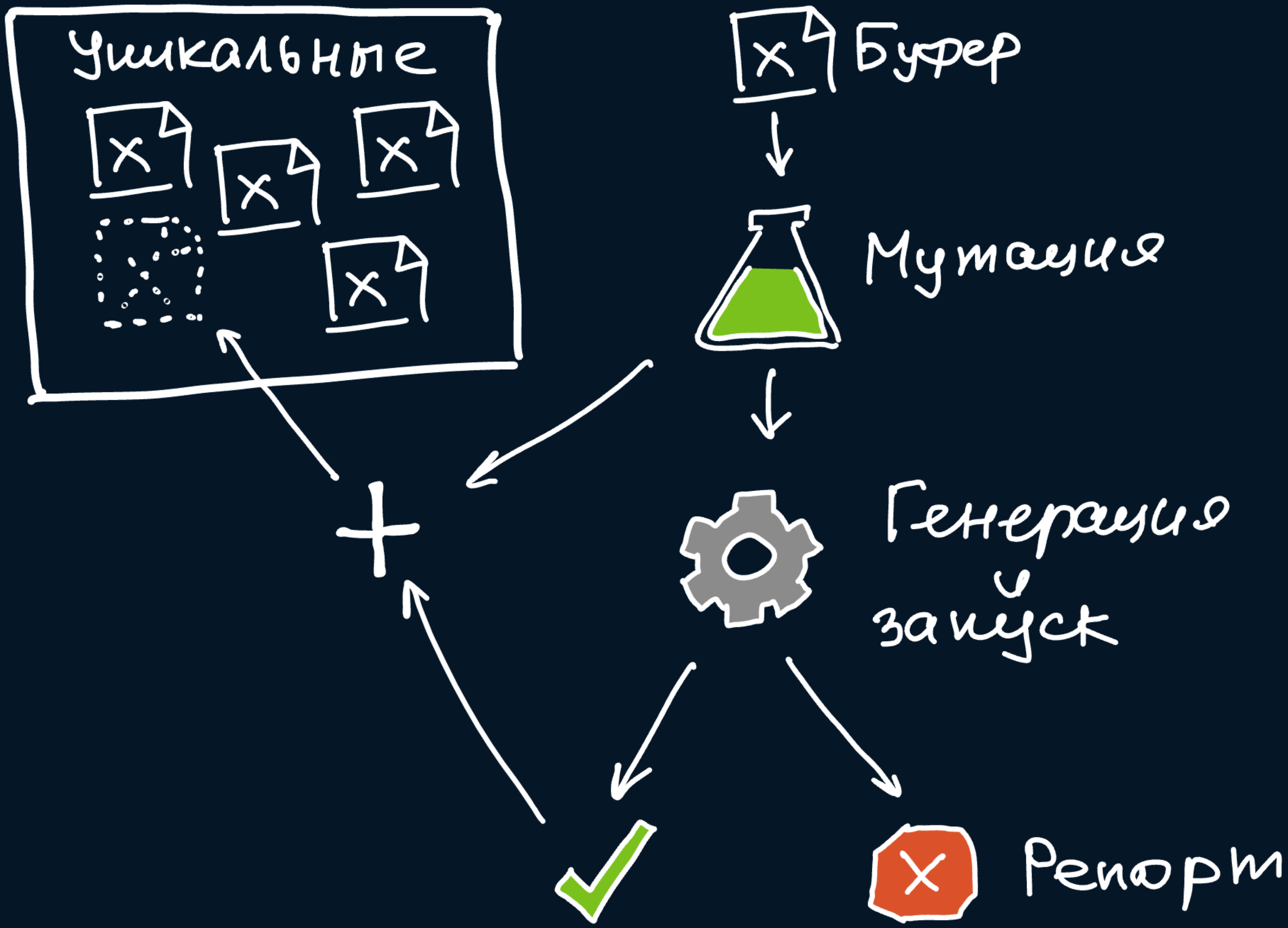

x
Буфер
Мутация

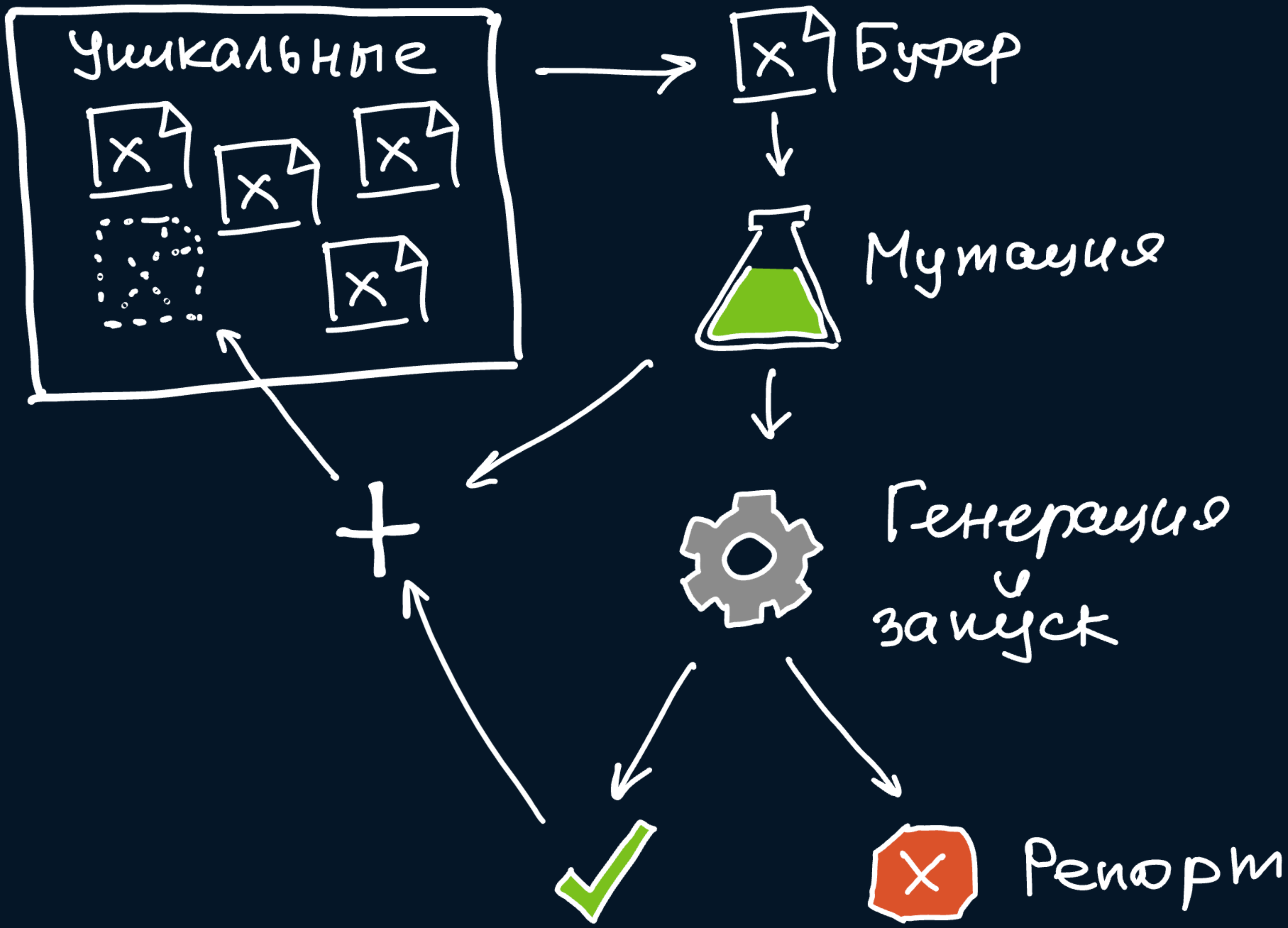
Mr.F


x
Буфер
Мутация
Генерация
запуск

Mr.F

Буфер
Мутация
Генерация и запуск
Репорт

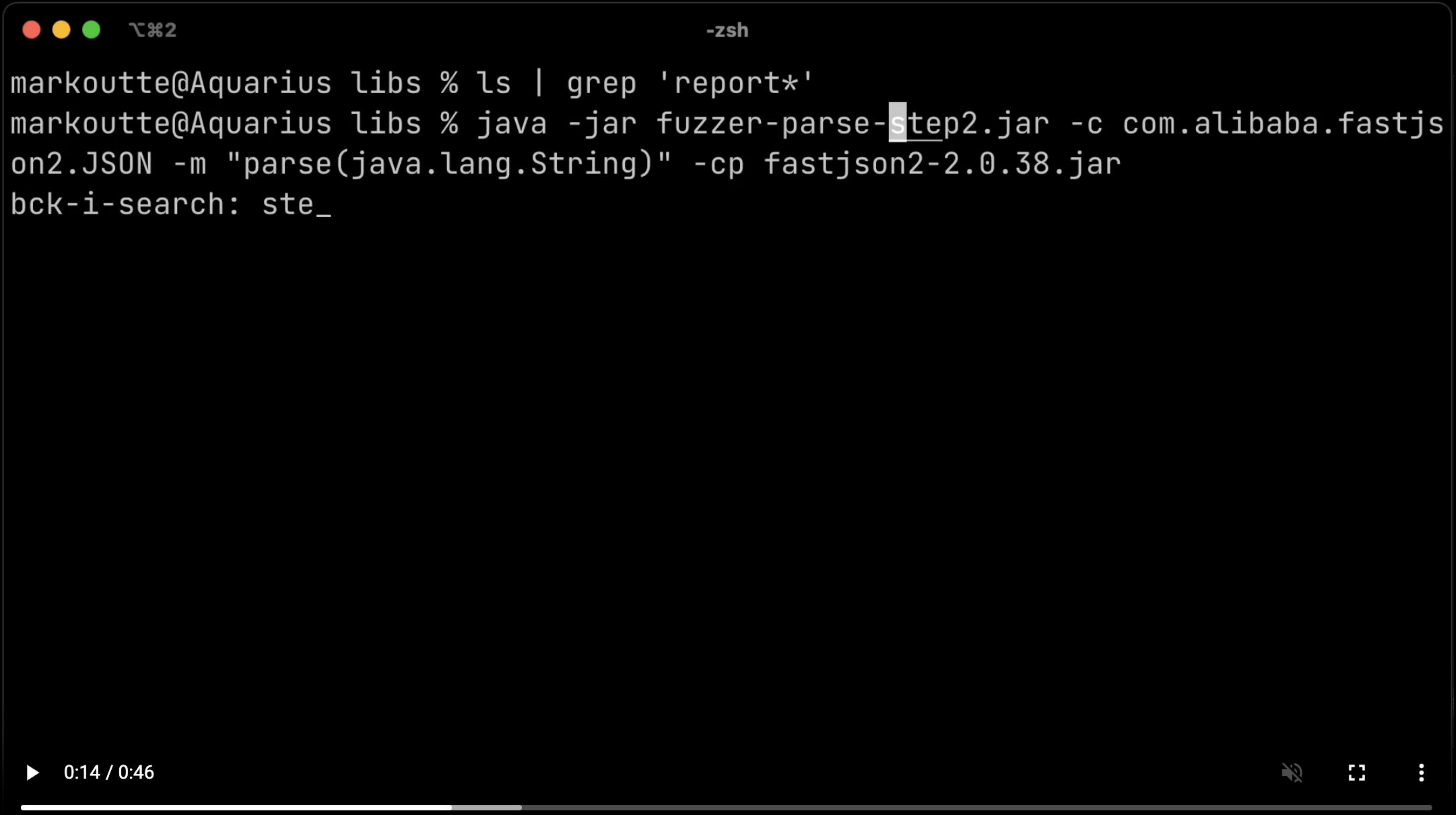

Mr. F
Буфер
Мутация
Генерация и запуск
Репорт


Уникальные
Буфер
Мутация
Генерация и запуск
Репорт

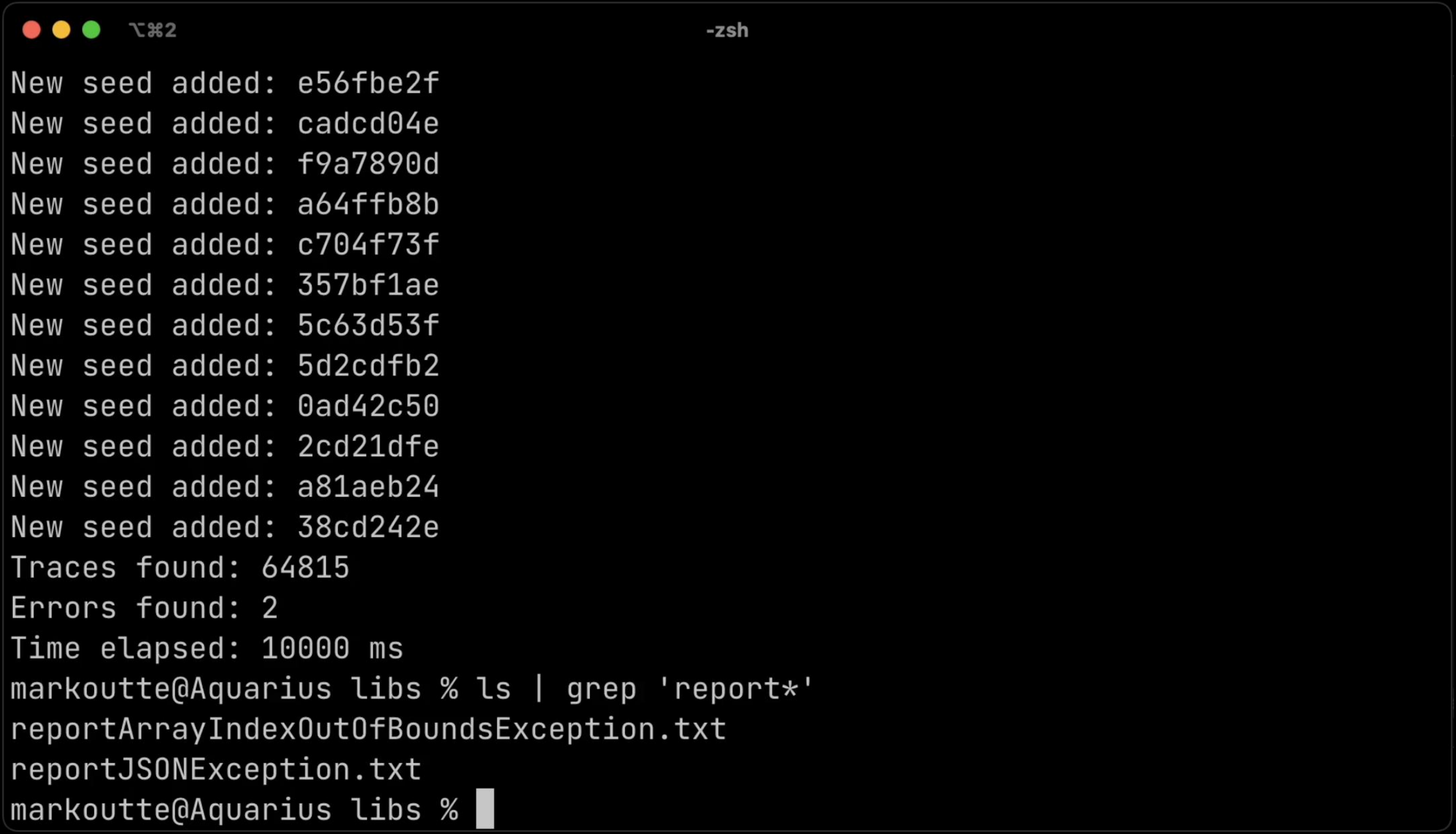

Уникальные
Буфер
Мутация
Генерация и запуск
Репорт

```kotlin
println("Running: $className.$methodName) with seed = $seed")
val errors = mutableSetOf<String>()
val b = ByteArray(300)
val start = System.nanoTime()

val javaMethod = try {
    loadJavaMethod(className, methodName, classPath)
} catch (t: Throwable) {
    println("Method $className#$methodName is not found")
    return
}

while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
    val buffer = b.apply(random::nextBytes)
    val inputValues = generateInputValues(javaMethod, buffer)
    val inputValuesString = "${javaMethod.name}: ${inputValues.contentDeepToString()}"
    try {
        javaMethod.invoke(null, *inputValues)
    } catch (e: InvocationTargetException) {
        if (errors.add(e.targetException::class.qualifiedName!!)) {
            val errorName = e.targetException::class.simpleName
            println("New error found: $errorName")
            val path = Paths.get("report$errorName.txt")
            Files.write(path, listOf(
                "${e.targetException.stackTraceToString()}\n",
                "$inputValuesString\n",
                "${buffer.contentToString()}\n",
            ))
```

```kotlin
val javaMethod = try {
    loadJavaMethod(className, methodName, classPath)
} catch (t: Throwable) {
    println("Method $className#$methodName is not found")
    return
}

val seeds = mutableMapOf<Int, ByteArray>()

while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
    val buffer = seeds.values.randomOrNull(random)?.let(Random::mutate)
        ?: b.apply(random::nextBytes)
    val inputValues = generateInputValues(javaMethod, buffer)
    val inputValuesString = "${javaMethod.name}: ${inputValues.contentDeepToString()}"
    try {
        javaMethod.invoke(null, *inputValues).apply {
            val seedId = buffer.contentHashCode()
            if (seeds.putIfAbsent(seedId, buffer) == null) {
                println("New seed added: ${seedId.toHexString()}")
            }
        }
    } catch (e: InvocationTargetException) {
        if (errors.add(e.targetException::class.qualifiedName!!)) {
            val errorName = e.targetException::class.simpleName
            println("New error found: $errorName")
            val path = Paths.get("report$errorName.txt")
            Files.write(path, listOf(
                "${e.targetException.stackTraceToString()}\n"
            String::class.java -> String(ByteArray(
                buffer.get().toUByte().toInt() + 1
            ) {
                buffer.get()
            }, Charset.forName("koi8"))
            else -> error("Cannot create value of type ${parameterTypes[it]}")
        }
    }
}

fun Random.mutate(buffer: ByteArray): ByteArray = buffer.clone().apply {
    val position = nextInt(0, size)
    val repeat = nextInt((size - position))
    val from = nextInt(-128, 127)
    val until = nextInt(from + 1, 128)
    repeat(repeat) { i ->
        set(position + i, nextInt(from, until).toByte())
    }
}
```



```
markoutte@Aquarius libs % ls | grep 'report*'
markoutte@Aquarius libs % java -jar fuzzer-parse-step2.jar -c com.alibaba.fastjs
on2.JSON -m "parse(java.lang.String)" -cp fastjson2-2.0.38.jar
bck-i-search: ste_
```


⌥⌘2 -zsh

```
New seed added: e56fbe2f
New seed added: cadcd04e
New seed added: f9a7890d
New seed added: a64ffb8b
New seed added: c704f73f
New seed added: 357bf1ae
New seed added: 5c63d53f
New seed added: 5d2cdfb2
New seed added: 0ad42c50
New seed added: 2cd21dfe
New seed added: a81aeb24
New seed added: 38cd242e
Traces found: 64815
Errors found: 2
Time elapsed: 10000 ms
markoutte@Aquarius libs % ls | grep 'report*'
reportArrayIndexOutOfBoundsException.txt
reportJSONException.txt
markoutte@Aquarius libs %
```

```
void choose(int x) {
    if (x>0) {
        // Hello 1
    }else {
        // GoodBuy 2
    }
}
```

```
void  choose(int x) {
    if (x>0) {
        // Hello 1
    }else {
        // GoodBuy 2
    }
}
```

```
choose(1)
```

```
void choose ( int x ) {
    if (x >0) {
        // Hello 1
    } else {
        // GoodBuy 2
    }
}
```

```
choose(1)
choose (2)
```

```
void  choose ( int x ) {
      if  (x >0 )  {
          // Hello 1
      } else {
          // GoodBuy 2
      }
}
```

```
choose(1)
choose (2)
choose (3)
```

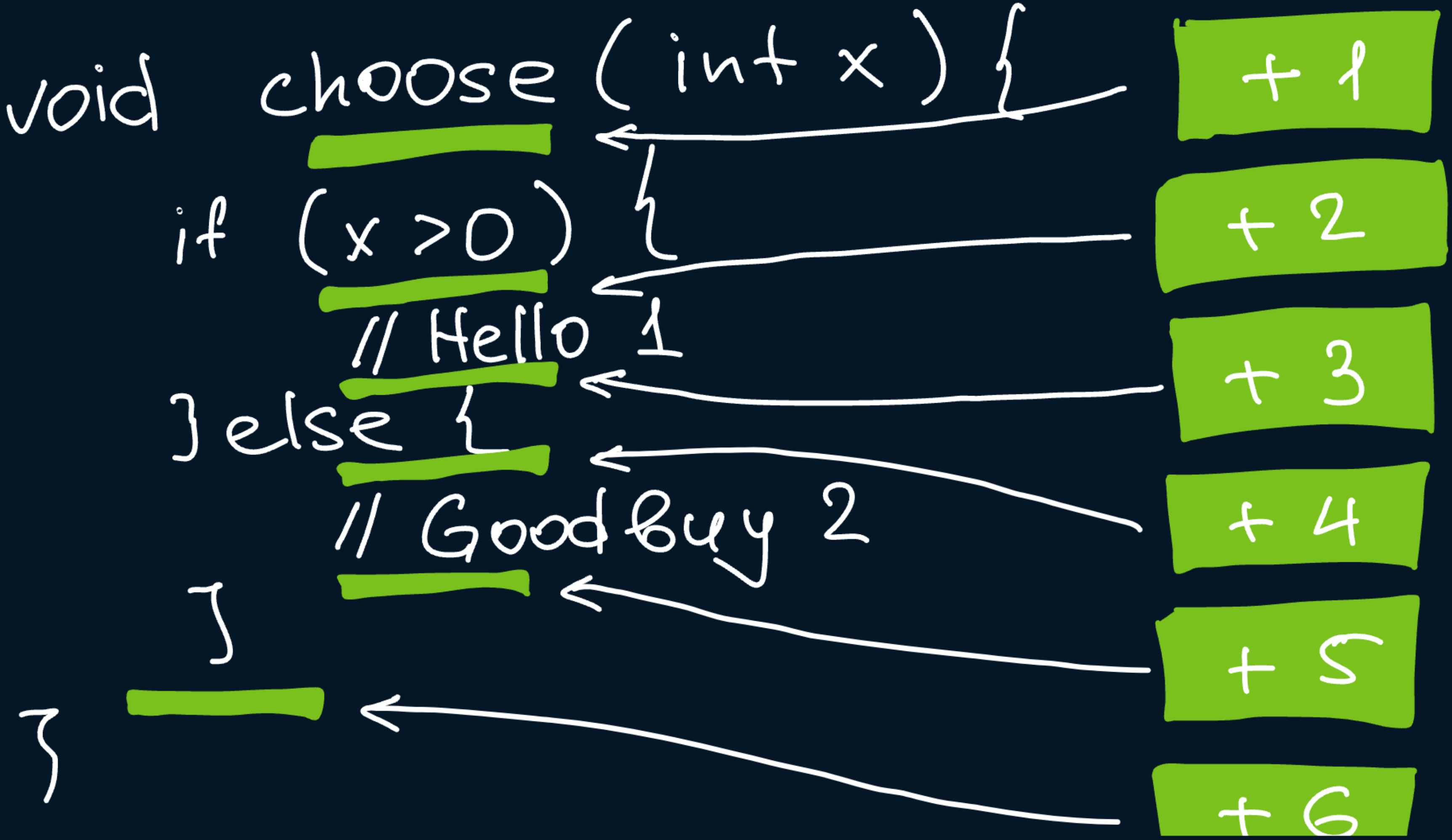
```
void  choose ( int x ) {
    if  (x >0 ) {
        // Hello 1
    } else {
        // GoodBuy 2
    }

}
```

```
choose(1)
choose (2)
choose (3)
choose (-10)
```

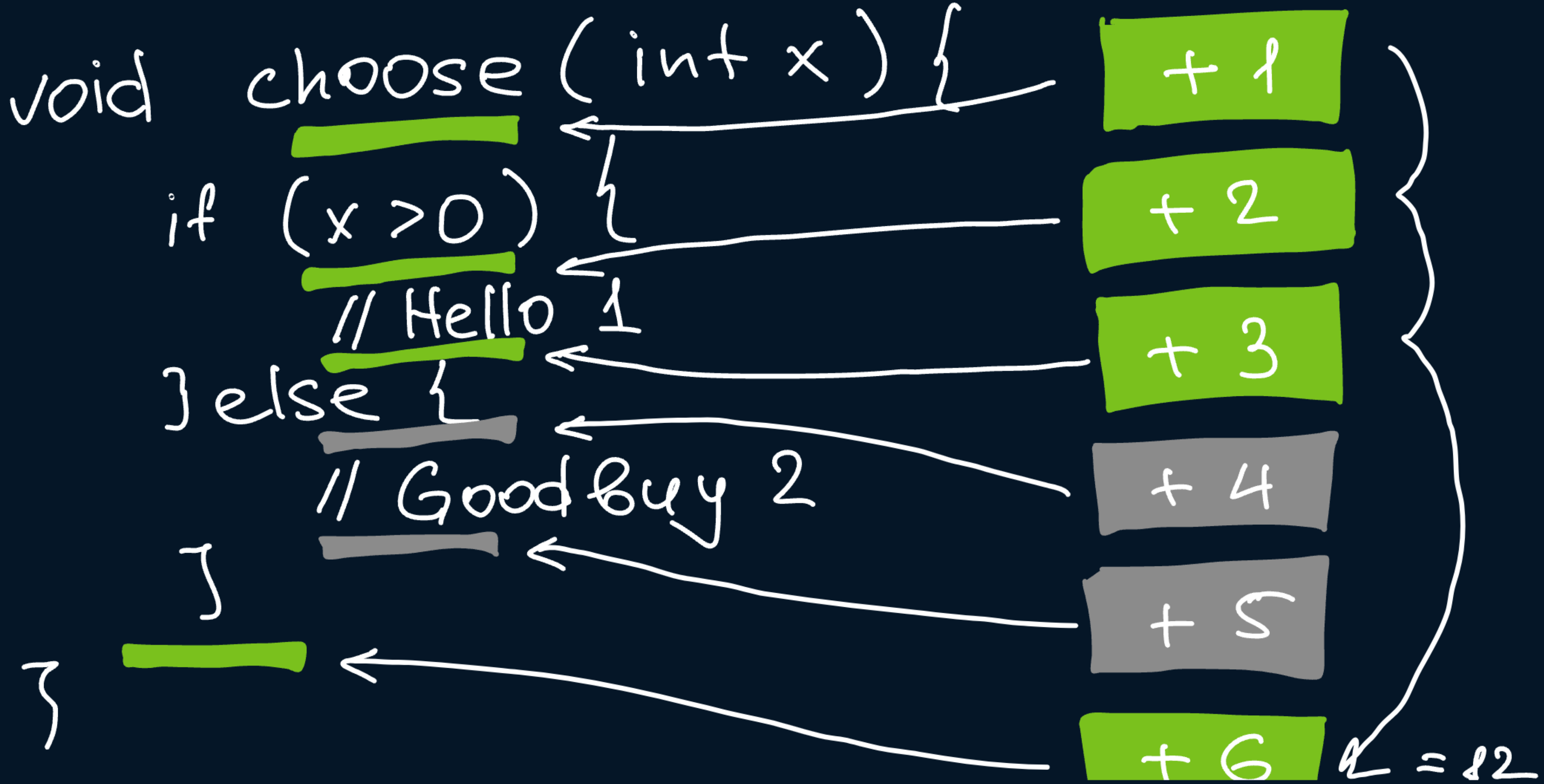
```
void  choose ( int x ) {
    if  (x >0 ) {
        // Hello 1
    } else {
        // GoodBuy 2
    }
}
```

```
choose(1)
choose (2)
choose (3)
choose (-10)
choose (0)
```

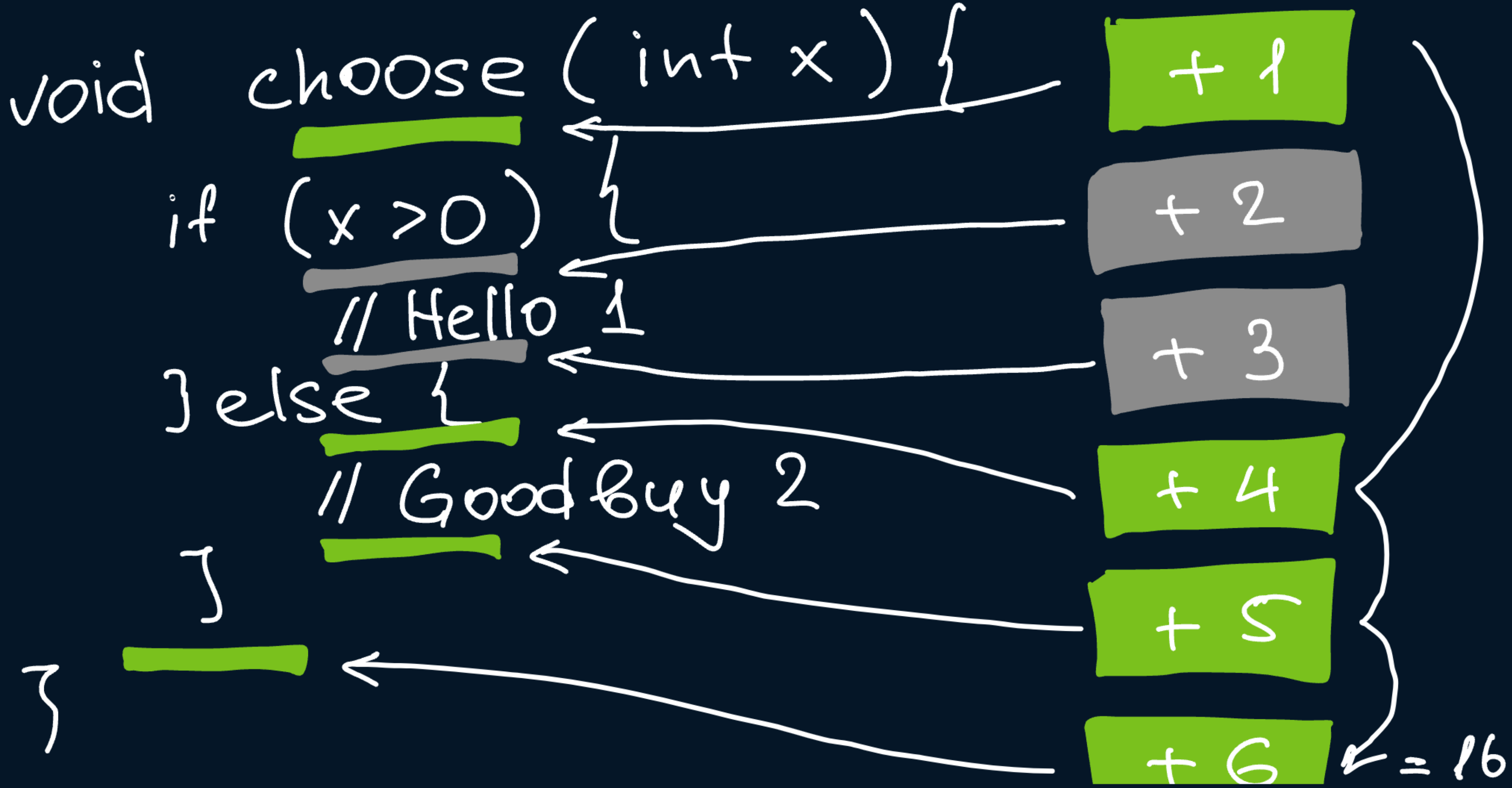
```
void choose(int x) {
    if (x>0) {
        // Hello 1
    } else {
        // GoodBuy 2
    }
}
```



```
void choose(int x) {
    if (x>0) {
        // Hello 1
    } else {
        // GoodBuy 2
    }
}
```



```
void  choose ( int x ) {
    if  ( x > 0 )  {
        // Hello 1
    } else {
        // GoodBuy 2
    }
}
```



```
void  choose ( int x ) {
    if  (x >0 )  {
        // Hello  1
    } else {
        // GoodBuy  2
    }
}
```

```kotlin
    } catch (t: Throwable) {
        println("Method $className#$methodName is not found")
        return
    }

    val seeds = mutableMapOf<Int, ByteArray>()

    while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
        val buffer = seeds.values.randomOrNull(random)?.let(Random::mutate)
            ?: b.apply(random::nextBytes)
        val inputValues = generateInputValues(javaMethod, buffer)
        val inputValuesString = "${javaMethod.name}: ${inputValues.contentDeepToString()}"
        try {
            javaMethod.invoke(null, *inputValues).apply {
                val seedId = buffer.contentHashCode()
                if (seeds.putIfAbsent(seedId, buffer) == null) {
                    println("New seed added: ${seedId.toHexString()}")
                }
            }
        } catch (e: InvocationTargetException) {
            if (errors.add(e.targetException::class.qualifiedName!!)) {
                val errorName = e.targetException::class.simpleName
                println("New error found: $errorName")
                val path = Paths.get("report$errorName.txt")
                Files.write(path, listOf(
                    "${e.targetException.stackTraceToString()}\n",
                    "$inputValuesString\n",
                    "${buffer.contentToString()}\n",
                ))
```

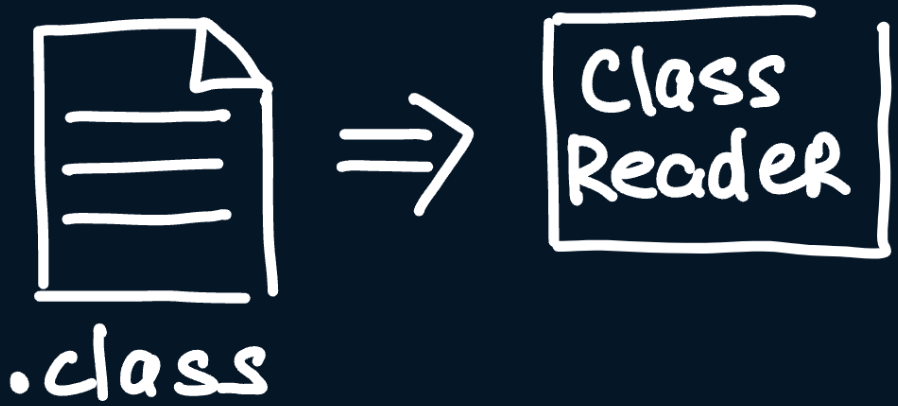
```
} catch (t: Throwable) {
    println("Method $className#$methodName is not found")
    return
}

val seeds = mutableMapOf<Int, ByteArray>()

while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
    val buffer = seeds.values.randomOrNull(random)?.let(Random::mutate)
        ?: b.apply(random::nextBytes)
    val inputValues = generateInputValues(javaMethod, buffer)
    val inputValuesString = "${javaMethod.name}: ${inputValues.contentDeepToString()}"
    try {
        ExecutionPath.id = 0
        javaMethod.invoke(null, *inputValues).apply {
            val seedId = ExecutionPath.id
            if (seeds.putIfAbsent(seedId, buffer) == null) {
                println("New seed added: ${seedId.toHexString()}")
            }
        }
    } catch (e: InvocationTargetException) {
        if (errors.add(e.targetException::class.qualifiedName!!)) {
            val errorName = e.targetException::class.simpleName
            println("New error found: $errorName")
            val path = Paths.get("report$errorName.txt")
            Files.write(path, listOf(
                "${e.targetException.stackTraceToString()}\n",
                "$inputValuesString\n",
                "${buffer.contentToString()}\n"
                buffer.get().toInt()
            }
            String::class.java → String(ByteArray(
                buffer.get().toUByte().toInt() + 1
            ) {
                buffer.get()
            }, Charset.forName("koi8"))
            else → error("Cannot create value of type ${parameterTypes[it]}")
        }
    }
}

object ExecutionPath {
    @JvmField
    var id: Int = 0
}

fun Random.mutate(buffer: ByteArray): ByteArray = buffer.clone().apply {
    val position = nextInt(0, 300)
    val repeat = nextInt((300 - position))
    val from = nextInt(-128, 127)
    val until = nextInt(from + 1, 128)
    repeat(repeat) { i →
        set(position + i, nextInt(from, until).toByte())
    }
}
```

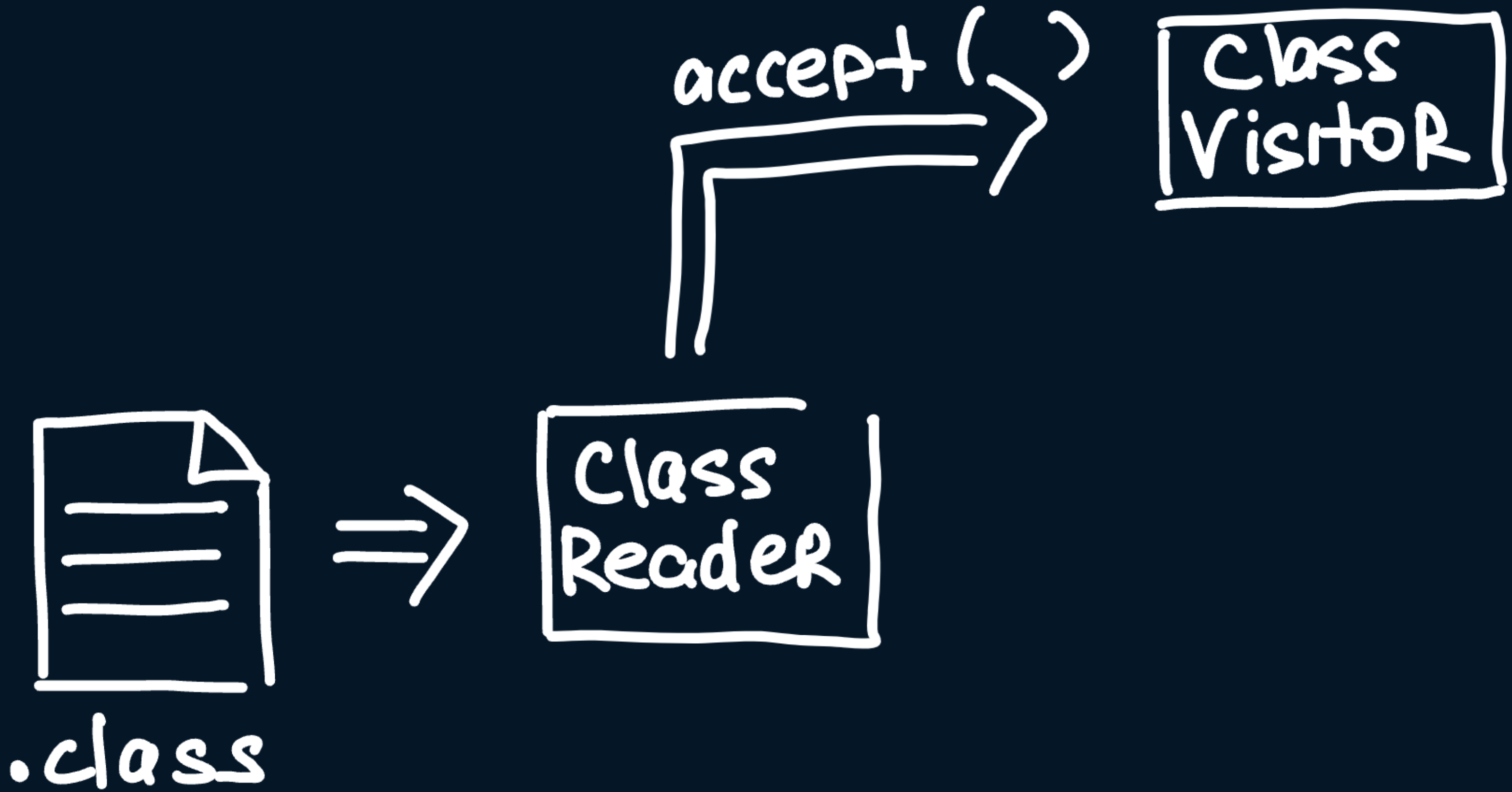
```kotlin
    }

    println("Seeds found: ${seeds.size}")
    println("Errors found: ${errors.size}")
    println("Time elapsed: ${TimeUnit.NANOSECONDS.toMillis(
        System.nanoTime() - start
    )} ms")
}

fun loadJavaMethod(className: String, methodName: String, classPath: String): Method {
    val libraries = classPath
        .split(File.pathSeparatorChar)
        .map { File(it).toURI().toURL() }
        .toTypedArray()
    val classLoader = URLClassLoader(libraries)
    val javaClass = classLoader.loadClass(className)
    val javaMethod = javaClass.declaredMethods.first {
        "${it.name}(${it.parameterTypes.joinToString(",") {
                c -> c.typeName
        }})" == methodName
    }
    return javaMethod
}

fun generateInputValues(method: Method, data: ByteArray): Array<Any> {
    val buffer = ByteBuffer.wrap(data)
    val parameterTypes = method.parameterTypes
    return Array(parameterTypes.size) {
        when (parameterTypes[it]) {
```

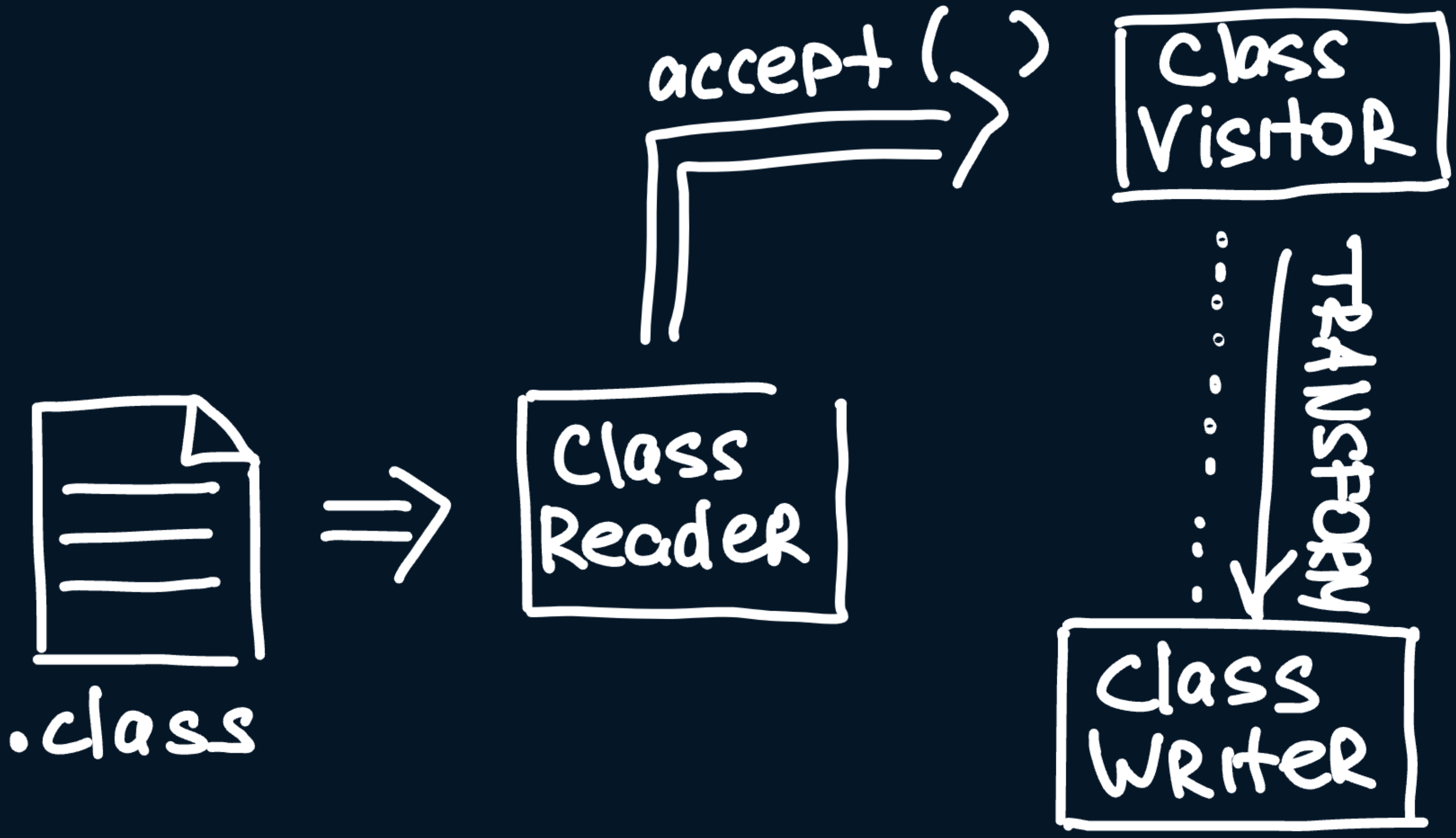
```
fun loadJavaMethod(className: String, methodName: String, classPath: String): Method {
    val libraries = classPath
        .split(File.pathSeparatorChar)
        .map { File(it).toURI().toURL() }
        .toTypedArray()
    val classLoader = object : URLClassLoader(libraries) {
        override fun loadClass(name: String, resolve: Boolean): Class<*> {
            return if (name.startsWith(className.substringBeforeLast('.'))) {
                transformAndGetClass(name).apply {
                    if (resolve) resolveClass(this)
                }
            } else {
                super.loadClass(name, resolve)
            }
        }

        fun transformAndGetClass(name: String): Class<*> {
            val owner = name.replace('.', '/')
            var bytes =
                getResourceAsStream("$owner.class")!!.use { it.readBytes() }
            val reader = ClassReader(bytes)
            val cl = this
            val writer = ComputeClassWriter(
                reader,
                ClassWriter.COMPUTE_MAXS or ClassWriter.COMPUTE_FRAMES,
                cl
            )
            val transformer = object : ClassVisitor(Opcodes.ASM9, writer) {
                override fun visitMethod(
                    access: Int,
                    name: String?,
                    descriptor: String?,
                    signature: String?,
                    exceptions: Array<out String>?
                ): MethodVisitor {
                    return object : MethodVisitor(
                        Opcodes.ASM9,
                        super.visitMethod(
                            access, name, descriptor, signature, exceptions
                        )
                    ) {
                        val ownerName =
                            ExecutionPath.javaClass.canonicalName.replace('.', '/')
                        val fieldName = "id"

                        override fun visitLineNumber(line: Int, start: Label?) {
                            visitFieldInsn(
                                Opcodes.GETSTATIC, ownerName, fieldName, "I"
                            )
                            visitLdcInsn(line)
                            visitInsn(Opcodes.IADD)
                            visitFieldInsn(
                                Opcodes.PUTSTATIC, ownerName, fieldName, "I"
                            )
                            super.visitLineNumber(line, start)
                        }
                    }
                }
            }
            reader.accept(transformer, ClassReader.SKIP_FRAMES)
            bytes = writer.toByteArray()
            return defineClass(name, bytes, 0, bytes.size)
        }
    }
    val javaClass = classLoader.loadClass(className)
    val javaMethod = javaClass.declaredMethods.first {
        "${it.name}(${it.parameterTypes.joinToString(",") {
                c -> c.typeName
        }})" == methodName
    }
```

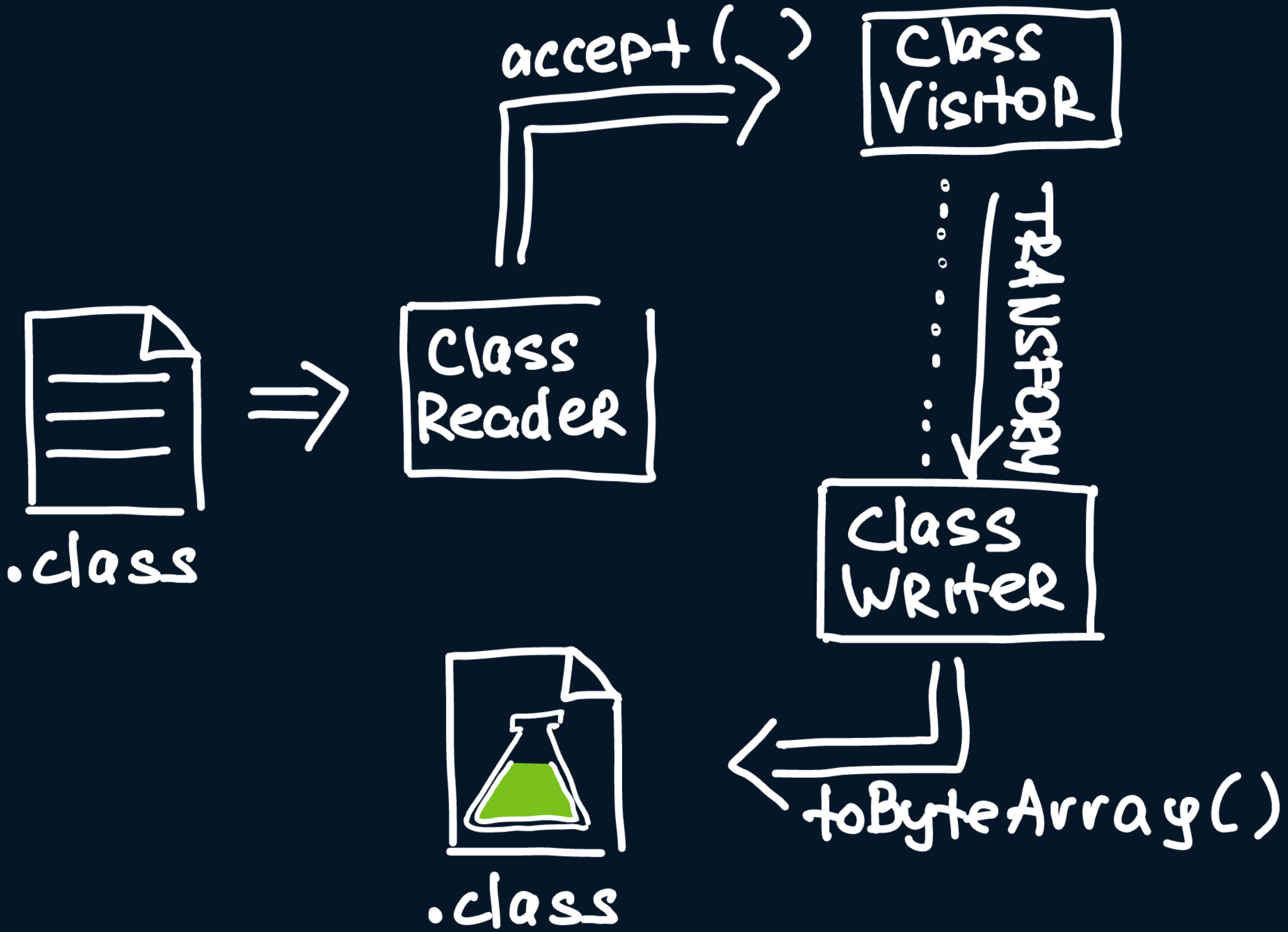
asm.ow2.io

.class


.class
Class Reader


accept( )
Class Visitor
Class Reader
.class


.class
Class Reader
accept( )
Class Visitor
TRANSFORM
Class Writer

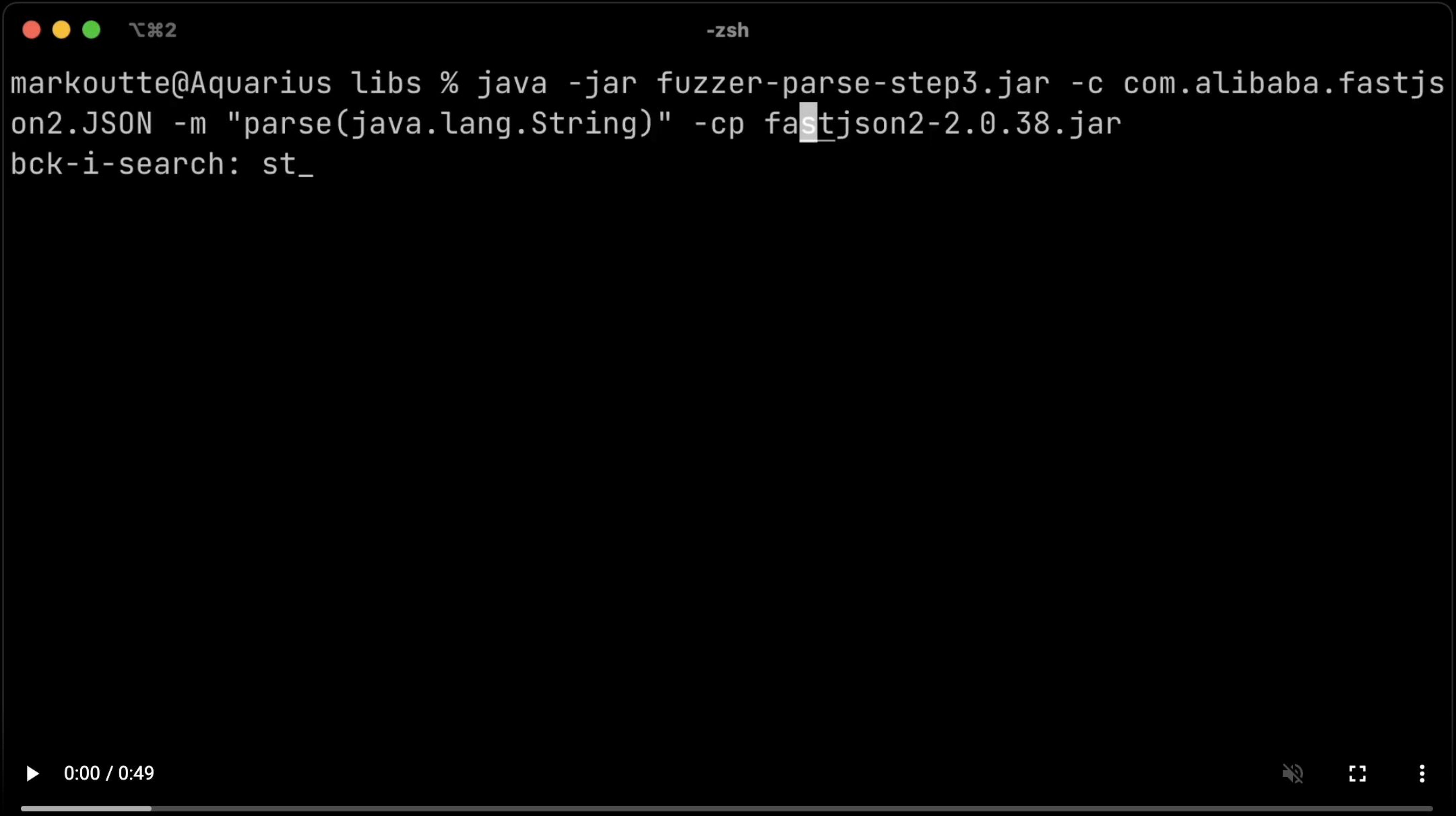

.class
Class Reader
accept( )
Class Visitor
TRANSFORM
Class Writer
toByteArray()
.class

```
        System.nanoTime() - start
    )} ms")
}

fun loadJavaMethod(className: String, methodName: String, classPath: String): Method {
    val libraries = classPath
        .split(File.pathSeparatorChar)
        .map { File(it).toURI().toURL() }
        .toTypedArray()
    val classLoader = object : URLClassLoader(libraries) {
        override fun loadClass(name: String, resolve: Boolean): Class<*> {
            return if (name.startsWith(className.substringBeforeLast('.'))) {
                transformAndGetClass(name).apply {
                    if (resolve) resolveClass(this)
                }
            } else {
                super.loadClass(name, resolve)
            }
        }

        fun transformAndGetClass(name: String): Class<*> {
            val owner = name.replace('.', '/')
            var bytes =
                getResourceAsStream("$owner.class")!!.use { it.readBytes() }
            val reader = ClassReader(bytes)
            val cl = this
            val writer = ComputeClassWriter(
                reader,
                ClassWriter.COMPUTE_MAXS or ClassWriter.COMPUTE_FRAMES,
```

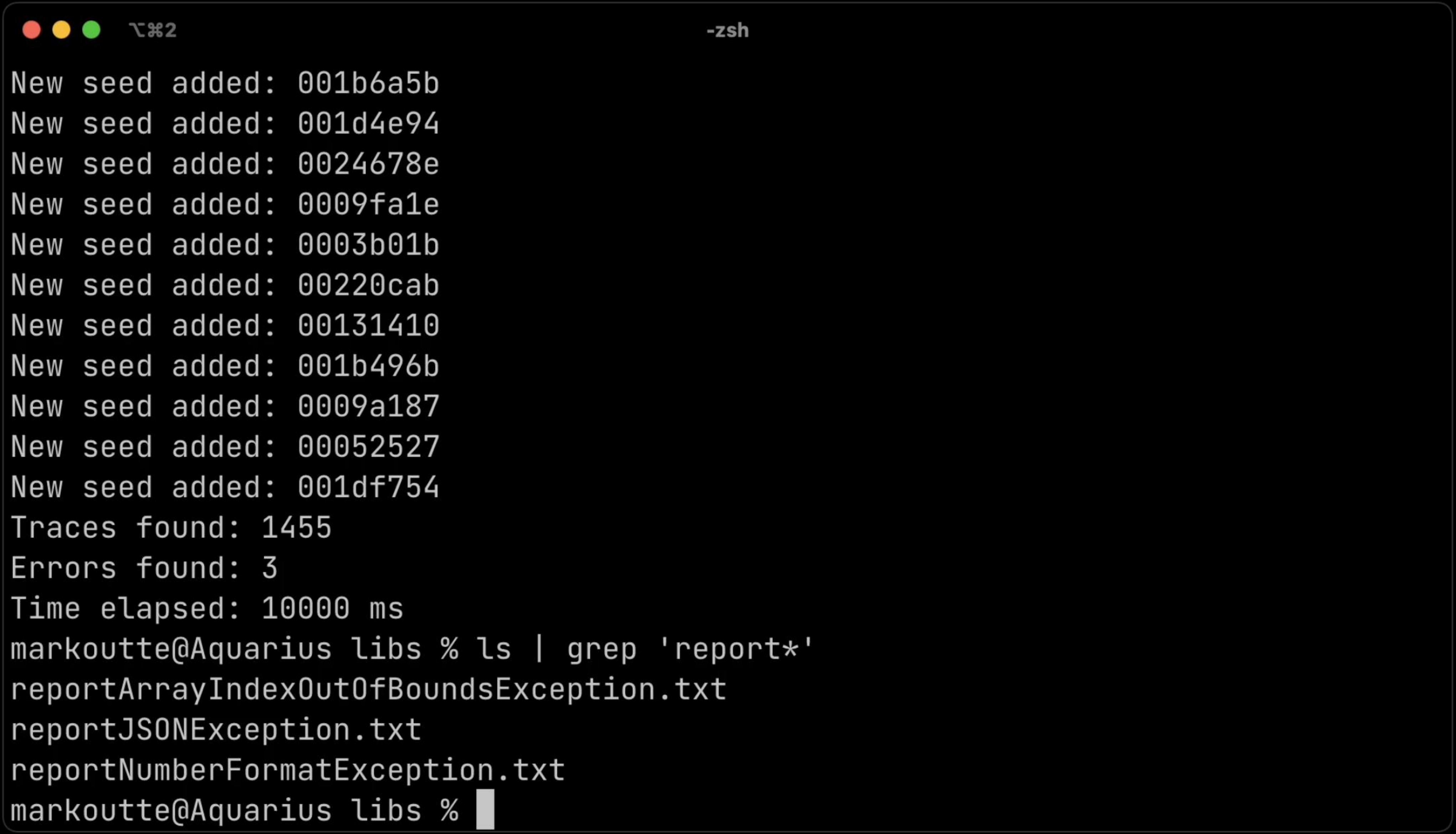
```kotlin
        .toTypedArray()
    val classLoader = object : URLClassLoader(libraries) {
        override fun loadClass(name: String, resolve: Boolean): Class<*> {
            return if (name.startsWith(className.substringBeforeLast('.'))) {
                transformAndGetClass(name).apply {
                    if (resolve) resolveClass(this)
                }
            } else {
                super.loadClass(name, resolve)
            }
        }

        fun transformAndGetClass(name: String): Class<*> {
            val owner = name.replace('.', '/')
            var bytes =
                getResourceAsStream("$owner.class")!!.use { it.readBytes() }
            val reader = ClassReader(bytes)
            val cl = this
            val writer = ComputeClassWriter(
                reader,
                ClassWriter.COMPUTE_MAXS or ClassWriter.COMPUTE_FRAMES,
                cl
            )
            val transformer = object : ClassVisitor(Opcodes.ASM9, writer) {
                override fun visitMethod(
                    access: Int,
                    name: String?,
                    descriptor: String?,
                    signature: String?
            }
        } else {
            super.loadClass(name, resolve)
        }
    }

    fun transformAndGetClass(name: String): Class<*> {
        val owner = name.replace('.', '/')
        var bytes =
            getResourceAsStream("$owner.class")!!.use { it.readBytes() }
        val reader = ClassReader(bytes)
        val cl = this
        val writer = ComputeClassWriter(
            reader,
            ClassWriter.COMPUTE_MAXS or ClassWriter.COMPUTE_FRAMES,
            cl
        )
        val transformer = object : ClassVisitor(Opcodes.ASM9, writer) {
            override fun visitMethod(
                access: Int,
                name: String?,
                descriptor: String?,
                signature: String?,
                exceptions: Array<out String>?
            ): MethodVisitor {
                return object : MethodVisitor(
                    Opcodes.ASM9,
                    super.visitMethod(
```

```kotlin
    val owner = name.replace('.', '/')
    var bytes =
        getResourceAsStream("$owner.class")!!.use { it.readBytes() }
    val reader = ClassReader(bytes)
    val cl = this
    val writer = ComputeClassWriter(
        reader,
        ClassWriter.COMPUTE_MAXS or ClassWriter.COMPUTE_FRAMES,
        cl
    )
    val transformer = object : ClassVisitor(Opcodes.ASM9, writer) {
        override fun visitMethod(
            access: Int,
            name: String?,
            descriptor: String?,
            signature: String?,
            exceptions: Array<out String>?
        ): MethodVisitor {
            return object : MethodVisitor(
                Opcodes.ASM9,
                super.visitMethod(
                    access, name, descriptor, signature, exceptions
                )
            ) {
                val ownerName =
                    ExecutionPath.javaClass.canonicalName.replace('.', '/')
                val fieldName = "id"
        signature: String?,
        exceptions: Array<out String>?
    ): MethodVisitor {
        return object : MethodVisitor(
            Opcodes.ASM9,
            super.visitMethod(
                access, name, descriptor, signature, exceptions
            )
        ) {
            val ownerName =
                ExecutionPath.javaClass.canonicalName.replace('.', '/')
            val fieldName = "id"

            override fun visitLineNumber(line: Int, start: Label?) {
                visitFieldInsn(
                    Opcodes.GETSTATIC, ownerName, fieldName, "I"
                )
                visitLdcInsn(line)
                visitInsn(Opcodes.IADD)
                visitFieldInsn(
                    Opcodes.PUTSTATIC, ownerName, fieldName, "I"
                )
                super.visitLineNumber(line, start)
            }
        }
    }
}
reader.accept(transformer, ClassReader.SKIP_FRAMES)
```

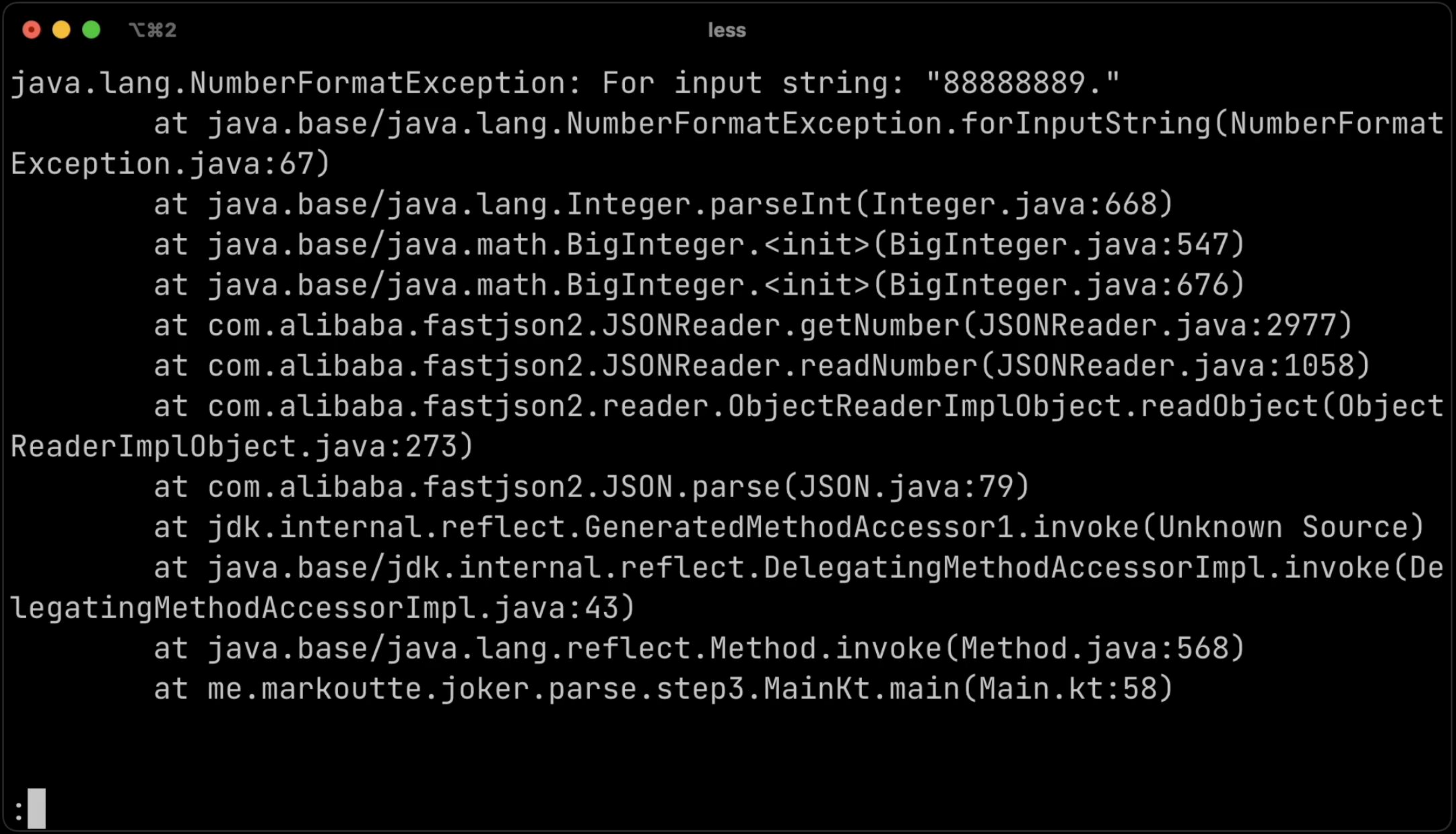
```kotlin
                return object : MethodVisitor(
                    Opcodes.ASM9,
                    super.visitMethod(
                        access, name, descriptor, signature, exceptions
                    )
                ) {
                    val ownerName =
                        ExecutionPath.javaClass.canonicalName.replace('.', '/')
                    val fieldName = "id"

                    override fun visitLineNumber(line: Int, start: Label?) {
                        visitFieldInsn(
                            Opcodes.GETSTATIC, ownerName, fieldName, "I"
                        )
                        visitLdcInsn(line)
                        visitInsn(Opcodes.IADD)
                        visitFieldInsn(
                            Opcodes.PUTSTATIC, ownerName, fieldName, "I"
                        )
                        super.visitLineNumber(line, start)
                    }
                }
            }
        }
        reader.accept(transformer, ClassReader.SKIP_FRAMES)
        bytes = writer.toByteArray()
        return defineClass(name, bytes, 0, bytes.size)
    }
}
```



```
markoutte@Aquarius libs % java -jar fuzzer-parse-step3.jar -c com.alibaba.fastjs
on2.JSON -m "parse(java.lang.String)" -cp fastjson2-2.0.38.jar
bck-i-search: st_
```



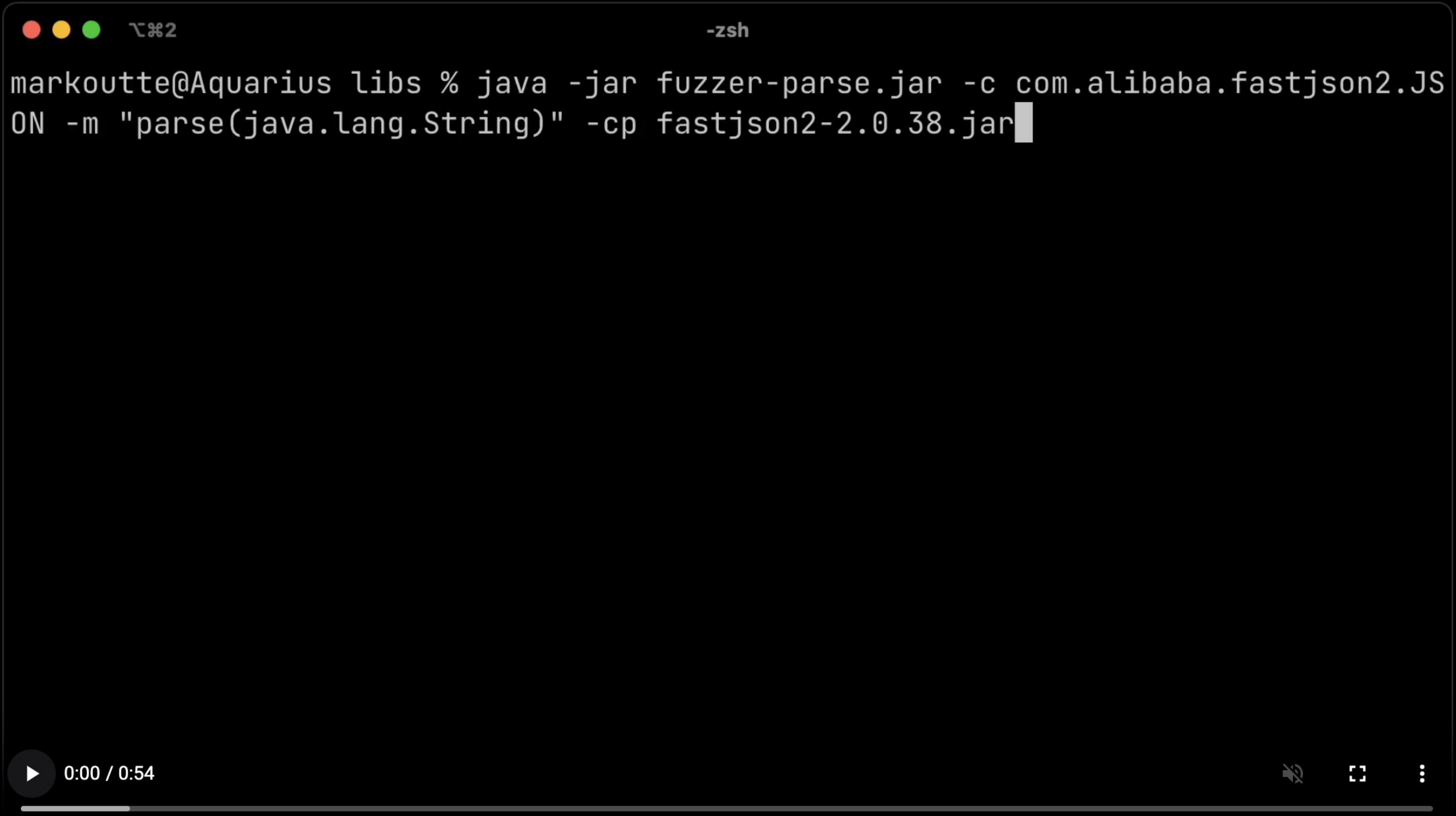
```
New seed added: 001b6a5b
New seed added: 001d4e94
New seed added: 0024678e
New seed added: 0009fa1e
New seed added: 0003b01b
New seed added: 00220cab
New seed added: 00131410
New seed added: 001b496b
New seed added: 0009a187
New seed added: 00052527
New seed added: 001df754
Traces found: 1455
Errors found: 3
Time elapsed: 10000 ms
markoutte@Aquarius libs % ls | grep 'report*'
reportArrayIndexOutOfBoundsException.txt
reportJSONException.txt
reportNumberFormatException.txt
markoutte@Aquarius libs %
```



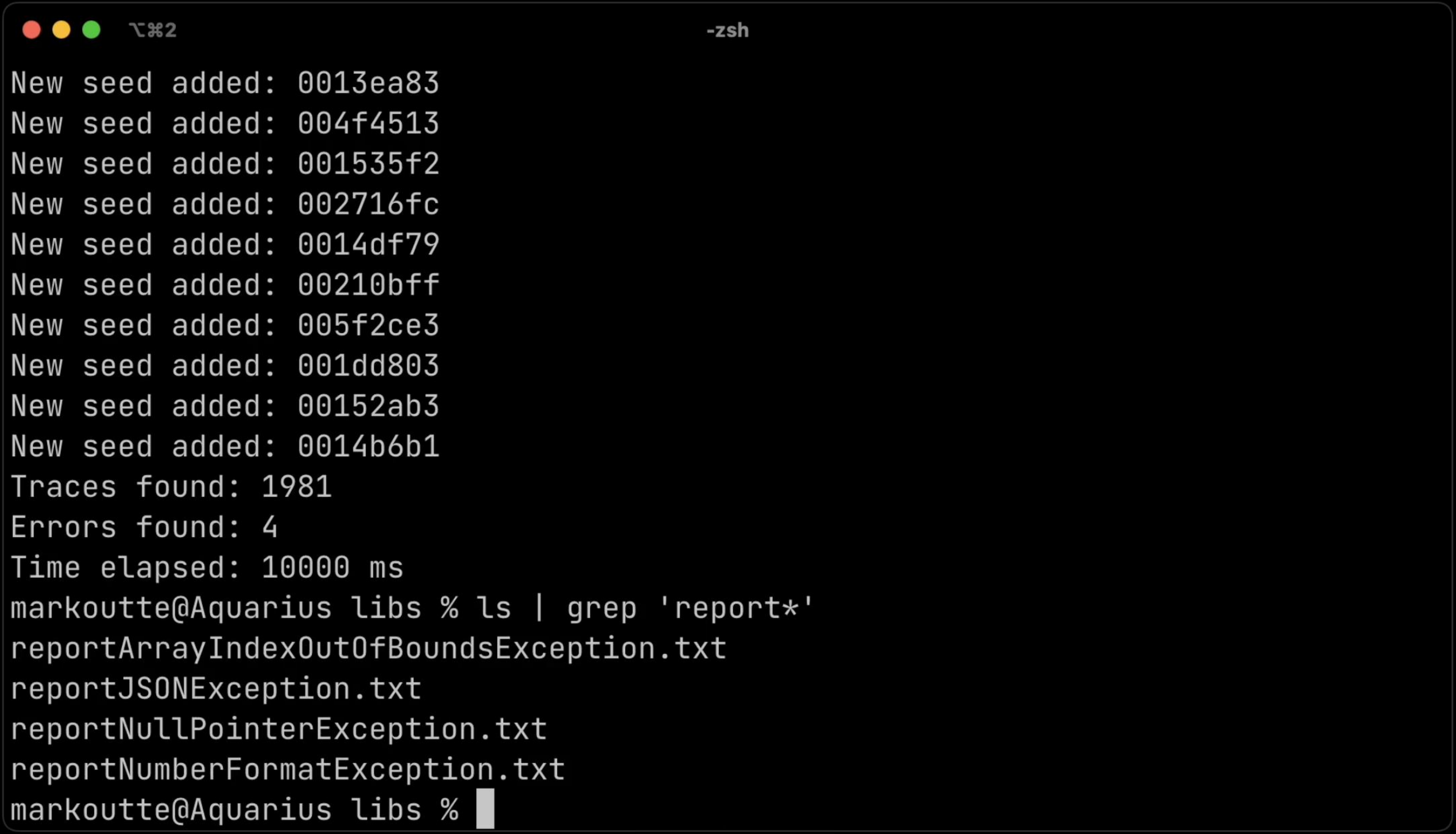
```
java.lang.NumberFormatException: For input string: "88888889."
        at java.base/java.lang.NumberFormatException.forInputString(NumberFormat
Exception.java:67)
        at java.base/java.lang.Integer.parseInt(Integer.java:668)
        at java.base/java.math.BigInteger.<init>(BigInteger.java:547)
        at java.base/java.math.BigInteger.<init>(BigInteger.java:676)
        at com.alibaba.fastjson2.JSONReader.getNumber(JSONReader.java:2977)
        at com.alibaba.fastjson2.JSONReader.readNumber(JSONReader.java:1058)
        at com.alibaba.fastjson2.reader.ObjectReaderImplObject.readObject(Object
ReaderImplObject.java:273)
        at com.alibaba.fastjson2.JSON.parse(JSON.java:79)
        at jdk.internal.reflect.GeneratedMethodAccessor1.invoke(Unknown Source)
        at java.base/jdk.internal.reflect.DelegatingMethodAccessorImpl.invoke(De
legatingMethodAccessorImpl.java:43)
        at java.base/java.lang.reflect.Method.invoke(Method.java:568)
        at me.markoutte.joker.parse.step3.MainKt.main(Main.kt:58)



:
```

```kotlin
val random = Random(seed)

println("Running: $className.$methodName) with seed = $seed")
val errors = mutableSetOf<String>()
val b = ByteArray(300)
val start = System.nanoTime()

val javaMethod = try {
    loadJavaMethod(className, methodName, classPath)
} catch (t: Throwable) {
    println("Method $className#$methodName is not found")
    return
}

val seeds = mutableMapOf<Int, ByteArray>()

while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
    val buffer = seeds.values.randomOrNull(random)?.let(Random::mutate)
        ?: b.apply(random::nextBytes)
    val inputValues = generateInputValues(javaMethod, buffer)
    val inputValuesString = "${javaMethod.name}: ${inputValues.contentDeepToString()}"
    try {
        ExecutionPath.id = 0
        javaMethod.invoke(null, *inputValues).apply {
            val seedId = ExecutionPath.id
            if (seeds.putIfAbsent(seedId, buffer) == null) {
                println("New seed added: ${seedId.toHexString()}")
            }
        }
```

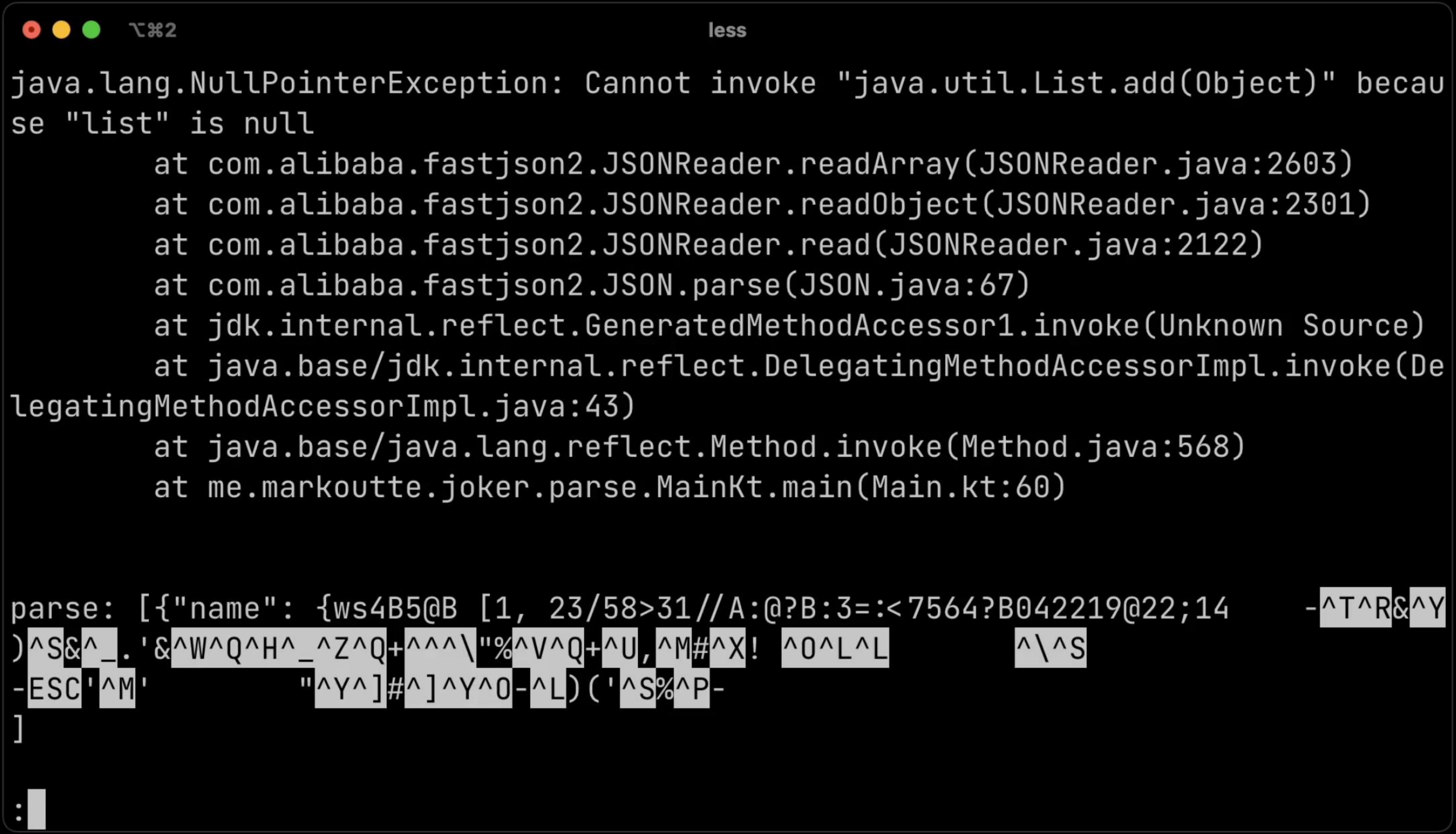
```kotlin
println("Running: $className.$methodName) with seed = $seed")
val errors = mutableSetOf<String>()
val b = ByteArray(300)
val start = System.nanoTime()

val javaMethod = try {
    loadJavaMethod(className, methodName, classPath)
} catch (t: Throwable) {
    println("Method $className#$methodName is not found")
    return
}

val seeds = mutableMapOf<Int, ByteArray>(
    -1 to """{"name": { "arr": [1, 2, 3] }}""".asByteArray(b.size)!!
)

while(System.nanoTime() - start < TimeUnit.SECONDS.toNanos(timeout)) {
    val buffer = seeds.values.randomOrNull(random)?.let(Random::mutate)
        ?: b.apply(random::nextBytes)
    val inputValues = generateInputValues(javaMethod, buffer)
    val inputValuesString = "${javaMethod.name}: ${inputValues.contentDeepToString()}"
    try {
        ExecutionPath.id = 0
        javaMethod.invoke(null, *inputValues).apply {
            val seedId = ExecutionPath.id
            if (seeds.putIfAbsent(seedId, buffer) == null) {
                println("New seed added: ${seedId.toHexString()}")
            }
        val until = nextInt(from + 1, 128)
        repeat(repeat) { i ->
            set(position + i, nextInt(from, until).toByte())
        }
    }

fun Any.asByteArray(length: Int): ByteArray? = when (this) {
    is String -> {
        val bytes = toByteArray(Charset.forName("koi8"))
        ByteArray(length) {
            if (it == 0) {
                (bytes.size - 1).toUByte().toByte()
            } else if (it - 1 < bytes.size) {
                bytes[it - 1]
            } else {
                0
            }
        }
    }
    else -> null
}
```



```
markoutte@Aquarius libs % java -jar fuzzer-parse.jar -c com.alibaba.fastjson2.JS
ON -m "parse(java.lang.String)" -cp fastjson2-2.0.38.jar
```



```
New seed added: 0013ea83
New seed added: 004f4513
New seed added: 001535f2
New seed added: 002716fc
New seed added: 0014df79
New seed added: 00210bff
New seed added: 005f2ce3
New seed added: 001dd803
New seed added: 00152ab3
New seed added: 0014b6b1
Traces found: 1981
Errors found: 4
Time elapsed: 10000 ms
markoutte@Aquarius libs % ls | grep 'report*'
reportArrayIndexOutOfBoundsException.txt
reportJSONException.txt
reportNullPointerException.txt
reportNumberFormatException.txt
markoutte@Aquarius libs % 
```



```
java.lang.NullPointerException: Cannot invoke "java.util.List.add(Object)" becau
se "list" is null
        at com.alibaba.fastjson2.JSONReader.readArray(JSONReader.java:2603)
        at com.alibaba.fastjson2.JSONReader.readObject(JSONReader.java:2301)
        at com.alibaba.fastjson2.JSONReader.read(JSONReader.java:2122)
        at com.alibaba.fastjson2.JSON.parse(JSON.java:67)
        at jdk.internal.reflect.GeneratedMethodAccessor1.invoke(Unknown Source)
        at java.base/jdk.internal.reflect.DelegatingMethodAccessorImpl.invoke(De
legatingMethodAccessorImpl.java:43)
        at java.base/java.lang.reflect.Method.invoke(Method.java:568)
        at me.markoutte.joker.parse.MainKt.main(Main.kt:60)


parse: [{"name": {ws4B5@B [1, 23/58>31//A:@?B:3=:<7564?B042219@22;14    -^T^R&^Y
)^S&^_.'&^W^Q^H^_^Z^Q+^^^\"%^V^Q+^U,^M#^X! ^O^L^L       ^\^S
-ESC'^M'         "^Y^]#^]^Y^O-^L)('^S%^P-
]

:
```

Что в итоге?

Coverage guided mutation-based grey-box fuzzer

Что в итоге?

5 ошибок в опенсурс проектах

Как попробовать?

Markoutte/Joker2023

UNITTEST BOT

https://utbot.org

Генерация тестов для Spring: из чего же, из чего же сделаны тесты

Денис Фокин, Егор Куликов

Joker, 14 октября, 12:00 – 12:45

Вывести типы из Python: проблемы анализа Python-кода

Екатерина Точилина, Вячеслав Тамарин

PiterPy, 13 ноября, 11:30 – 12:15

Максим Пелевин

markoutte