Socio-Technical Solution to Large-Scale Formal Specification Mining

May1620

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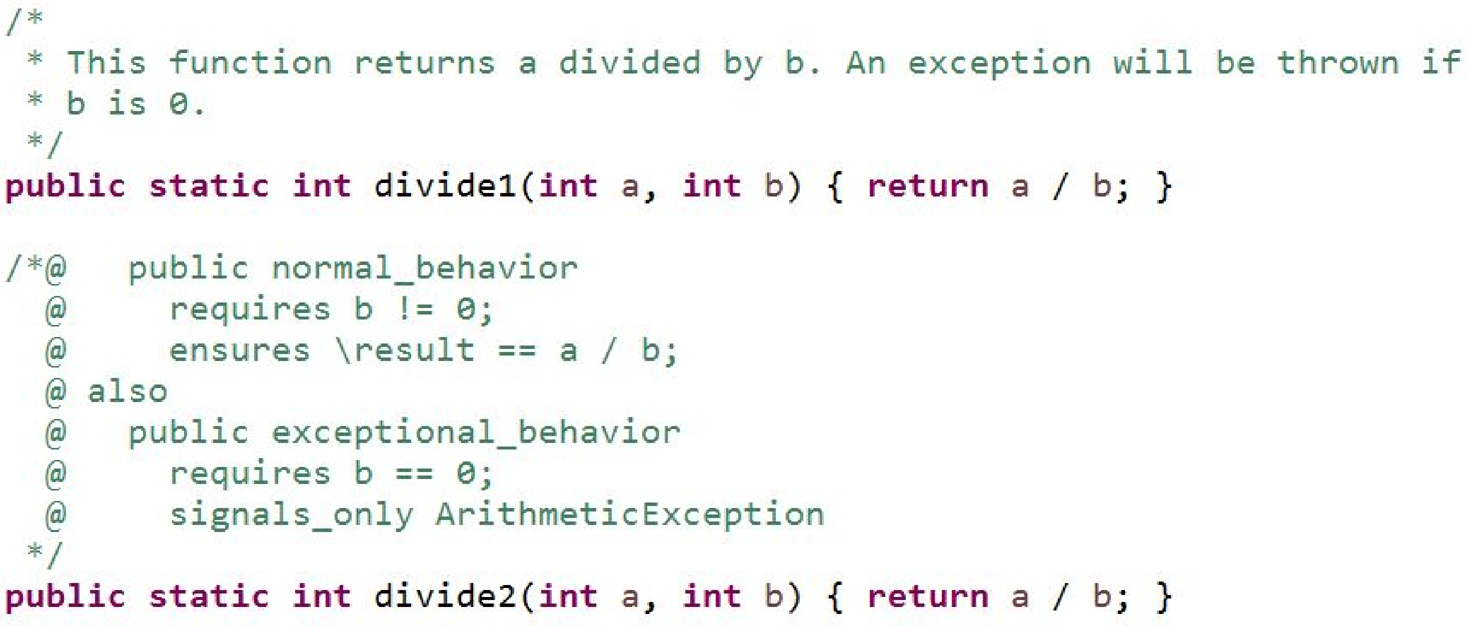
Project Website: http://may1620.github.io/

What are formal specifications?

- Allow a programmer to describe the behavior of a piece of code in a programmatic and verifiable manner.
- Consist of a precondition and postcondition pair that specify what must be true about the program state
- Allow programmers to more easily write correct code
- Research has been conducted to create formal specification languages (JML) that can be applied to many programming languages

Informal vs. Formal Specifications



```
/*
 * This function returns a divided by b. An exception will be thrown if
 * b is 0.
 */
public static int divide1(int a, int b) { return a / b; }

/*@   public normal_behavior
  @     requires b != 0;
  @     ensures \result == a / b;
  @ also
  @   public exceptional_behavior
  @     requires b == 0;
  @     signals_only ArithmeticException
 */
public static int divide2(int a, int b) { return a / b; }
```

The Problem

- Formal specifications are not widely available to programmers
- Many programmers do not know how to use formal specifications
- It can be difficult to write new formal specifications without a lot of experience using them
- It is difficult to automatically generate formal specifications by analyzing pieces of code

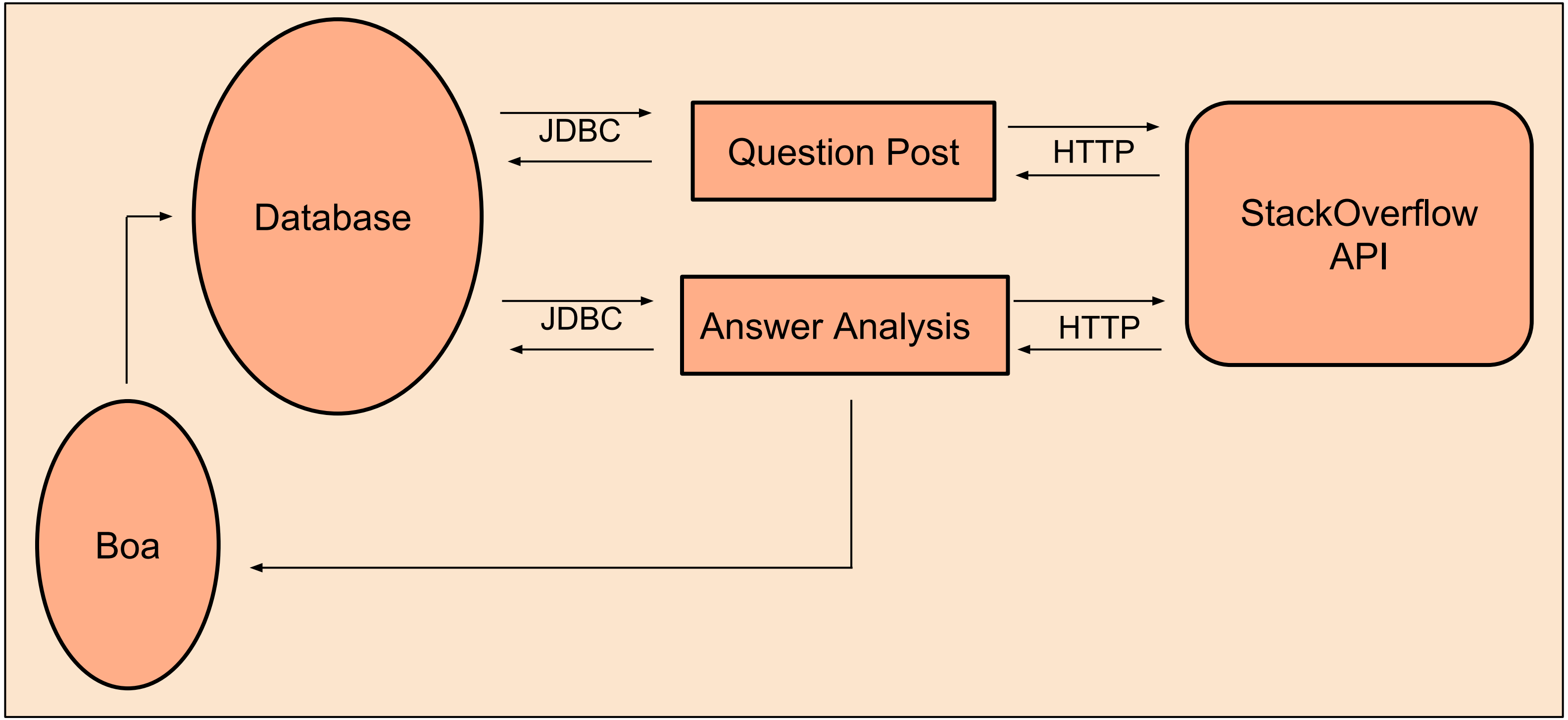
Initial Approach

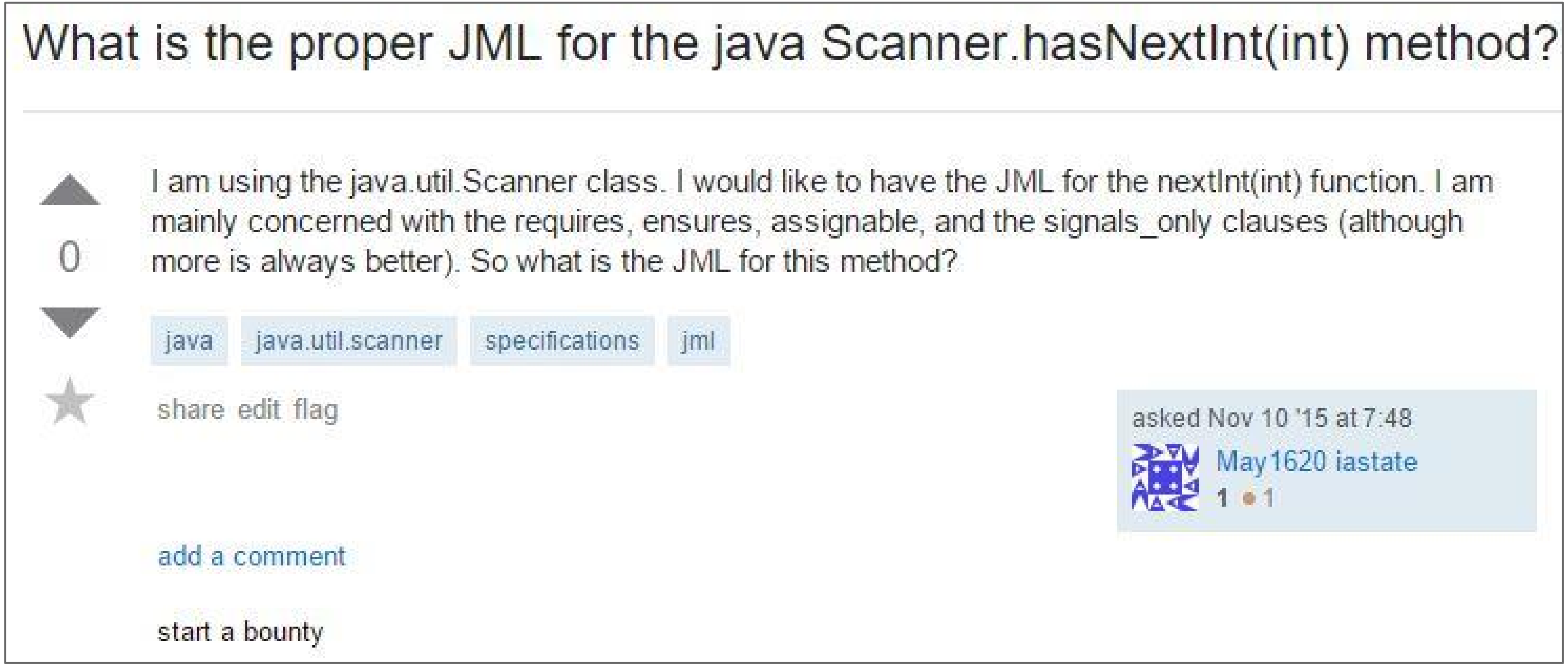
- Use the success of the popular StackOverflow site to crowdsource the specifications
- A system will automatically post questions asking for specifications, then automatically pull down the answers
- Store these specifications in Boa, a software repository mining infrastructure, to make them available to users
- Eventually link our project with a custom Q&A site based on StackOverflow developed by another group

(Big) Risks

- As formal specifications are not well understood by the general programmer, there may be trouble getting quality responses from users
- StackOverflow may restrict us to posting very rarely

System Overview





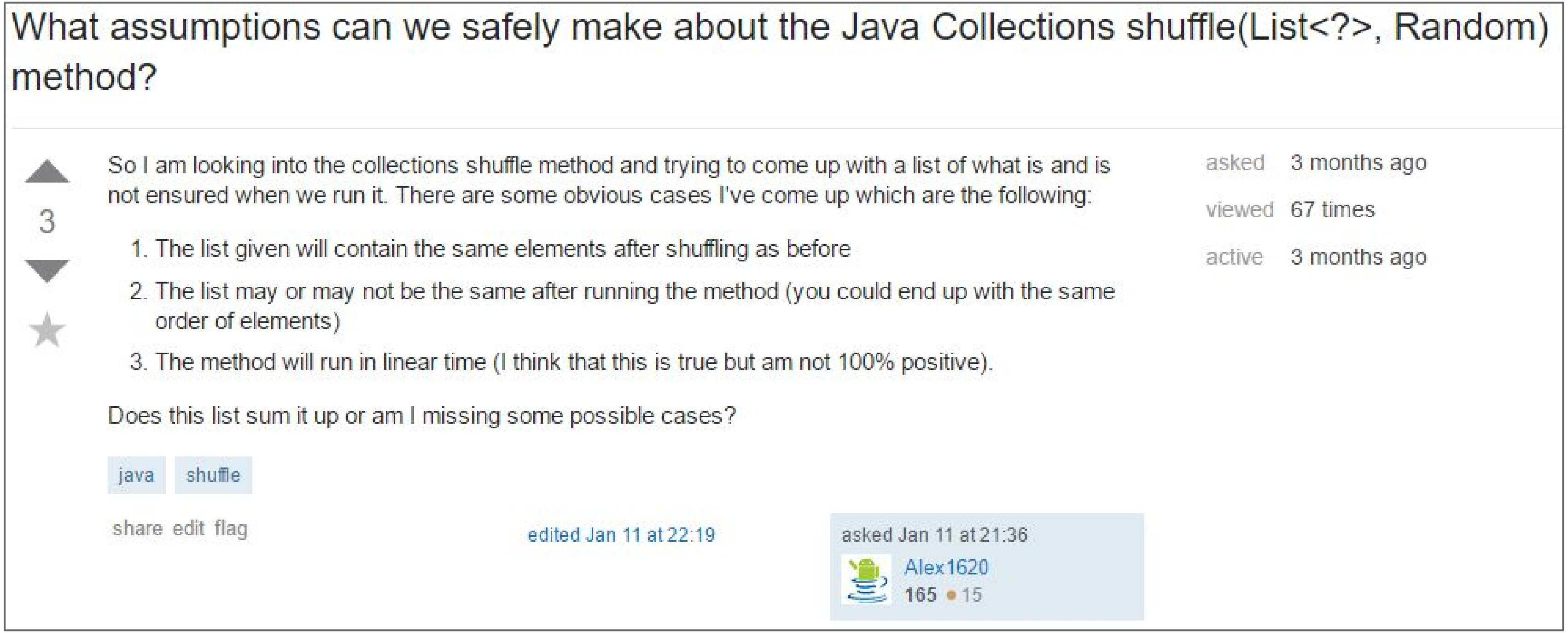
What is the proper JML for the java Scanner.hasNextInt(int) method?

I am using the java.util.Scanner class. I would like to have the JML for the nextInt(int) function. I am mainly concerned with the requires, ensures, assignable, and the signals_only clauses (although more is always better). So what is the JML for this method?

asked Nov 10 '15 at 7:48

May1620 iastate

Our initial ideal question that would be answered



What assumptions can we safely make about the Java Collections shuffle(List<?>, Random) method?

So I am looking into the collections shuffle method and trying to come up with a list of what is and is not ensured when we run it. There are some obvious cases I've come up which are the following:

1. The list given will contain the same elements after shuffling as before
2. The list may or may not be the same after running the method (you could end up with the same order of elements)
3. The method will run in linear time (I think that this is true but am not 100% positive).

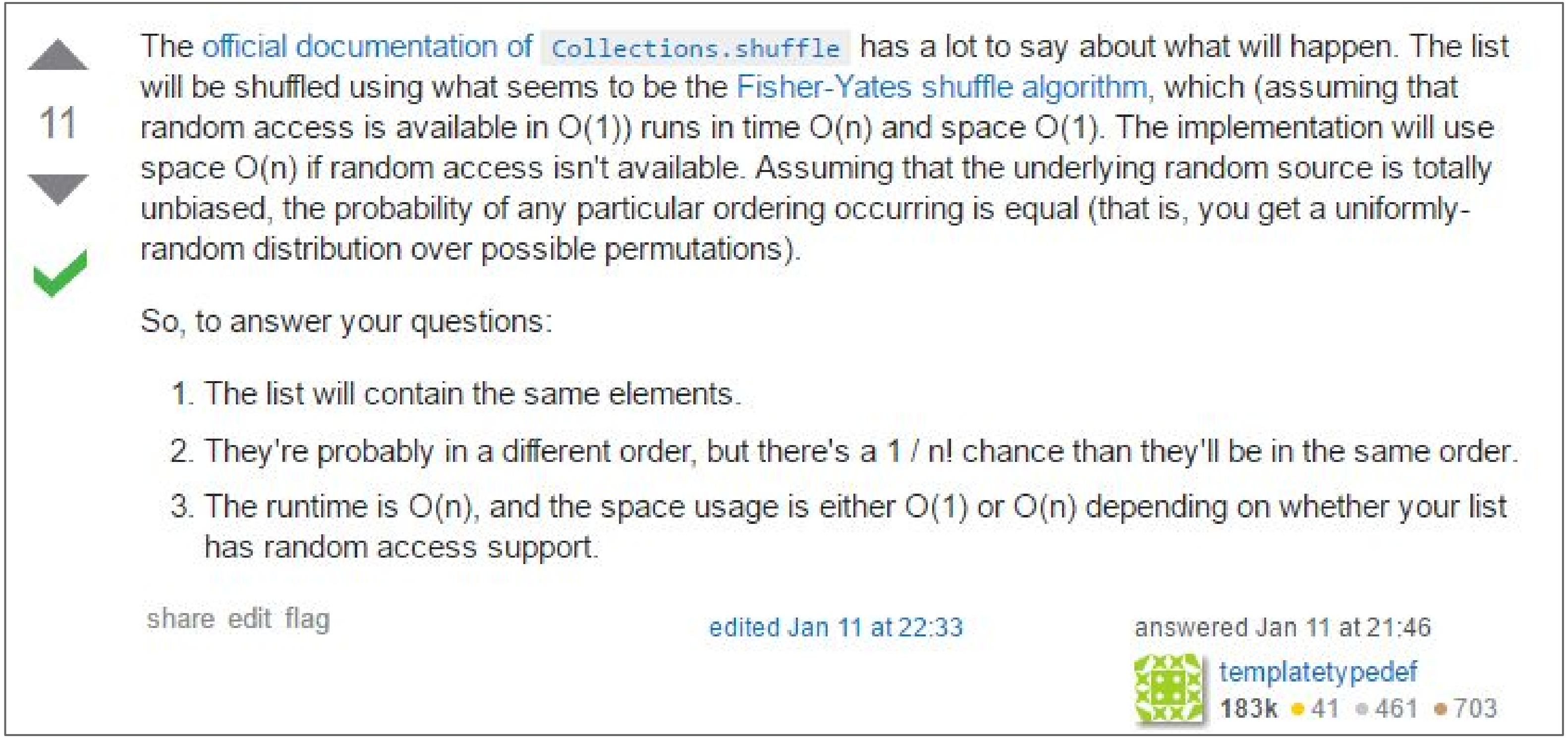
Does this list sum it up or am I missing some possible cases?

edited Jan 11 at 22:19

asked Jan 11 at 21:36
Alex1620
165 ● 15

asked 3 months ago
viewed 67 times
active 3 months ago

Successful question



The official documentation of `Collections.shuffle` has a lot to say about what will happen. The list will be shuffled using what seems to be the Fisher-Yates shuffle algorithm, which (assuming that random access is available in O(1)) runs in time O(n) and space O(1). The implementation will use space O(n) if random access isn't available. Assuming that the underlying random source is totally unbiased, the probability of any particular ordering occurring is equal (that is, you get a uniformly-random distribution over possible permutations).

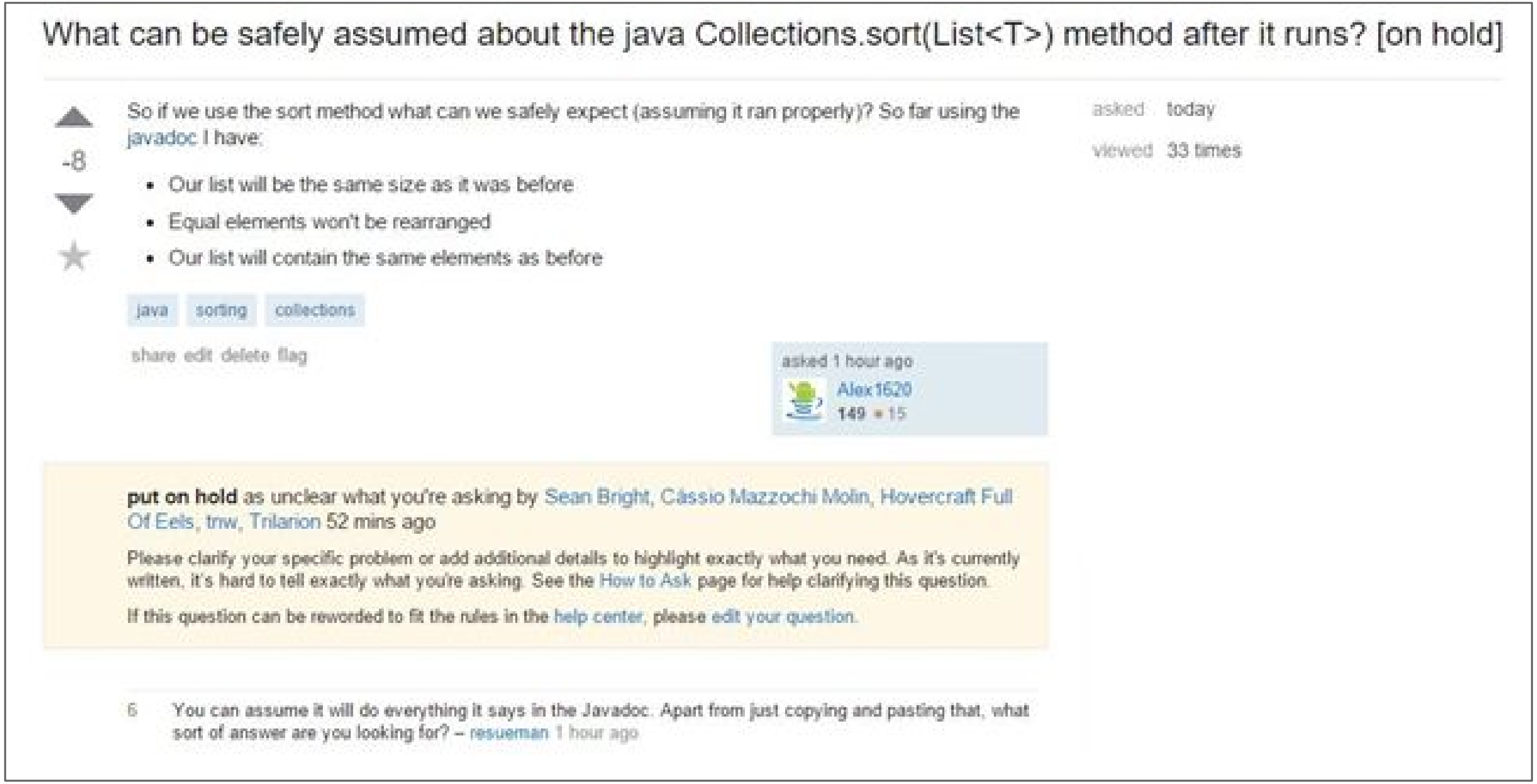
So, to answer your questions:

1. The list will contain the same elements.
2. They're probably in a different order, but there's a 1 / n! chance than they'll be in the same order.
3. The runtime is O(n), and the space usage is either O(1) or O(n) depending on whether your list has random access support.

edited Jan 11 at 22:33

answered Jan 11 at 21:46
templatetypedef
183k ● 41 ● 461 ● 703

Unstructured answer



What can be safely assumed about the java Collections.sort(List<T>) method after it runs? [on hold]

-8

So if we use the sort method what can we safely expect (assuming it ran properly)? So far using the javadoc I have:

- Our list will be the same size as it was before
- Equal elements won't be rearranged
- Our list will contain the same elements as before

asked 1 hour ago

Alex1620

149 • 15

asked today

viewed 33 times

put on hold as unclear what you're asking by Sean Bright, Cássio Mazzochi Molin, Hovercraft Full Of Eels, tnw, Trilarion 52 mins ago

Please clarify your specific problem or add additional details to highlight exactly what you need. As it's currently written, it's hard to tell exactly what you're asking. See the How to Ask page for help clarifying this question.

If this question can be reworded to fit the rules in the help center, please edit your question.

6 You can assume it will do everything it says in the Javadoc. Apart from just copying and pasting that, what sort of answer are you looking for? – resueman 1 hour ago

Typical comment/answer

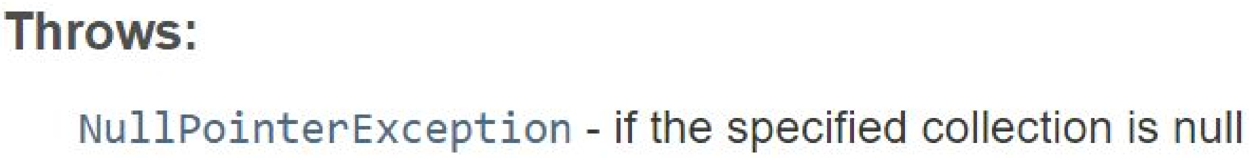
Issues

- The risks we were initially concerned with became real problems
- The lack of JML knowledge forced us to ask more informal questions which were not typically well received
- When questions were answered they typically involved telling us to look at the documentation
- Our StackOverflow account was eventually banned

New Approach

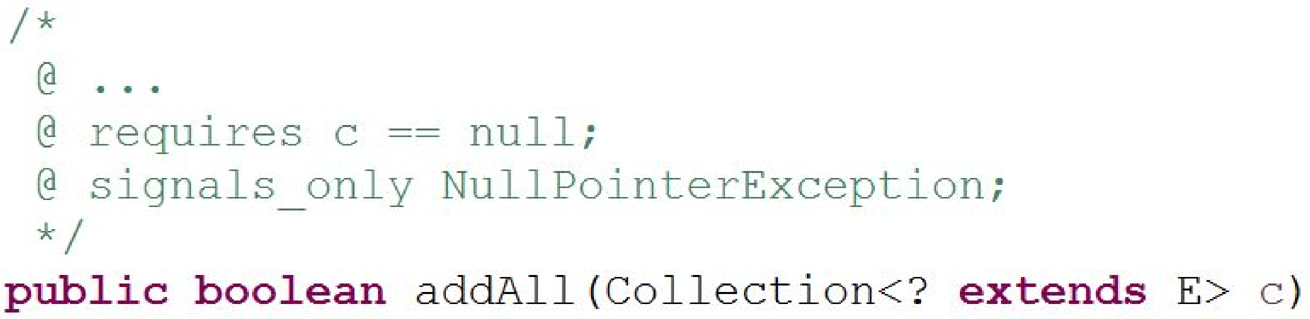
- Use currently existing javadoc to gather informal specifications
    - Javadoc solves the structuring problem
- Generate JML utilizing a natural language processor
- Attempt to handle the most commonly occurring specifications first in order to maximize coverage

Goal for the New Approach



Throws:

`NullPointerException` - if the specified collection is null



```
/*
 @ ...
 @ requires c == null;
 @ signals_only NullPointerException;
 */
public boolean addAll(Collection<? extends E> c)
```

New Risks

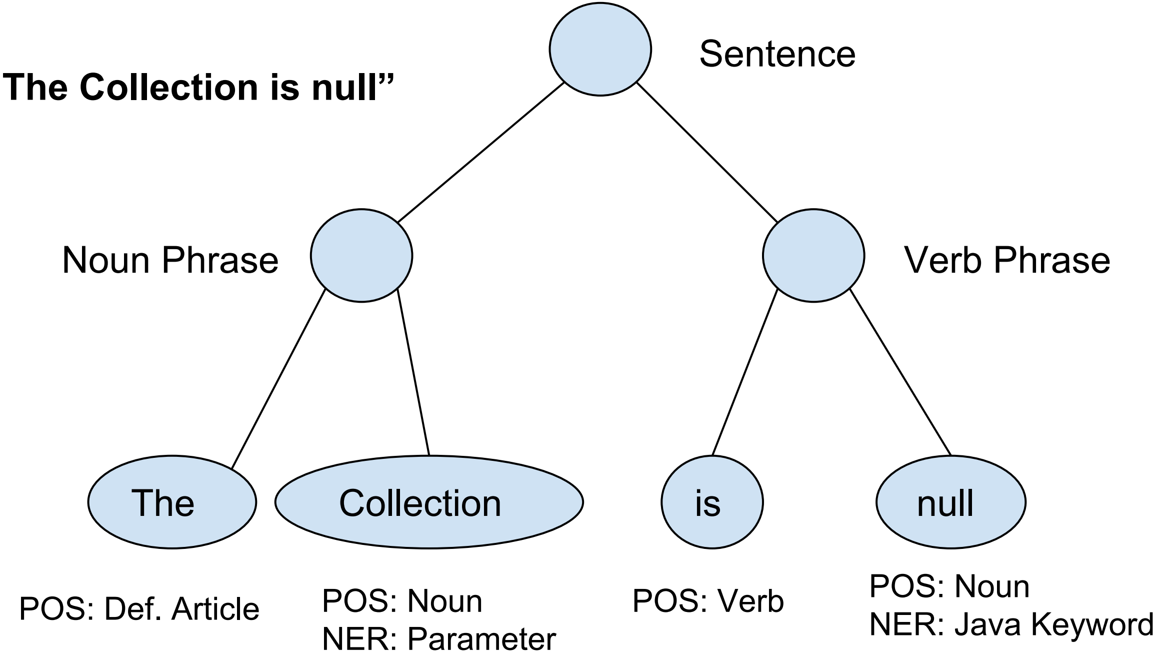
- This is a really difficult problem
- Limited time
- Our group had no prior knowledge of natural language processors
- Javadoc is not written in a consistent manner (helpful for parsing)

StanfordNLP

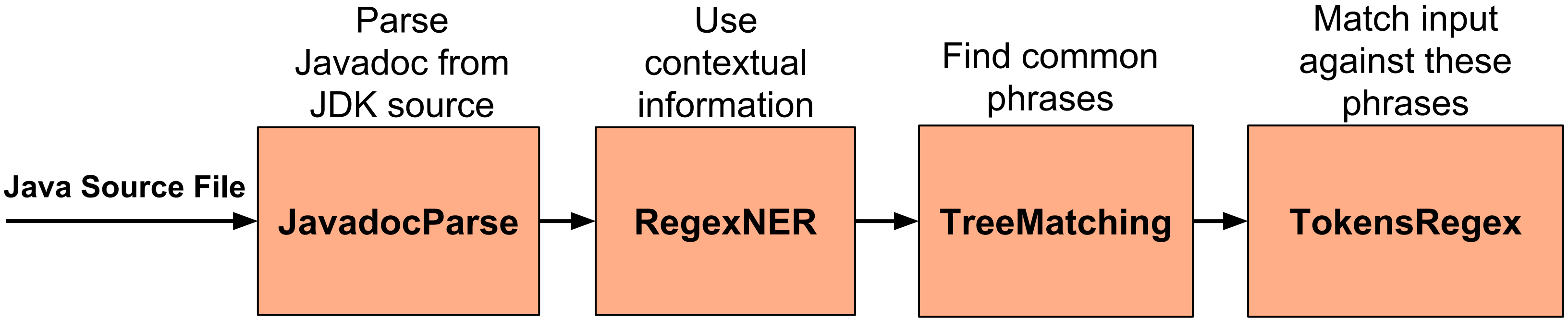
- Powerful many-featured natural language processor built with Java
- Breaks sentences into “tokens” (words) and analyzes based on things such as part of speech
- The analysis results in a parse tree

Example Parse Tree

“The Collection is null”



New System Overview



Parse Javadoc from JDK source

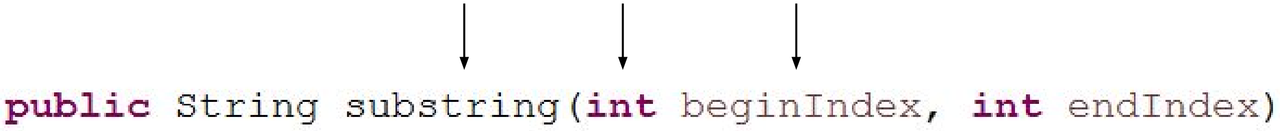
Use contextual information

Find common phrases

Match input against these phrases

RegexNER Stage

- We need a way to use contextual information
  - Method name
  - Method parameter types/names
  - Java keywords
- This stage looks at each word and adds an NER annotation that marks words that relate to the context



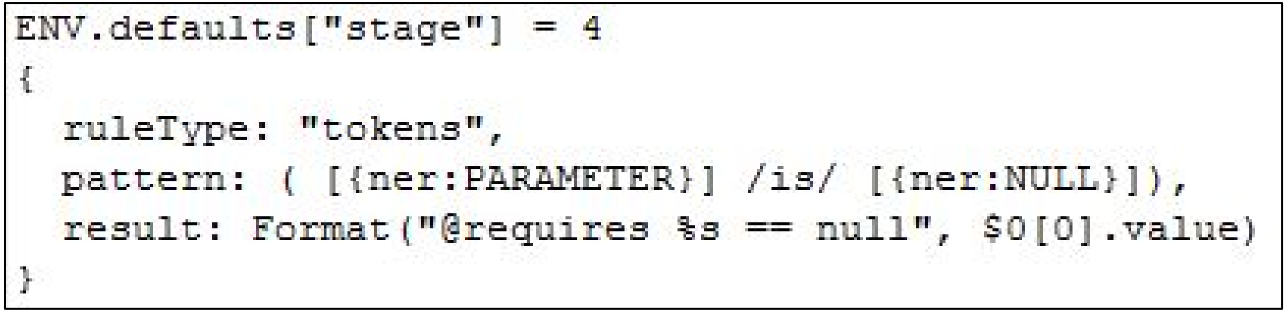
```
public String substring(int beginIndex, int endIndex)
```

TreeMatching Stage

- As seen earlier SNLP creates parse trees
- Processing the entire JDK Javadoc results in similar parse trees (or similar subtrees of parse trees)
- These subtrees represent similar structure of informal specifications
- We find the most common identical subtrees to determine common informal spec patterns

TokensRegex Stage

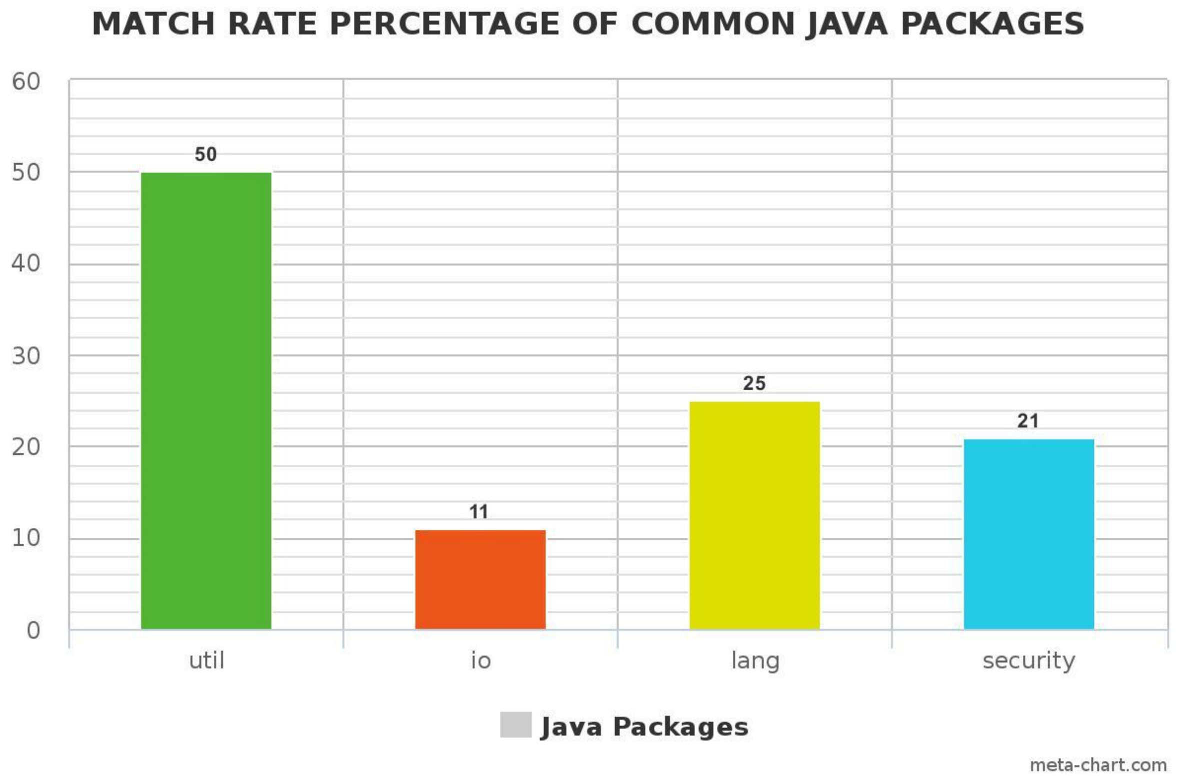
- TokensRegex takes regular expression “rule” files
- These files dictate how informal specifications will be transformed

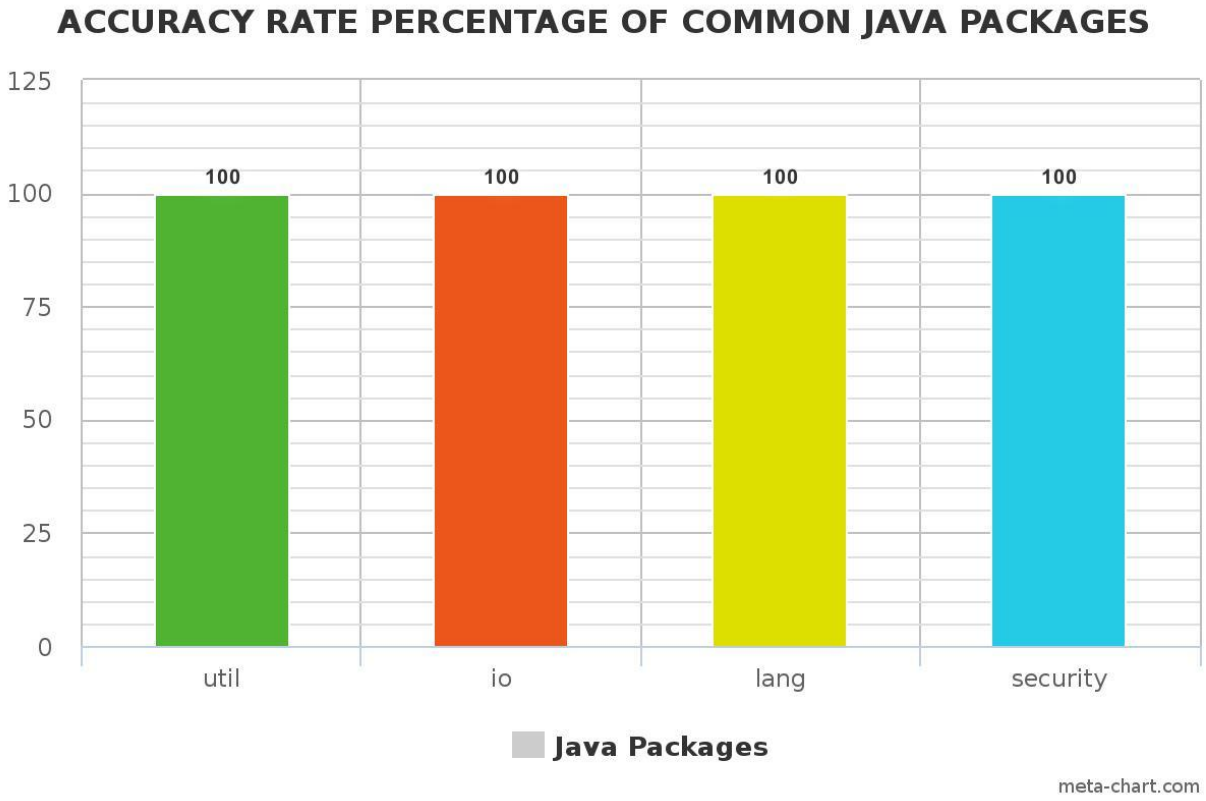


```
ENV.defaults["stage"] = 4
{
  ruleType: "tokens",
  pattern: ( [{ner:PARAMETER}] /is/ [{ner:NULL}]),
  result: Format("@requires %s == null", $0[0].value)
}
```

Result: ‘Throws NullPointerException if collection is null’ -> ‘collection is null’ -> ‘PARAMETER is NULL’ -> ‘@requires c == null; @signals_only NullPointerException;’

Results


MATCH RATE PERCENTAGE OF COMMON JAVA PACKAGES
60
50
40
30
20
10
0
50
11
25
21
util
io
lang
security
Java Packages
meta-chart.com


ACCURACY RATE PERCENTAGE OF COMMON JAVA PACKAGES
125
100
75
50
25
0
100
100
100
100
util
io
lang
security
Java Packages
meta-chart.com

Examples

IndexOutOfBoundsException - if an endpoint index value is out of range (fromIndex < 0 || toIndex > size)

@requires fromIndex < 0;
@signals_only IndexOutOfBoundsException;

ArithmeticException - if **val** is zero.

@requires val == 0;
@signals_only NumberFormatException;

Closing Remarks

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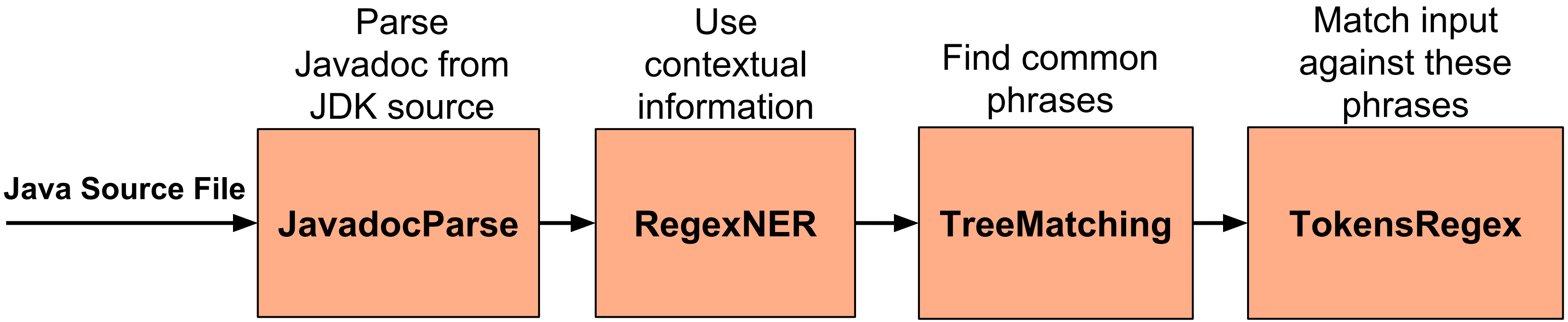
Project Website: http://may1620.github.io/



Java Source File

Parse Javadoc from JDK source

JavadocParse

Use contextual information

RegexNER

Find common phrases

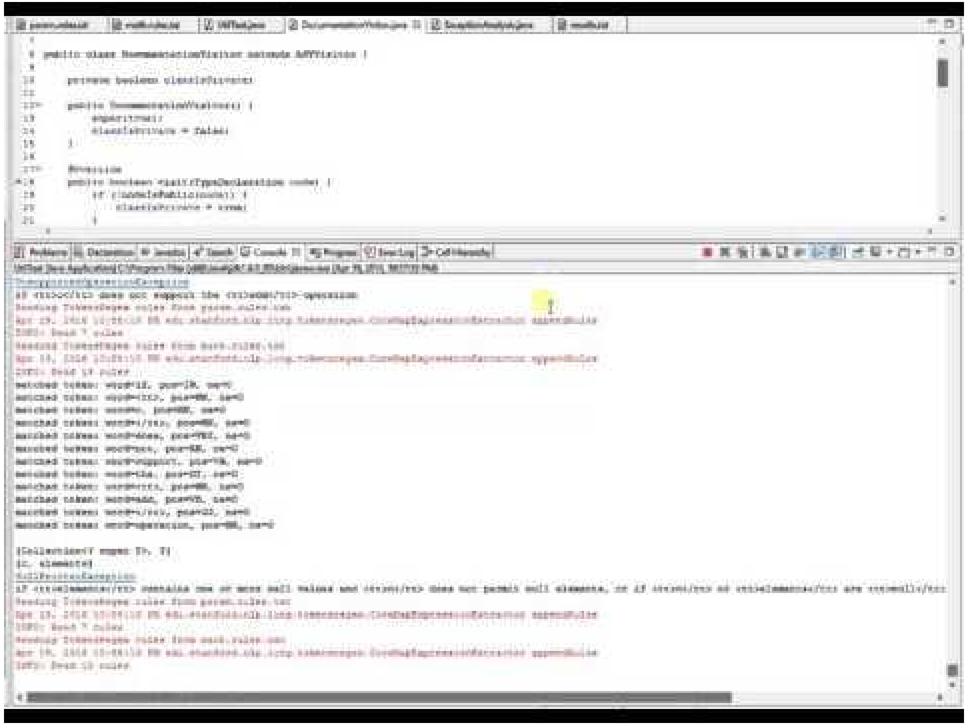
TreeMatching

Match input against these phrases

TokensRegex

In Action

Analysis run on the Java util package



```
public class DocumentationVisitor extends ASTVisitor {

    private boolean classIsPrivate;

    public DocumentationVisitor() {
        super(true);
        classIsPrivate = false;
    }

    @Override
    public boolean visit(TypeDeclaration node) {
        if (!isNodePublic(node)) {
            classIsPrivate = true;
        }
```

```
UnsupportedOperationException
if <tt>c</tt> does not support the <tt>add</tt> operation
Reading TokensRegex rules from param.rules.txt
Apr 19, 2016 [illegible] PM edu.stanford.nlp.ling.tokensregex.CoreMapExpressionExtractor appendRules
INFO: Read 7 rules
Reading TokensRegex rules from mark.rules.txt
Apr 19, 2016 [illegible] PM edu.stanford.nlp.ling.tokensregex.CoreMapExpressionExtractor appendRules
INFO: Read 13 rules
matched token: word=if, pos=IN, ne=O
matched token: word=<tt>, pos=NN, ne=O
matched token: word=c, pos=NN, ne=O
matched token: word=</tt>, pos=NN, ne=O
matched token: word=does, pos=VBZ, ne=O
matched token: word=not, pos=RB, ne=O
matched token: word=support, pos=VB, ne=O
matched token: word=the, pos=DT, ne=O
matched token: word=<tt>, pos=NN, ne=O
matched token: word=add, pos=VB, ne=O
matched token: word=</tt>, pos=JJ, ne=O
matched token: word=operation, pos=NN, ne=O

[Collection<? super T>, T]
[c, elements]
NullPointerException
if <tt>elements</tt> contains one or more null values and <tt>c</tt> does not permit null elements, or if <tt>c</tt> or <tt>elements</tt> are <tt>null</tt>
Reading TokensRegex rules from param.rules.txt
Apr 19, 2016 [illegible] PM edu.stanford.nlp.ling.tokensregex.CoreMapExpressionExtractor appendRules
INFO: Read 7 rules
Reading TokensRegex rules from mark.rules.txt
Apr 19, 2016 [illegible] PM edu.stanford.nlp.ling.tokensregex.CoreMapExpressionExtractor appendRules
INFO: Read 13 rules
```