Why are program analysis tools difficult to understand?

A tool (mis)communication theory and adaptive approach for supporting developers during tool use

Brittany Johnson

NC State University
bijohnso@ncsu.edu

Abstract.

Table of Contents

1 Introduction

If program analysis *tool use* is a form of *communication* and *inability to resolve* notifications is *miscommunication*, tools can adopt a theory similar to *constructivism* where tools can *approximate* individual developer's *conceptual knowledge* to adapt notifications, leading to *reduced time and effort* required for developers to understand and resolve tool notifications.

2 Research Significance

2.1 What are program analysis tools?

Program analysis tools are tools designed to aide developers when developing software by automating the writing, analysis, and modification of source code. Often, program analysis is discussed as synonymous with static analysis [?]. For the purpose of my research, I define a program analysis tool as a tool that performs program analysis, whether it be static or dynamic analysis. Examples of program analysis tools include, but are not limited to, static code analyzers, code coverage tools, code smell detectors, and refactoring tools [?,?,?]. In the following sections, I will define and discuss static analysis and dynamic analysis tools separately; the reader should note that although we discuss static and dynamic analysis separately, it is not uncommon to find program analysis tools that combine static and dynamic analysis [?].

Static Analysis Tools Static analysis tools are designed to aide developers when developing software by statically analyzing source code, pre-runtime, and providing the developer with feedback about the state of their code [?]. Typically, static analysis works by examining the current state of the program and then predicting and reporting how the program may react in that state at runtime. Static analyses are often more conservative than dynamic analyses; this is to reduce the potential for false positives, as in most cases static analysis cannot say with 100% certainty what will happen during run-time. Examples of static analysis tools include defect detectors, such as FindBugs, compilers, code smell detectors, and refactoring tools.

Let's use the example of FindBugs [1], an open source static analysis tool, to better understand how static analysis tools work. FindBugs statically analyzes code to report potential defects. FindBugs determines the potential for defects using *bug patterns*

Dynamic Analysis Tools Dynamic analysis tools are designed to aide developers when developing software by analyzing source code during run-time and providing the developer with feedback about runtime behavior [?]. Dynamic analysis works by executing the program and then making observations about

[1] http://findbugs.sourceforge.net/factSheet.html

program execution; because dynamic analysis runs the code, it is typically more precise than static analysis. Though dynamic analysis can produce more precise results in a similar amount of time as static analysis, dynamic analysis is less likely to generalize to future executions. Examples of dynamic analysis tools include testing, code coverage, and profiling tools.

Let's use the example of EclEmma, an open source dynamic test and code coverage tool, to better understand how dynamic analysis tools work.

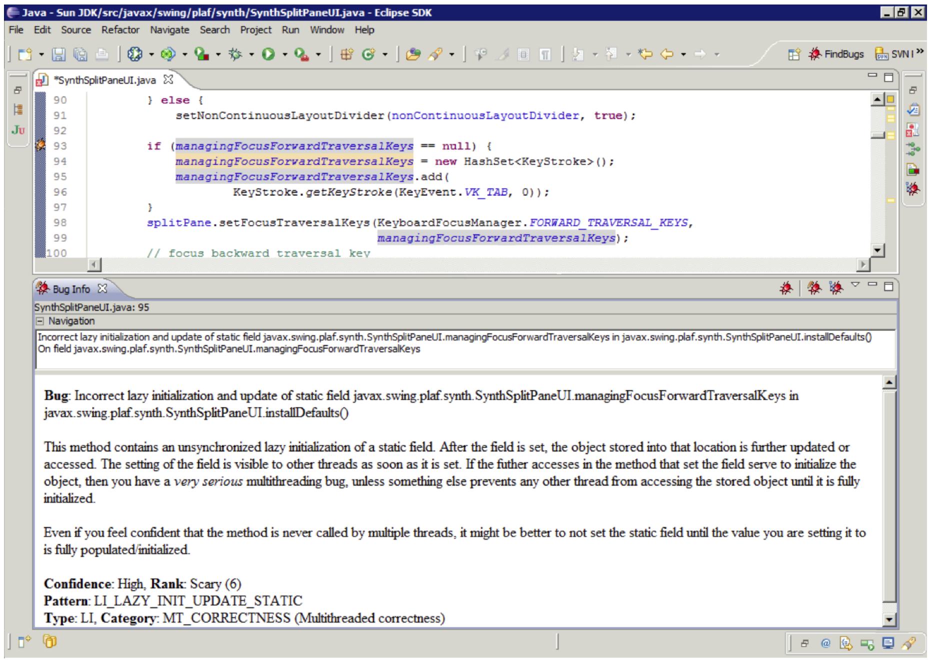
2.2 How do they communicate?

2.3 What do they communicate about?

2.4 How does tool communication relate to verbal communication?

2.5 Why don't developers use program analysis tools?

Motivating Example


Java - Sun JDK/src/javax/swing/plaf/synth/SynthSplitPaneUI.java - Eclipse SDK
File Edit Source Refactor Navigate Search Project Run Window Help
FindBugs
SVN I
*SynthSplitPaneUI.java
Bug Info

```
            } else {
                setNonContinuousLayoutDivider(nonContinuousLayoutDivider, true);

            if (managingFocusForwardTraversalKeys == null) {
                managingFocusForwardTraversalKeys = new HashSet<KeyStroke>();
                managingFocusForwardTraversalKeys.add(
                        KeyStroke.getKeyStroke(KeyEvent.VK_TAB, 0));
            }
            splitPane.setFocusTraversalKeys(KeyboardFocusManager.FORWARD_TRAVERSAL_KEYS,
                                            managingFocusForwardTraversalKeys);
            // focus backward traversal key
```

SynthSplitPaneUI.java: 95

Navigation

Incorrect lazy initialization and update of static field javax.swing.plaf.synth.SynthSplitPaneUI.managingFocusForwardTraversalKeys in javax.swing.plaf.synth.SynthSplitPaneUI.installDefaults()
On field javax.swing.plaf.synth.SynthSplitPaneUI.managingFocusForwardTraversalKeys

Bug: Incorrect lazy initialization and update of static field javax.swing.plaf.synth.SynthSplitPaneUI.managingFocusForwardTraversalKeys in javax.swing.plaf.synth.SynthSplitPaneUI.installDefaults()

This method contains an unsynchronized lazy initialization of a static field. After the field is set, the object stored into that location is further updated or accessed. The setting of the field is visible to other threads as soon as it is set. If the futher accesses in the method that set the field serve to initialize the object, then you have a *very serious* multithreading bug, unless something else prevents any other thread from accessing the stored object until it is fully initialized.

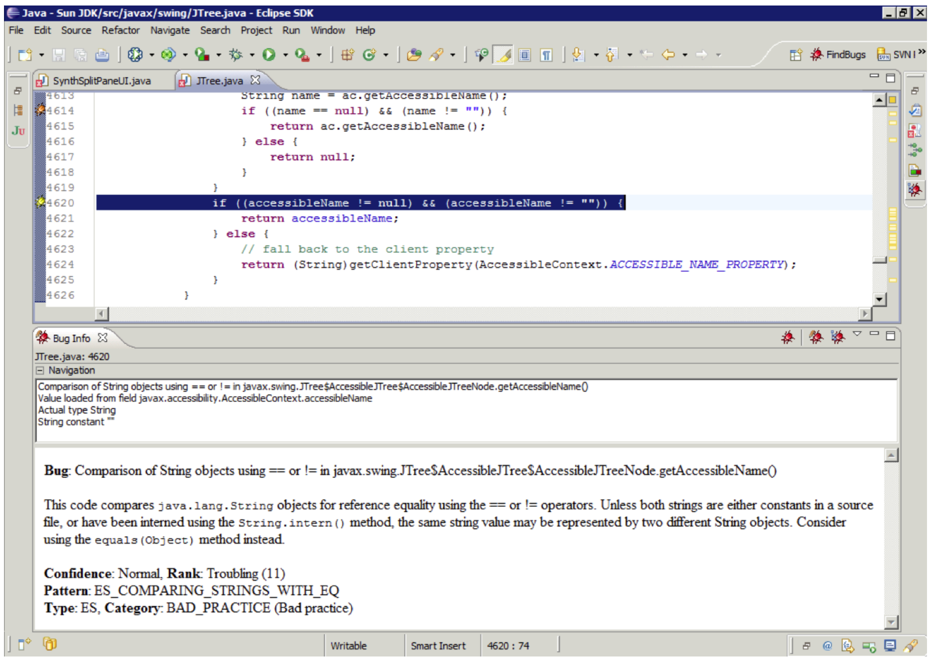
Even if you feel confident that the method is never called by multiple threads, it might be better to not set the static field until the value you are setting it to is fully populated/initialized.

Confidence: High, **Rank**: Scary (6)
Pattern: LI_LAZY_INIT_UPDATE_STATIC
Type: LI, **Category**: MT_CORRECTNESS (Multithreaded correctness)

Fig. 1. Findbugs notification in the Eclipse IDE concerning multi-threading.

Valerie is a software developer at a start-up company. She primarily writes Java code, though she did not learn to program in Java, and uses the Eclipse Integrated Development Environment (IDE). In her spare time, she builds her knowledge of Java programming concepts by contributing to open source software and using tools that provide feedback about the code she writes. While modifying code in the Sun JDK source code repository, she contributes code that results in the notification shown in Figure 1. She has experience using FindBugs, so she is familiar with some of the ways FindBugs communicates. For example, she knows that an orange bug icon indicates a *scary* bug and that by clicking the bug icon she can gain access to more information about the bug.

As she explores the information provided by FindBugs, she realizes that despite her experience with FindBugs, she is having difficulty determining how to resolve the notification. She first attempts to use what knowledge she does have regarding multi-threading, which she accrued from struggling with and resolving compiler synchronization warnings, to better understand the problem. However, she is unfamiliar with the concept central to the notification in Figure 1 (lazy initialization). Though the notification tells her that the problem relates to multi-threading, she is unable to make a connection between her knowledge regarding multi-threading and the message FindBugs is attempting to communicate and therefore cannot resolve the notification without outside help. As done previously with compiler synchronization notifications, she toggles between the web and her IDE to understand and resolve the notification.


Java - Sun JDK/src/javax/swing/JTree.java - Eclipse SDK
File Edit Source Refactor Navigate Search Project Run Window Help
FindBugs
SVN I
SynthSplitPaneUI.java
JTree.java
Bug Info
Navigation
Writable
Smart Insert
4620 : 74

```
4613                    String name = ac.getAccessibleName();
4614                    if ((name == null) && (name != "")) {
4615                        return ac.getAccessibleName();
4616                    } else {
4617                        return null;
4618                    }
4619                }
4620                if ((accessibleName != null) && (accessibleName != "")) {
4621                    return accessibleName;
4622                } else {
4623                    // fall back to the client property
4624                    return (String)getClientProperty(AccessibleContext.ACCESSIBLE_NAME_PROPERTY);
4625                }
4626            }
```

JTree.java: 4620

Comparison of String objects using == or != in javax.swing.JTree$AccessibleJTree$AccessibleJTreeNode.getAccessibleName()
Value loaded from field javax.accessibility.AccessibleContext.accessibleName
Actual type String
String constant ""

Bug: Comparison of String objects using == or != in javax.swing.JTree$AccessibleJTree$AccessibleJTreeNode.getAccessibleName()

This code compares `java.lang.String` objects for reference equality using the == or != operators. Unless both strings are either constants in a source file, or have been interned using the `String.intern()` method, the same string value may be represented by two different String objects. Consider using the `equals(Object)` method instead.

Confidence: Normal, **Rank**: Troubling (11)
Pattern: ES_COMPARING_STRINGS_WITH_EQ
Type: ES, **Category**: BAD_PRACTICE (Bad practice)

Fig. 2. Findbugs notification in the Eclipse IDE on checking string equality.

One goal developers have when using tools like FindBugs is to find and resolve defects, which requires the ability to interpret the notifications provided by the tools. Valerie's secondary goal when using tools was to learn more about Java programming concepts. She found, however, that some notifications are better at communicating problems while contributing to knowledge than others. For example, when first learning how to work with strings in Java, Valerie encountered the notification in Figure 2. The first time she encountered the problem she was able to understand and resolve the notification. Looking back, she realizes this is because the notification in Figure 2 filled in gaps in her own knowledge of the concept by informing her *why* what she was doing was wrong and *how* she can fix it.

Because the tools Valerie uses have no notion of with what she does and does not know, some notifications are able to communicate effectively, while others run the risk of a miscommunication. Based on the challenges developers may encounter, like the ones Valerie encountered, I propose a tool miscommunication theory that can be used to inform the design of developer tools, such as FindBugs.

3 A Tool Miscommunication Theory

4 An Approach for Modeling Developer Knowledge

4.1 Using Concept Inventories to Assess Concept Knowledge

4.2 Using Public Git Repositories to Predict Concept Knowledge

5 A Proposed Approach for Notification Adaptation

6 Experiments & Evaluations

7 Related Work

8 Project Plan

Acknowledgments

References

Clarke, F., Ekeland, I.: Nonlinear oscillations and boundary-value problems for Hamiltonian systems. Arch. Rat. Mech. Anal. 78, 315–333 (1982)