New Frontiers of Mining Software Repositories
Usability and **Information Delivery**

Miryung Kim
University of California, Los Angeles

UCLA

Why software **specification inference**?

focus cooperative and human aspects of SE

What Makes APIs Hard to Learn? Answers from Developers

Martin P. Robillard, *McGill University*

A study of obstacles that professional Microsoft developers faced when learning to use APIs uncovered challenges and

Most software projects reuse components exposed through APIs. In fact, current-day software development technologies are becoming inseparable from the large APIs they provide. To name two prominent examples, both the Java Software Development Kit and the .NET framework ship with APIs comprising thousands of classes supporting tasks that range from reading files to managing complex process workflows.

An API is the interface to implemented func- and interviewing developers about the obstacles

Response categories for API learning obstacles

Main category	Subcategories/descriptions		Associated respondents
Resources	Obstacles caused by inadequate or absent resources for learning the API (for example, documentation)		50
	Examples	Insufficient or inadequate examples	20
	General	Unspecified issues with the documentation	14
	Content	A specific piece of content is missing or inadequately presented in the documentation (for example, information about all exceptions raised)	12
	Task	No reference on how to use the API to accomplish a specific task	9
	Format	Resources aren't available in the desired format	8
	Design	Insufficient or inadequate documentation on the high-level aspects of the API such as design or rationale	8
Structure	Obstacles related to the structure or design of the API		36
	Design	Issues with the API's structural design	20
	Testing and debugging	Issues related to the API's testing, debugging, and runtime behavior	10
Background	Obstacles caused by the respondent's background and prior experience		17
Technical environment	Obstacles caused by the technical environment in which the API is used (for example, heterogeneous system, hardware)		15
Process	Obstacles related to process issues (for example, time, interruptions)		13

What Makes APIs Hard to Learn? Answers from Developers, Robillard 2009

Learning Barriers for Developers

Six Learning Barriers in End-User Programming Systems

Andrew J. Ko, Brad A. Myers, and Htet Htet Aung
Human-Computer Interaction Institute
Carnegie Mellon University, Pittsburgh, PA 15213 USA
ajko@cmu.edu, bam+@cs.cmu.edu, hha@cs.cmu.edu

Abstract

As programming skills increase in demand and utility, the learnability of end-user programming systems is of utmost importance. However, research on learning barriers in programming systems has primarily focused on languages, overlooking potential barriers in the environment and accompanying libraries. To address this, a study of beginning programmers learning Visual Basic.NET was

2. Prior Research on Learning Barriers

One way to understand learning barriers is to study the learner. For example, imagine Jill, a user interface designer who just began learning VB. Shortly after starting, she realizes that she must learn about event handlers to proceed. This poses a potential learning barrier. From an attention-investment perspective [2], she will weigh the cost, risk, and reward of overcoming the barrier, and if the risk of failure outweighs the

Six Learning Barriers for Developers

Barrier Type	
Design	I don't know what I want the computer to do…
Selection	I think I know what I want the computer to do but I don't know what to use
Coordination	I think I know what things to use but I don't know how to make them work together…
Use	I think I know what to use, but I don't know how to use it...
Understanding	I thought I knew how to use this but it didn't do what I expected…
Information	I think I know why it didn't do what I expected but I don't know how to check

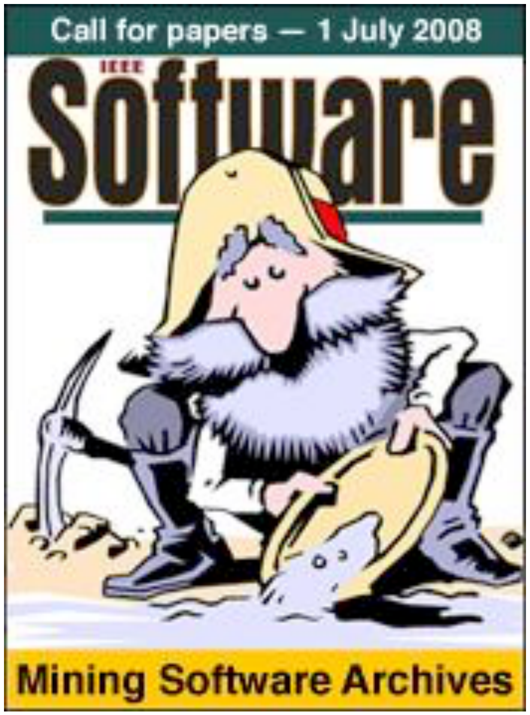
Six Learning Barriers in End-User Programming Systems, Ko et al. 2004

Six Learning Barriers for Developers

Barrier Type	
Design	I don't know what I want the computer to do…
Selection	I think I know what I want the computer to do but I don't know what to use
Coordination	I think I know what things to use but I don't know how to make them work together…
Use	I think I know what to use, but I don't know how to use it…
Understanding	I thought I knew how to use this but it didn't do what I expected…
Information	I think I know why it didn't do what I expected but I don't know how to check

Six Learning Barriers in End-User Programming Systems, Ko et al. 2004

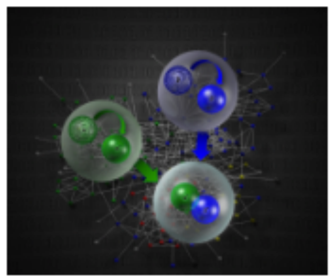
Rise of Mining Big Code



May 5, 2014

DARPA Launches 'Big Code' Initiative

George Leopold



The U.S. Defense Advanced Research Projects Agency is attempting to take big data analytics to the next level through a "big code" project designed to improve overall software reliability through a large-scale repository of software that drives big data.

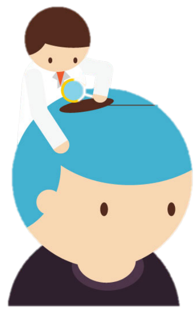
The DARPA "big code" initiative, formally known as Mining and Understanding Software Enclaves, or MUSE, seeks to leverage software analysis and big data analytics to improve the way software is built, debugged and verified.

DARPA

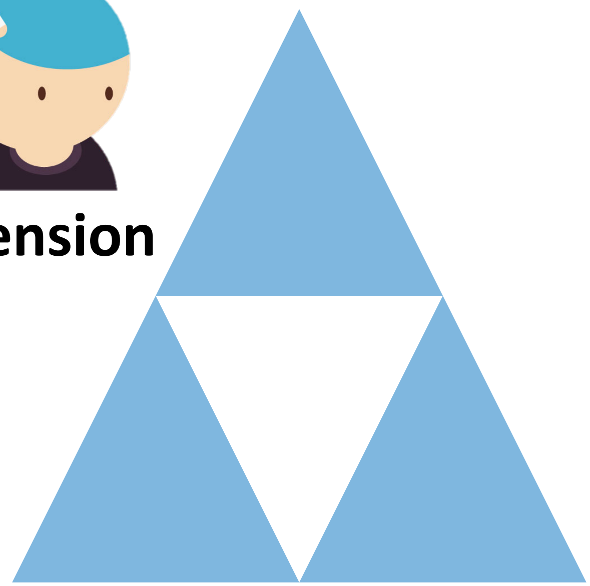
GitHub

Big Code Learning from "Big Code"

Information Delivery and Usability



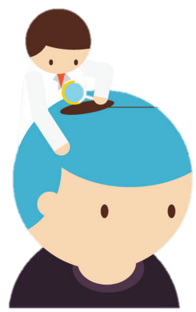
1. Comprehension



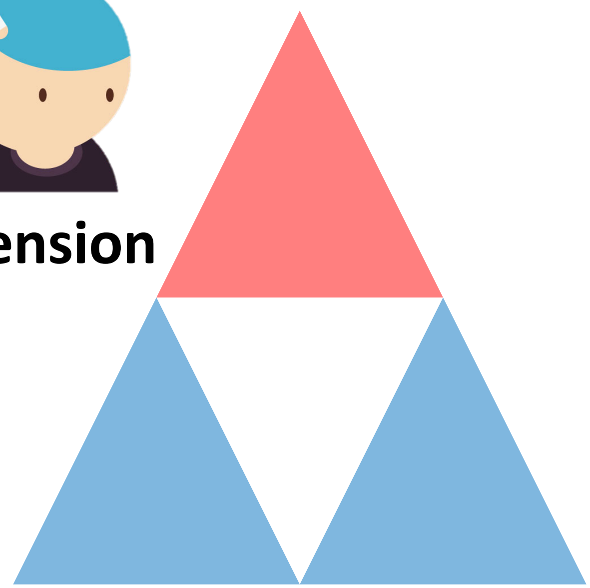
2. Interactive Navigation

3. Fit Developer Workflow

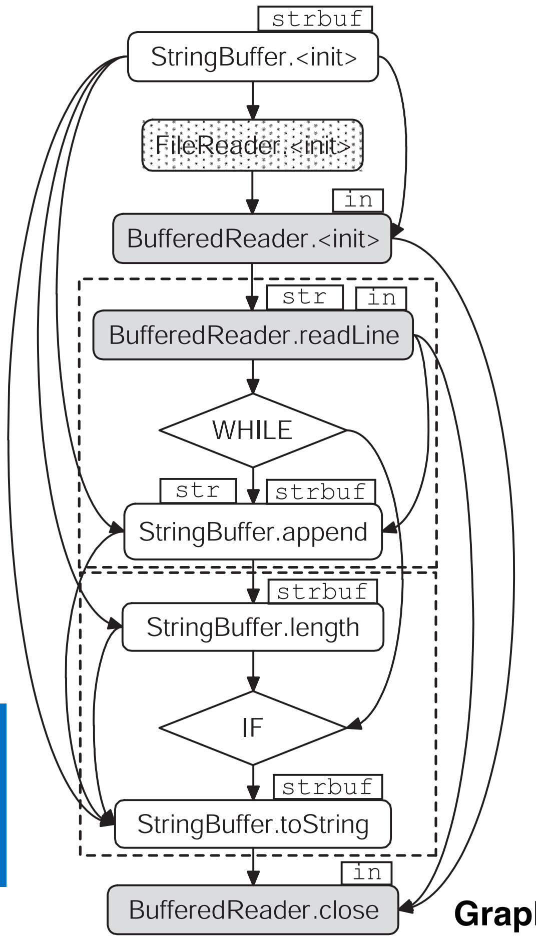
Information Delivery and Usability



1. Comprehension



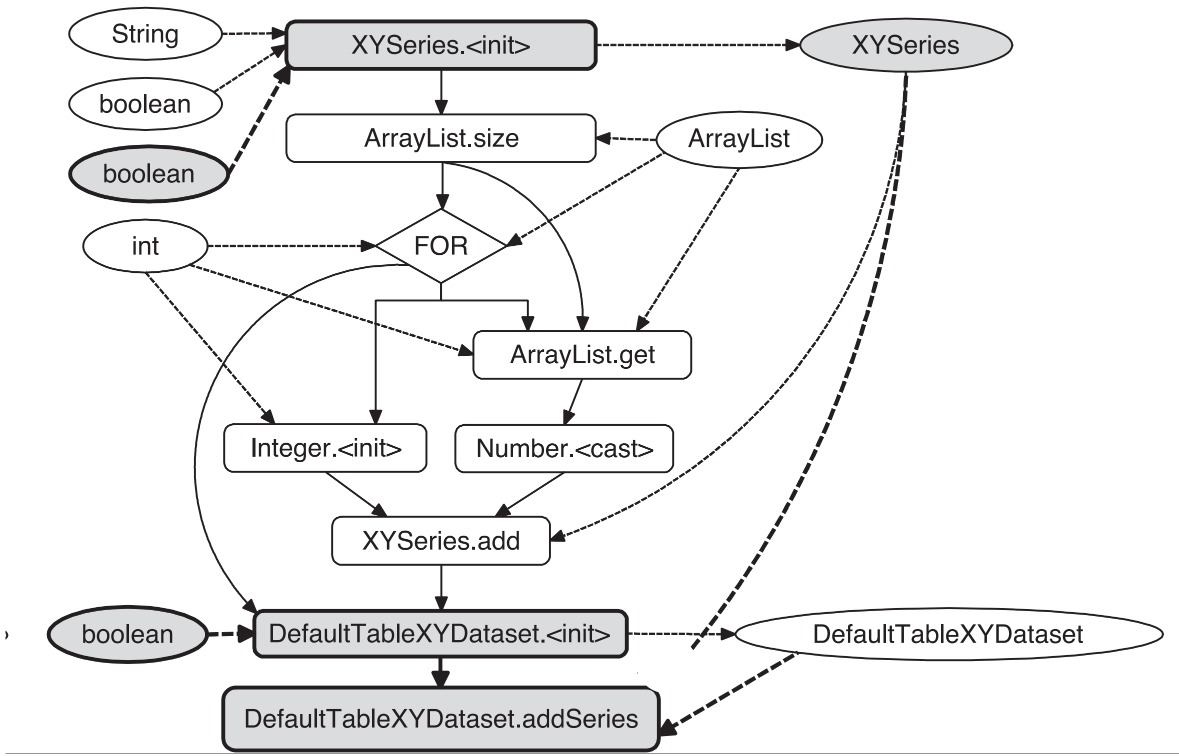
Not Easy to Comprehend



API Usage Graph

Graph-based Mining of Multiple Object Usage Patterns, Nguyen et al. 2009

Not Easy to Comprehend



A Graph-based Approach to API Usage Adaptation, Nguyen et al. 2010

API Usage Graph

What Makes a Good Code Example?

- “It shouldn’t model something extremely **specific**”
- “It must be able to show **multiple uses**.”
- “a good example is easy to **understand** and read.”
- “**less irrelevant**, unrelated stuff in the example is better”
- “clear **naming** of variables”

Synthesizing API Usage Examples, Buse and Weimer 2012

What Makes a Good Code Example?

- “It shouldn’t model something extremely **specific**”
- “It must be able to show **multiple uses**.”
- “a good example is easy to **understand** and read.”
- “**less irrelevant**, unrelated stuff in the example is better”
- “clear **naming** of variables”

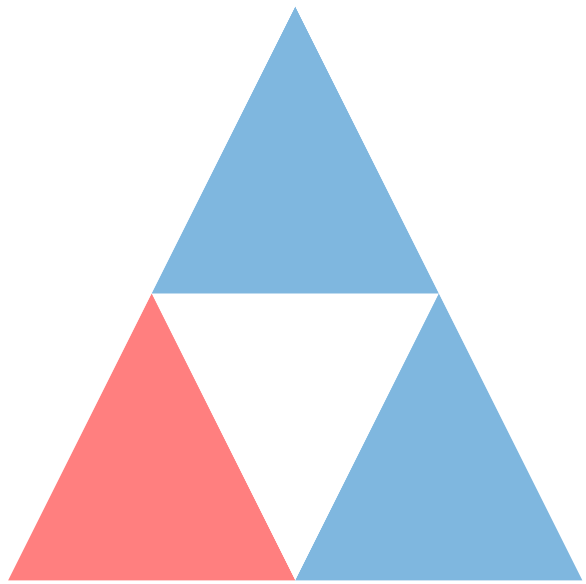
```
BufferedInputStream b;//initialized previousl
ObjectInputStream stream =
    new ObjectInputStream(b);
try {
  Object o = stream.readObject();
  //Do something with o
} catch(IOException e) {
} finally {
  stream.close();
}
```

Synthesized Code Example

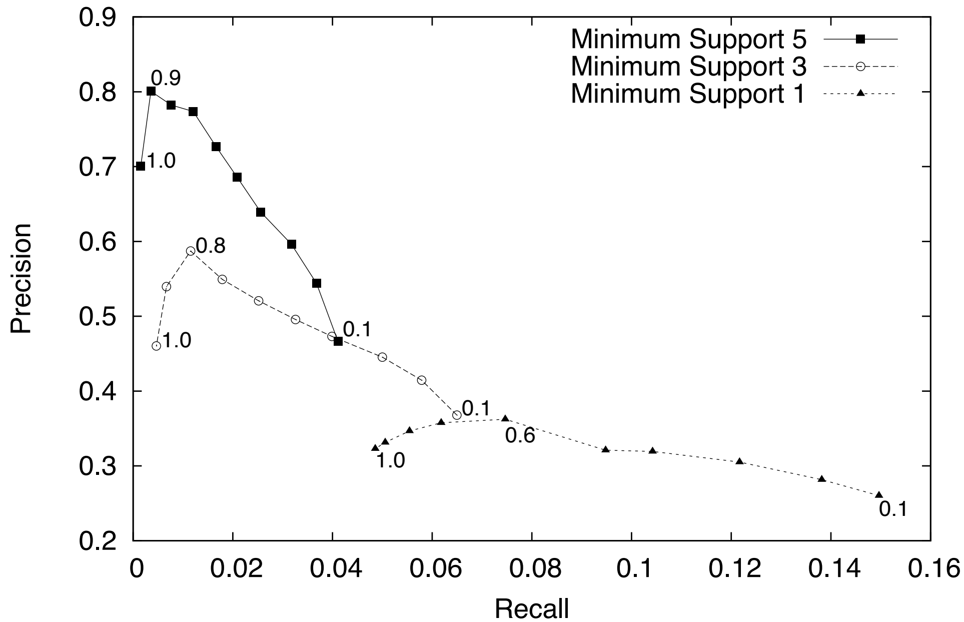
Synthesizing API Usage Examples, Buse and Weimer 2012

Information Delivery and Usability

2. Interactive Navigation



Precision and Recall are Not Enough

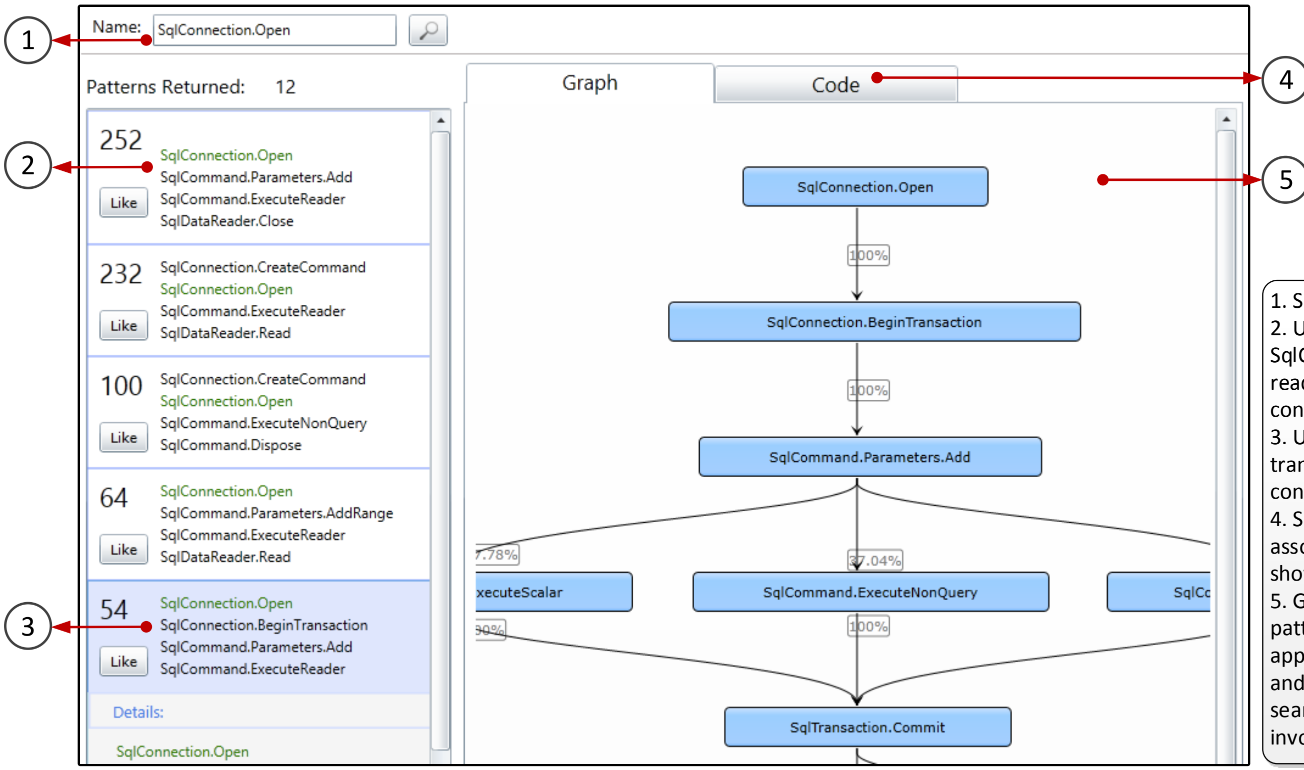


Mining Version Histories to Guide Software Changes, Zimmermann et al. 2004

Setting	Precision (%)	Recall (%)	Rank
	Top 5	Top 5	
k = 1	80	91	3
k = 2	79	92	4
k = 3	80	91	4
k = ∞	74	91	4
No Slicing	65	81	9

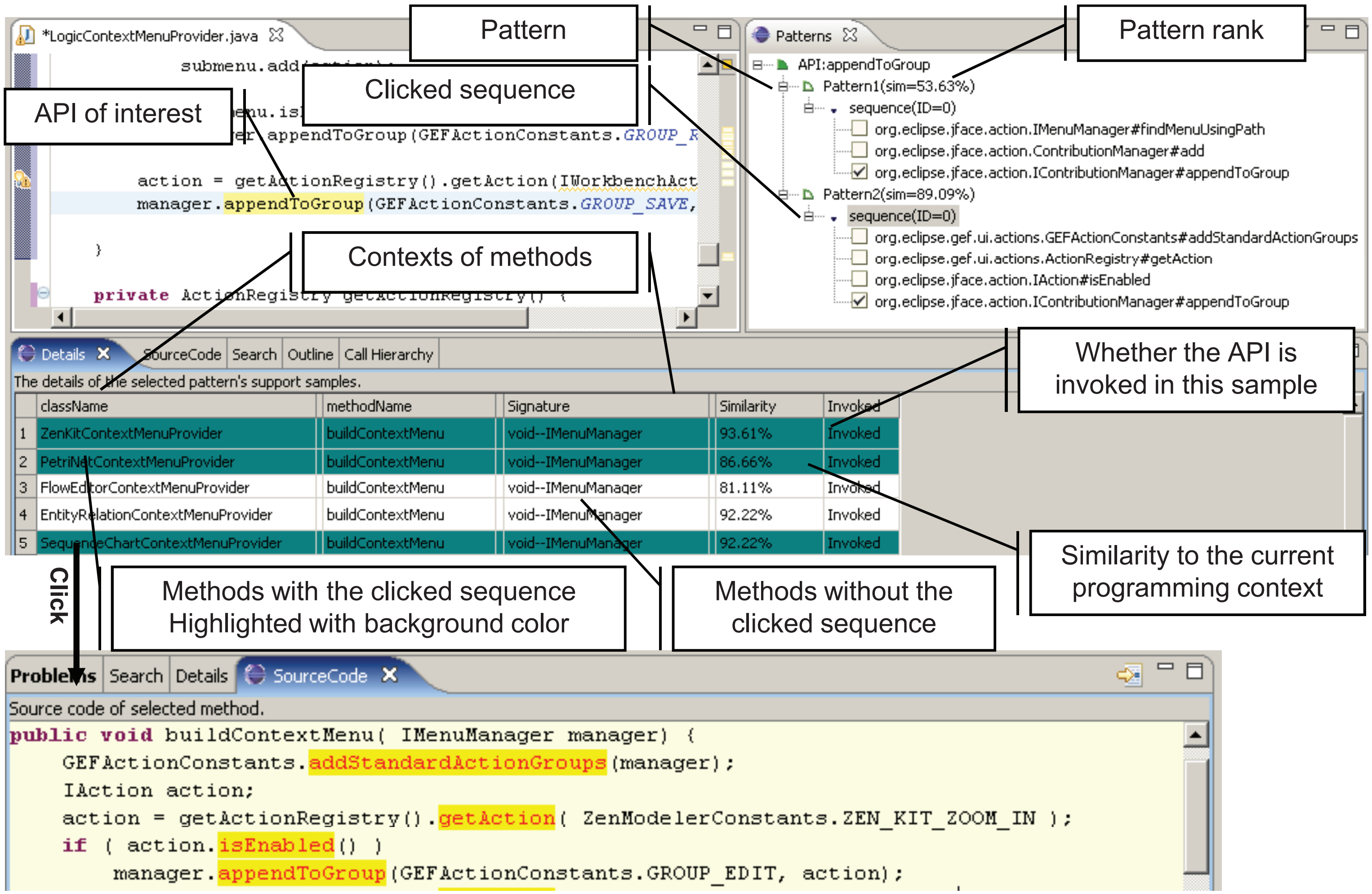
Are Code Examples on an Online Q&A Forum Reliable? Zhang et al. 2018

Not Easy to Navigate and Compare



1. Search box;
2. Usage pattern 1 for SqlConnection.Open: conducting a simple reading operation after opening a Sql connection;
3. Usage pattern 5: conducting a transaction operation after opening a Sql connection;
4. Sample code Tab: showed code snippets associated with the selected usage pattern shown in the left panel;
5. Graphical representation of usage pattern: aggregated view of API calls that appears before calling the searched API and API calls that appear after calling the searched API with probability of invocation relationship.

Mining Succinct and High-Coverage API Usage Patterns from Source Code, Wang et al. 2013



MAPO: Mining and Recommending API Usage Patterns, Zhong et al. 2009

Why Don't Software Developers Use Static Analysis Tools to Find Bugs?

Brittany Johnson, Yoonki Song, and Emerson Murphy-Hill
North Carolina State University
Raleigh, NC, U.S.A.
bijohnso,ysong2@ncsu.edu,emerson@csc.ncsu.edu

Robert Bowdidge
Google
Mountain View, CA, U.S.A.
bowdidge@google.com

***Abstract*—Using static analysis tools for automating code inspections can be beneficial for software engineers. Such tools can make finding bugs, or software defects, faster and cheaper than manual inspections. Despite the benefits of using static analysis tools to find bugs, research suggests that these tools are underused. In this paper, we investigate why developers are not widely using static analysis tools and how current tools could potentially be improved. We conducted interviews with 20 developers and found that although all of our participants felt that use is beneficial, false positives and the way in which the warnings are presented, among other things, are barriers to use. We discuss several implications of these results, such as the need for an interactive mechanism to help developers fix defects.**

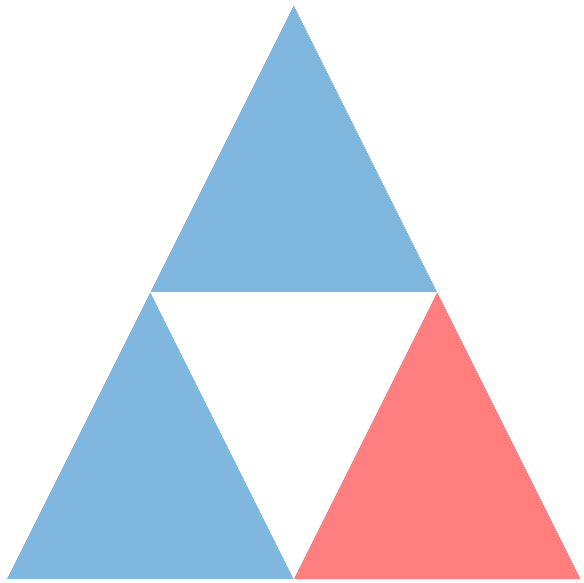
There are many situations where a developer may consider using a static analysis tool to find defects in their code. Let us consider a developer, Susie. Susie is a software developer at a small company. She wants to make sure that she is following the company's standards while maintaining quality code. She needs a way of checking her code in her IDE, before submitting it to the general code repository, without worrying about any outside dependencies that she has no control over. Susie decides that her best bet is to install a static analysis tool. She decides to install FindBugs because she likes the quality of the results and the fact that bugs can be found as she types; at first, she is very happy with her decision and

Disuse of Static Analysis Tools

- **Large volumes of false positives and warnings** outweigh true positives in volumes
- **Custom Navigation and Filter** Users would like to configure the ways that you see and filter results
- **Actionable Understandability** A developer not being able to understand what the tool is telling her is a barrier to use
  - **Quick Fixes** *"if you can tell me it's an error, you should be able to tell me how to fix it."*

Why Don't Software Developers Use Static Analysis Tools to Find Bugs? Johnson et al. 2013

Information Delivery and Usability



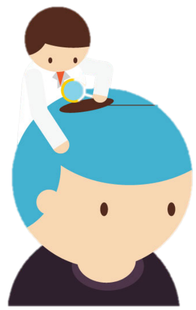
3. Fit Developer Workflow

Must Fit Developer Workflow

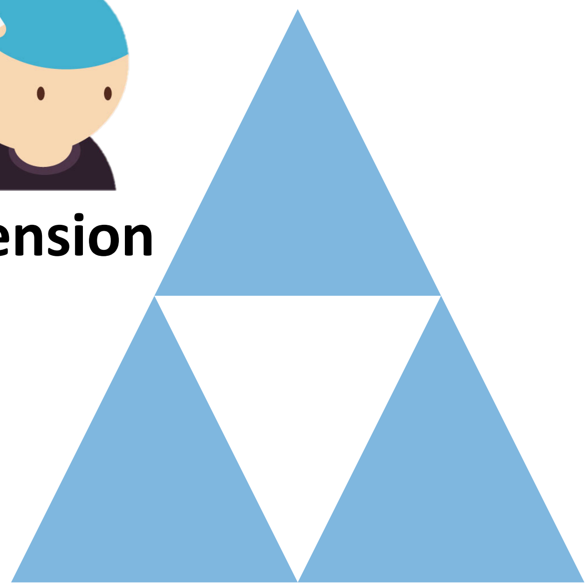
- Developers opportunistically interleave **web foraging of online resources**, learning, and writing code.
- Programmers search for code very frequently, conducting an average of 5 search sessions with **12 queries each workday**.
- 7% of respondents reused or modified code examples from **Stack Overflow** daily, 40% did at least weekly, and 62% did at least monthly.

Two Studies of Opportunistic Programming: Interleaving Web Foraging, Learning, and Writing Code, Brandt et al. 2009
How Developers Search for Code: A Case Study, Sadowski et al. 2015
How do developers utilize source code from stack overflow? Wu et al. 2018

Information Delivery and Usability

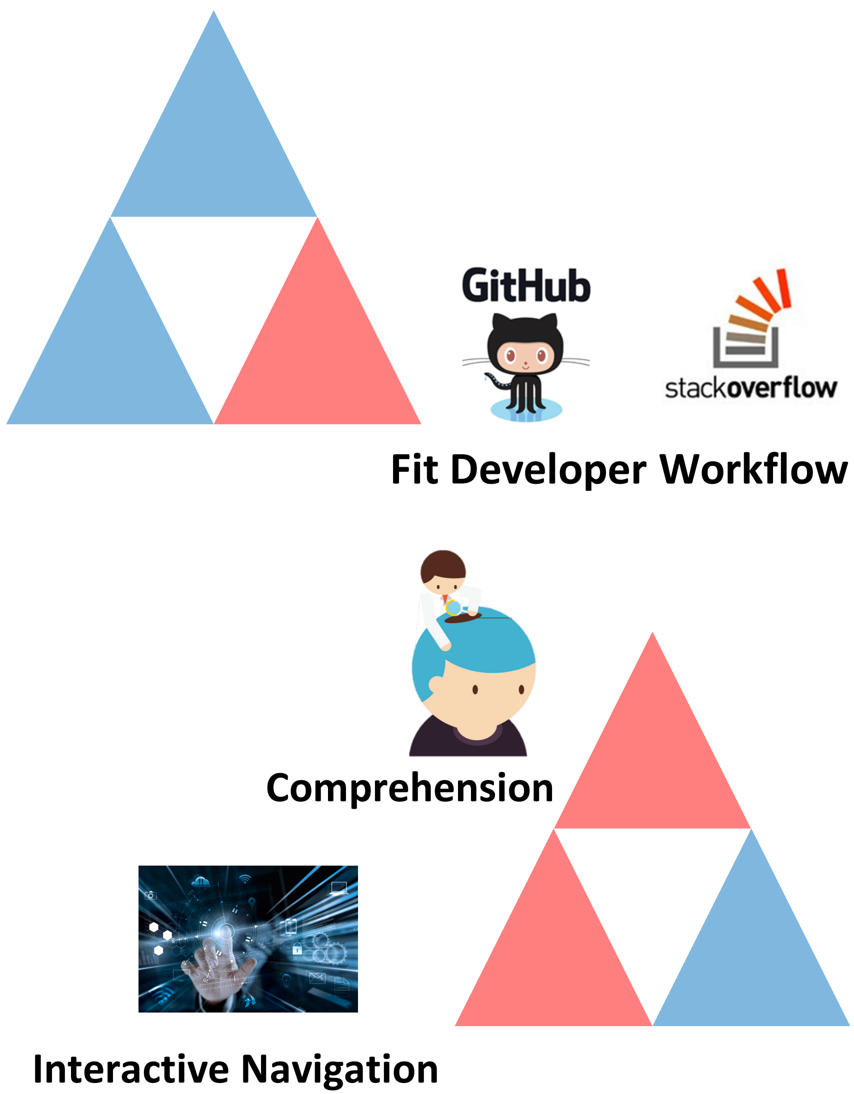


1. Comprehension



2. Interactive Navigation

3. Fit Developer Workflow



Part 1

API Usage Mining from GitHub
API Misuse Detection in Stack Overflow [ICSE 2018]

Part 2

Visualization of Code Examples at Scale [CHI 2018]

“How do I write data to a file using `FileChannel`*?”*

2

You're probably interested in a `FileChannel`. `Channel`s were designed to perform bulk IO operations to and from `Buffer`s.

Ex:

```
FileChannel fileOut = new FileOutputStream(file).getChannel();
fileOut.write(ByteBuffer.wrap("Whatever you want to write".getBytes()));
```

share improve this answer

answered Apr 8 '12 at 19:39
Jeffrey
35.7k ● 7 ● 60 ● 111

Actually, I want to maintain a large buffer (whose size I can mention) and periodically flush it. – Arpssss Apr 8 '12 at 19:43

@Arpssss You can maintain a `ByteBuffer` and periodically write it to the file system. You don't have to create your `ByteBuffer` inline like that. – Jeffrey Apr 8 '12 at 19:47

Thanks. Is it possible to use charbuffer of NIO ? – Arpssss Apr 8 '12 at 20:05

`FileChannel` cannot write a `CharBuffer`. You can, however, use `ByteBuffer#putChar` to put characters

“How do I write data to a file using `FileChannel`*?”*

2

You're probably interested in a `FileChannel`. `Channel`s were designed to perform bulk IO operations to and from `Buffer`s.

Ex:

```
FileChannel fileOut = new FileOutputStream(file).getChannel();
fileOut.write(ByteBuffer.wrap("Whatever you want to write".getBytes()));
```

This example forgets to close the FileChannel object properly.

35.7k ●7 ●60 ●111

Actually, I want to maintain a large buffer (whose size I can mention) and periodically flush it. – Arpssss Apr 8 '12 at 19:43

@Arpssss You can maintain a `ByteBuffer` and periodically write it to the file system. You don't have to create your `ByteBuffer` inline like that. – Jeffrey Apr 8 '12 at 19:47

Thanks. Is it possible to use charbuffer of NIO ? – Arpssss Apr 8 '12 at 20:05

`FileChannel` cannot write a `CharBuffer`. You can, however, use `ByteBuffer#putChar` to put characters into it. – Jeffrey Apr 8 '12 at 20:08

"How do I write data to a file using `FileChannel`*?"*

7

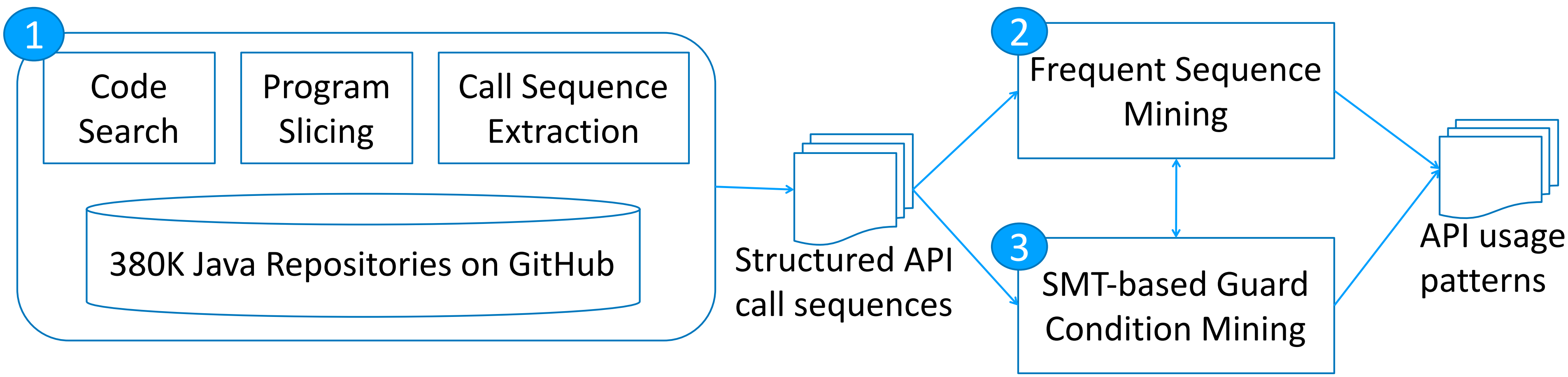
Somewhat like this:

```
short[] payload = {1,2,3,4,5,6,7,8,9,0};
ByteBuffer myByteBuffer = ByteBuffer.allocate(20);
myByteBuffer.order(ByteOrder.LITTLE_ENDIAN);

ShortBuffer myShortBuffer = myByteBuffer.asShortBuffer();
myShortBuffer.put(payload);

FileChannel out = new FileOutputStream("sample.bin").getChannel();
out.write(myByteBuffer);
out.close();
```

This example forgets to handle potential exceptions such as IOException and FileNotFoundException.

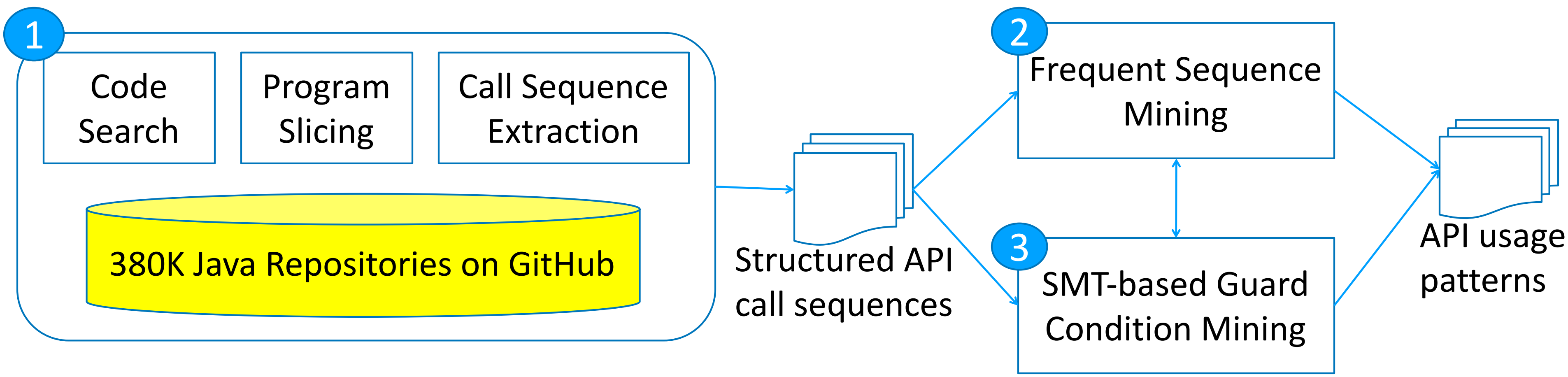
API Usage Mining from GitHub

- We mine API usage patterns from 380K GitHub projects.



Insight 1: Mining a Large Code Corpus

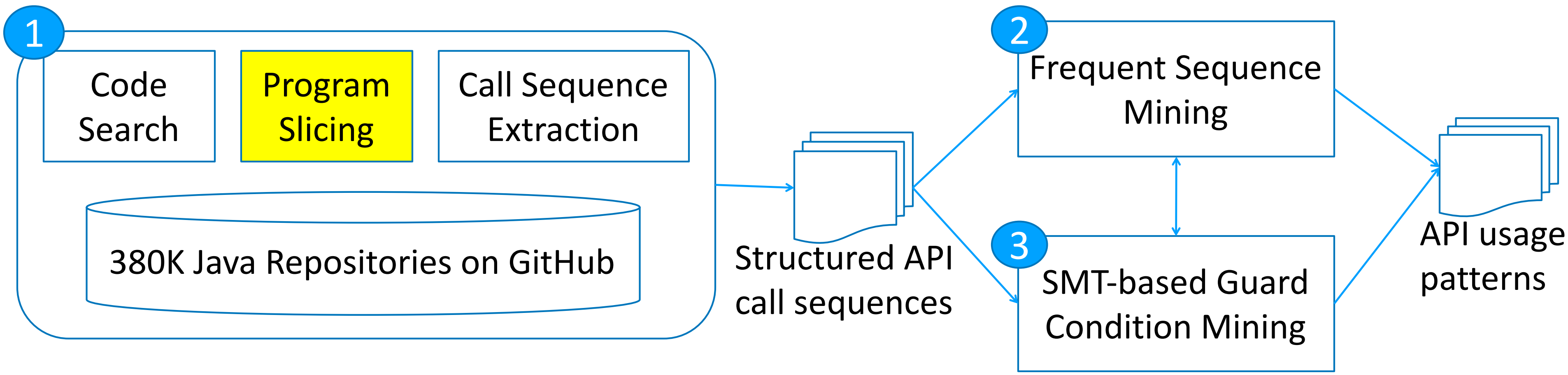
- Our code corpus includes 380K GitHub projects with at least 100 revisions and 2 contributors.



Dyer et al. Boa: A language and infrastructure for analyzing ultra-large-scale software repositories. ICSE 2013.

Insight 2: Removing Irrelevant Statements via Program Slicing

- We perform backward and forward slicing to identify data- and control-dependent statements to an API method of interest.



```
void initInterfaceProperties(String temp, File dDir) {
  if(!temp.equals("props.txt")) {
     log.error("Wrong Template.");
     return;
  }
  // load default properties
  FileInputStream in = new FileInputStream(temp);
  Properties prop = new Properties();
  prop.load(in);
  ... init properties ...
  // write to the property file
  String fPath=dDir.getAbsolutePath()+"/interface.prop";
  File file = new File(fPath);
  if(!file.exists()) {
      file.createNewFile();
  }
  FileOutputStream out = new FileOutputStream(file);
  prop.store(out, null);
  in.close();
}
```

Data dependency up to **one** hop, i.e., direct dependency

control

data

The focal API method

```java
void initInterfaceProperties(String temp, File dDir) {
  if(!temp.equals("props.txt")) {
     log.error("Wrong Template.");
     return;
  }
  // load default properties
  FileInputStream in = new FileInputStream(temp);
  Properties prop = new Properties();
  prop.load(in);
  ... init properties ...
  // write to the property file
  String fPath=dDir.getAbsolutePath()+"/interface.prop";
  File file = new File(fPath);
  if(!file.exists()) {
      file.createNewFile();
  }
  FileOutputStream out = new FileOutputStream(file);
  prop.store(out, null);
  in.close();
}
```

Data dependency up to two hops

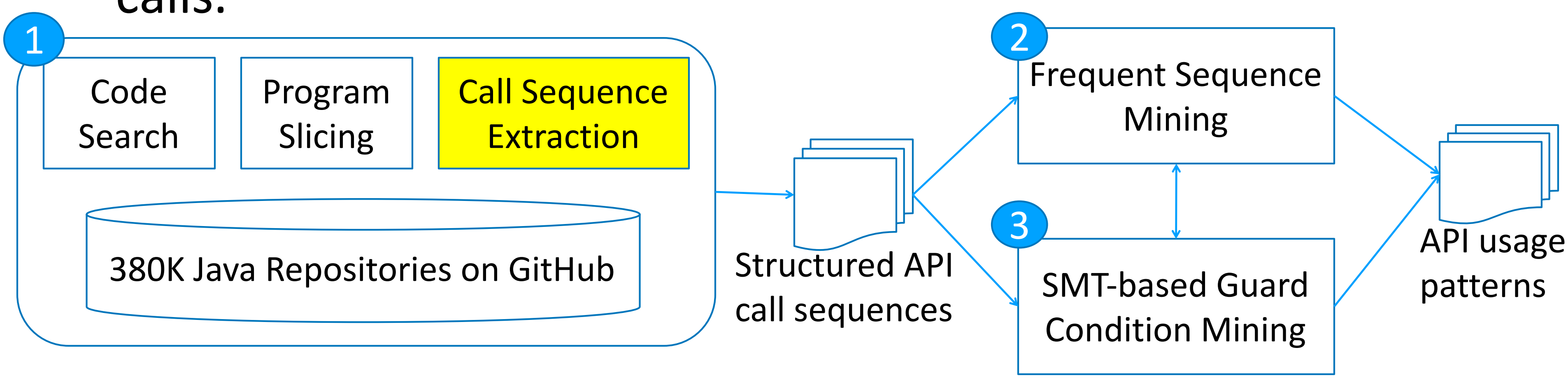
The focal API method

control

data

Insight 3: Capture the Semantics of API Usage

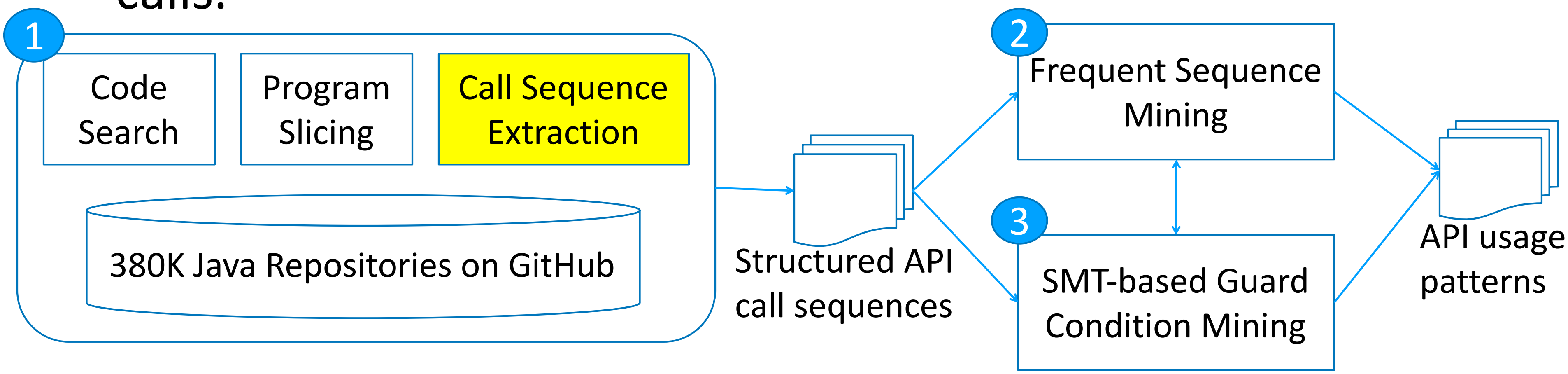
- It is important to capture the temporal ordering, enclosing control structures, and appropriate guard conditions of API calls.



new File (String); try { new FileInputStream(File)@arg0.exists(); } catch (IOException); }

Insight 3: Capture the Semantics of API Usage

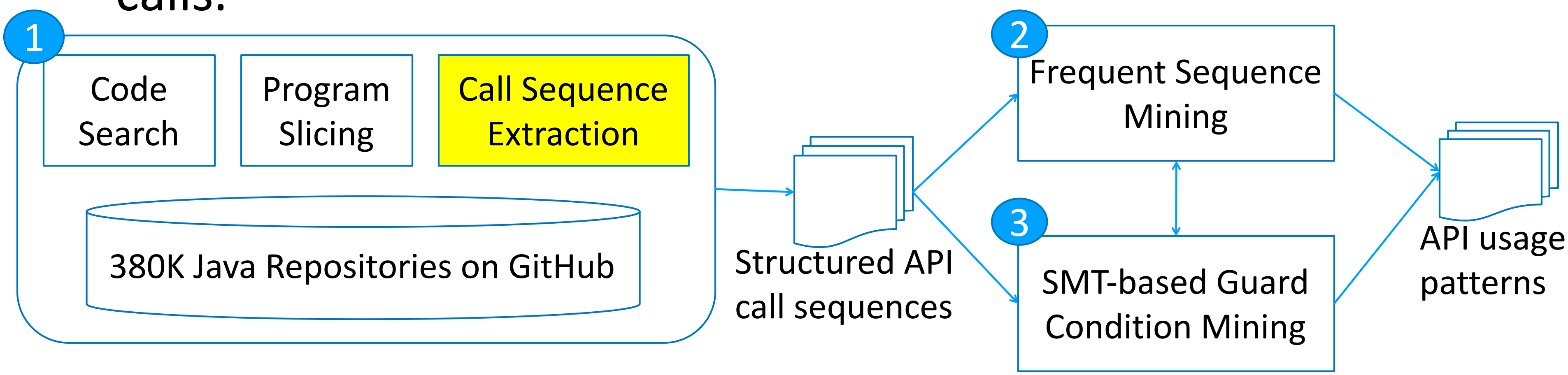
- It is important to capture the temporal ordering, enclosing control structures, and appropriate guard conditions of API calls.



new File (String); try { new FileInputStream(File)@arg0.exists(); } catch (IOException); }

Insight 3: Capture the Semantics of API Usage

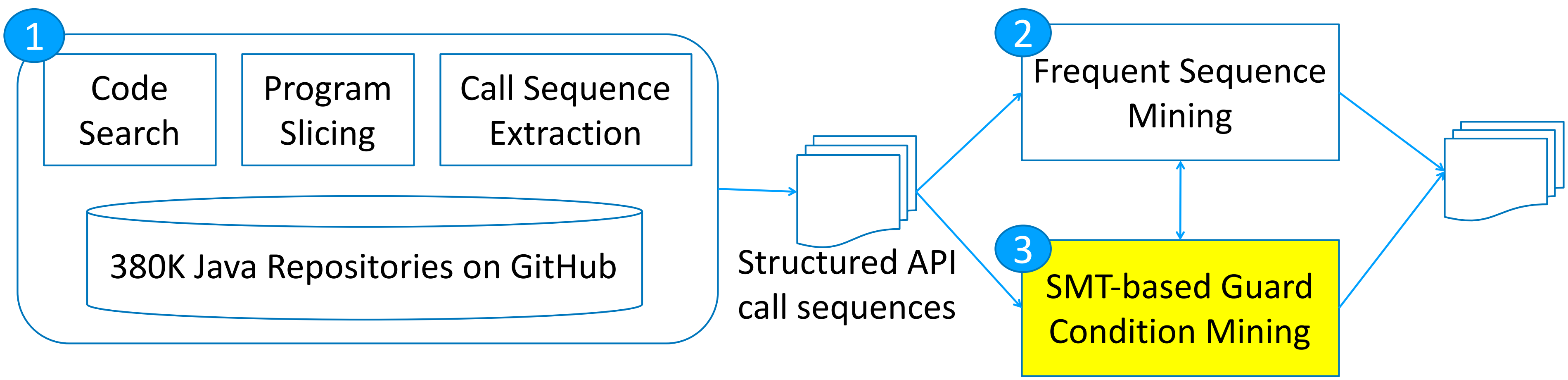
- It is important to capture the temporal ordering, enclosing control structures, and appropriate guard conditions of API calls.



new File (String); try { new FileInputStream(File)@arg0.exists(); } catch (IOException); }

Insight 4: Variations in Guard Conditions

- GitHub developers may write the same predicate in different ways.



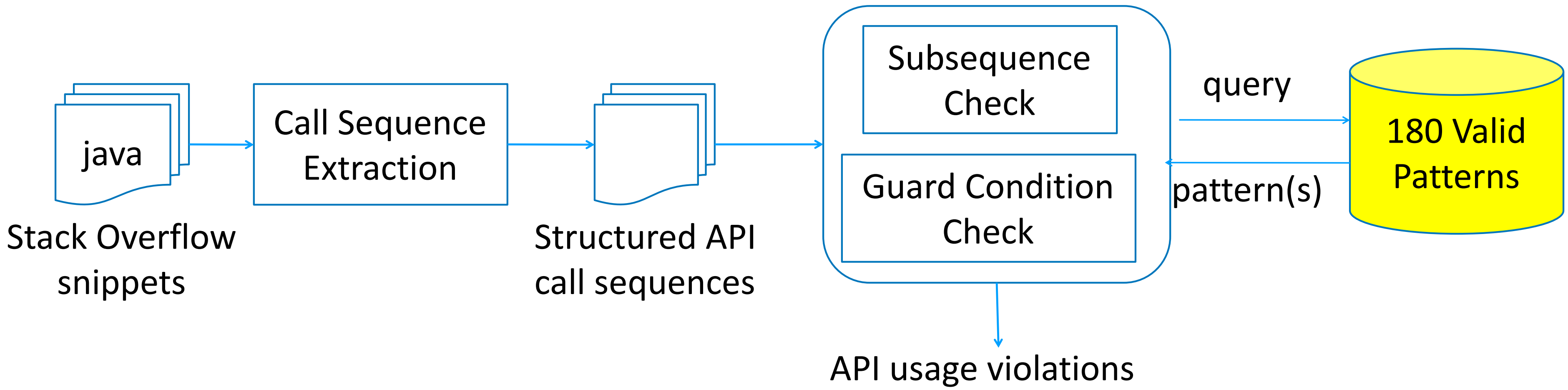
Two equivalent guard conditions for substring(int):

arg0>=0 && arg0<=rcv.length() ⇔ arg0>-1 && arg0<rcv.length()+1

Yet Another API Usage Mining Tool?

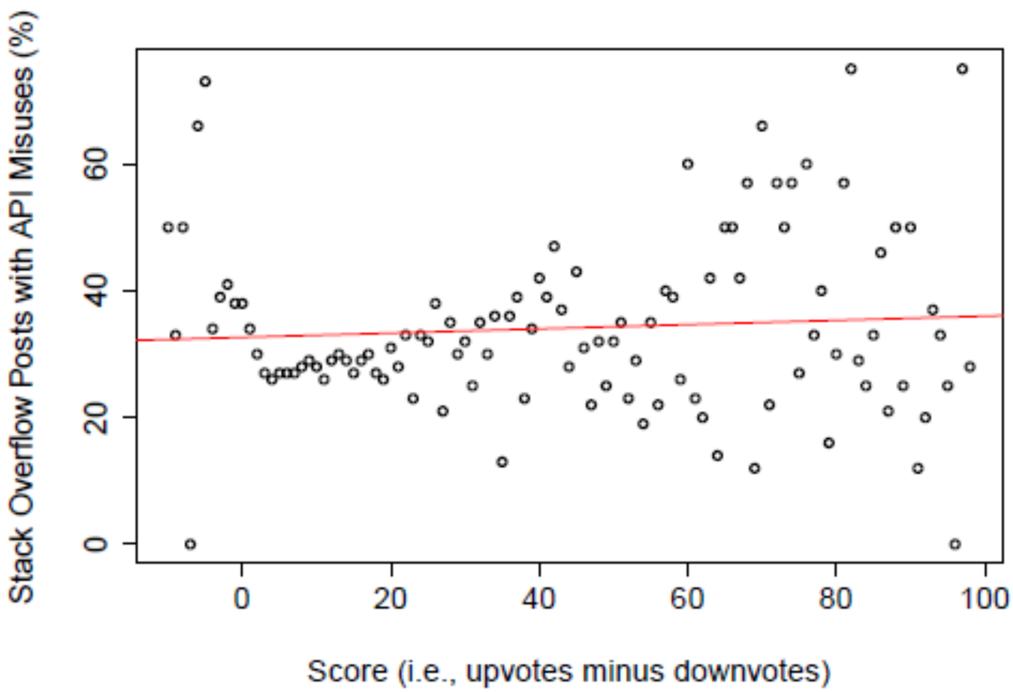
API Misuse Detection in Stack Overflow

- We examine 220K SO posts with 180 confirmed patterns.
- => 31% of SO posts contain API usage violations!

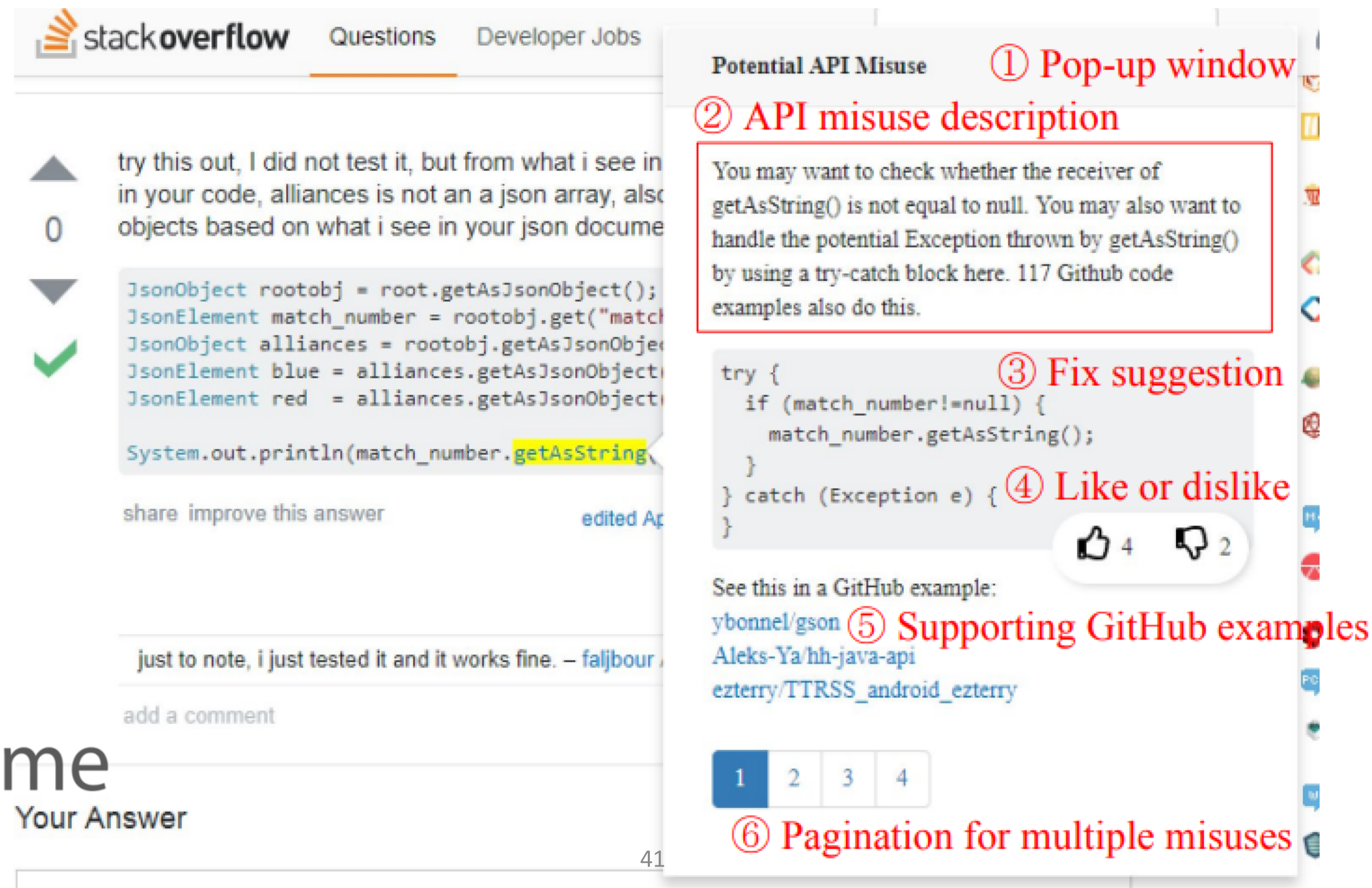


Dataset: http://web.cs.ucla.edu/~tianyi.zhang/examplecheck.html

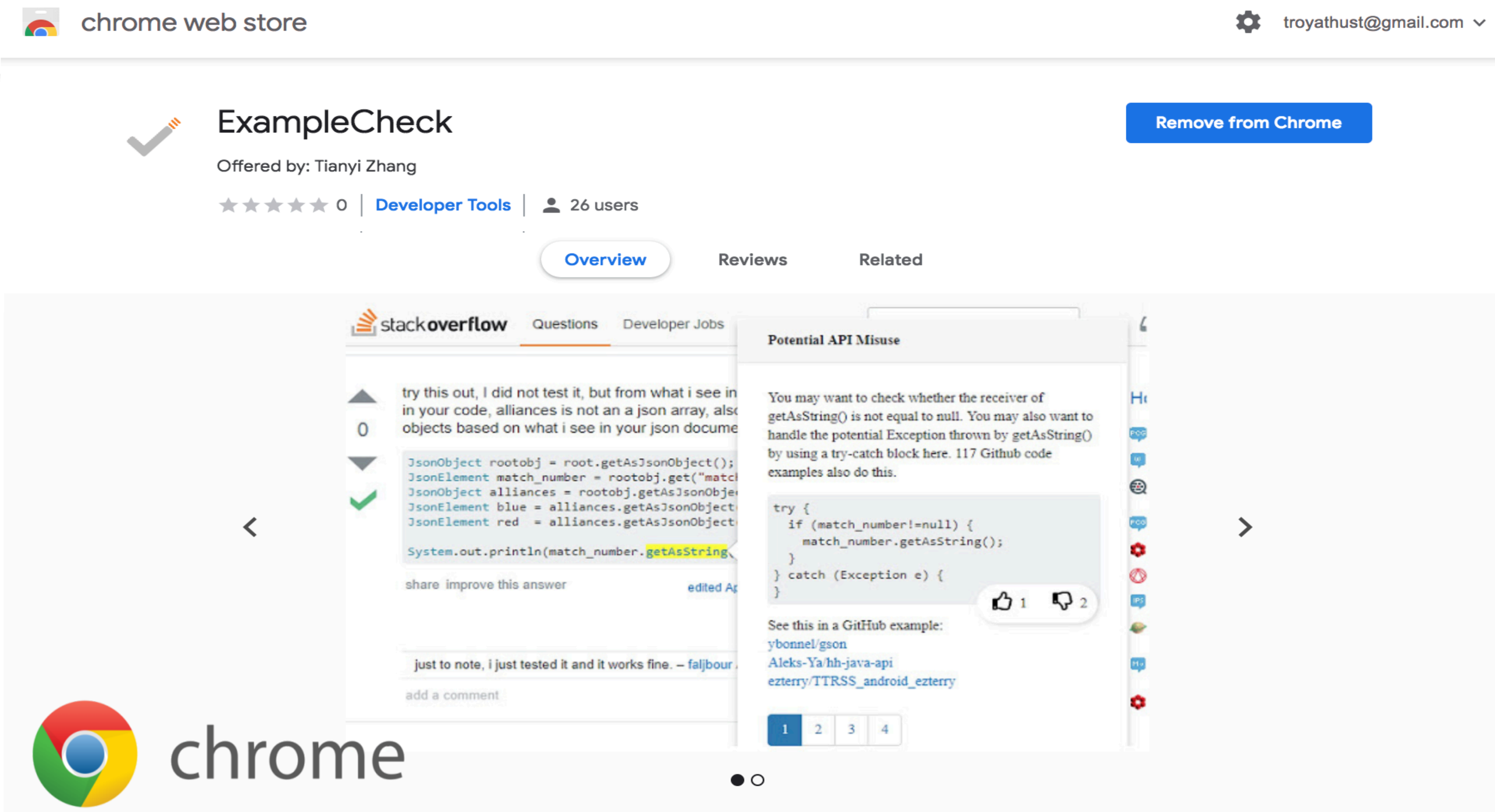
- Highly-voted posts are not necessarily more reliable in terms of correct API usage.

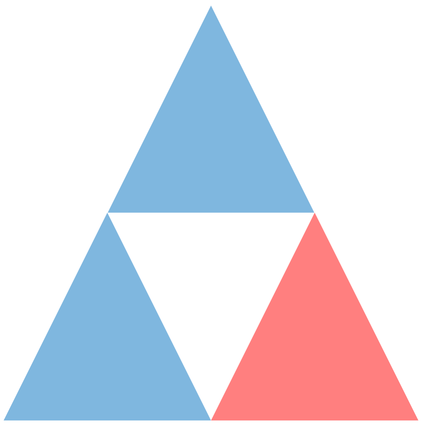


ExampleCheck [FSE’18 Demo]



chrome

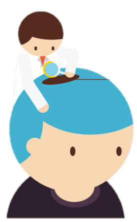

chrome web store
troyathust@gmail.com
ExampleCheck
Offered by: Tianyi Zhang
0
Developer Tools
26 users
Remove from Chrome
Overview
Reviews
Related
stackoverflow
Questions
Developer Jobs
try this out, I did not test it, but from what i see in
in your code, alliances is not an a json array, also
objects based on what i see in your json docume
JsonObject rootobj = root.getAsJsonObject();
JsonElement match_number = rootobj.get("matc
JsonObject alliances = rootobj.getAsJsonObje
JsonElement blue = alliances.getAsJsonObject
JsonElement red = alliances.getAsJsonObject
System.out.println(match_number.getAsString
share improve this answer
edited
just to note, i just tested it and it works fine. – faljbour
add a comment
Potential API Misuse
You may want to check whether the receiver of getAsString() is not equal to null. You may also want to handle the potential Exception thrown by getAsString() by using a try-catch block here. 117 Github code examples also do this.
try {
if (match_number!=null) {
match_number.getAsString();
}
} catch (Exception e) {
}
1
2
See this in a GitHub example:
ybonnel/gson
Aleks-Ya/hh-java-api
ezterry/TTRSS_android_ezterry
1 2 3 4
chrome



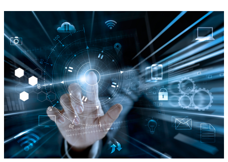
Fit Developer Workflow

Part 1

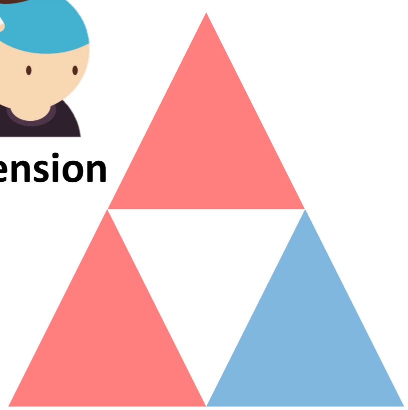
API Usage Mining from GitHub
API Misuse Detection in Stack Overflow [ICSE 2018]



Comprehension



Interactive Navigation



Part 2

Visualization of Code Examples at Scale [CHI 2018]

Examplore: Visualizing Examples at Scale

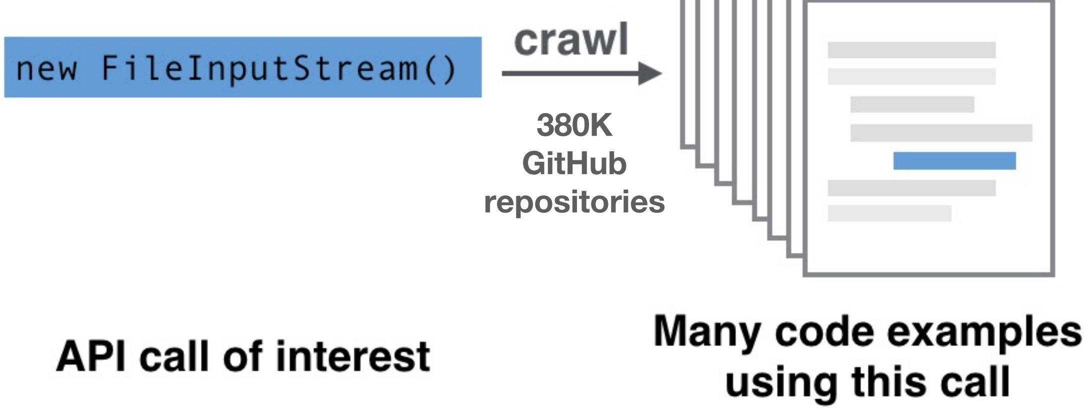
Focal API

Many code examples using this call

Interactive visualization showing common usage and frequency

Demo: http://examplore.cs.ucla.edu:3000

Mining API Usage from a Large Corpus




```
if (file != null) {
    return new FileInputStream(file);
} else {
    return new ByteArrayInputStream(…
}
File file = new File(_basePath + "/" + path);
try {
    return new FileInputStream(file);
} catch (FileNotFoundException e) {
    throw new IllegalArgumentException(e);
}
File propertiesFile = getPropertiesFile();
try {
    InputStream in = new FileInputStream(propertiesFile);
    workspaceProperties.load(in);
} catch (IOException e) {
}
```

Program Slicing and Labeling

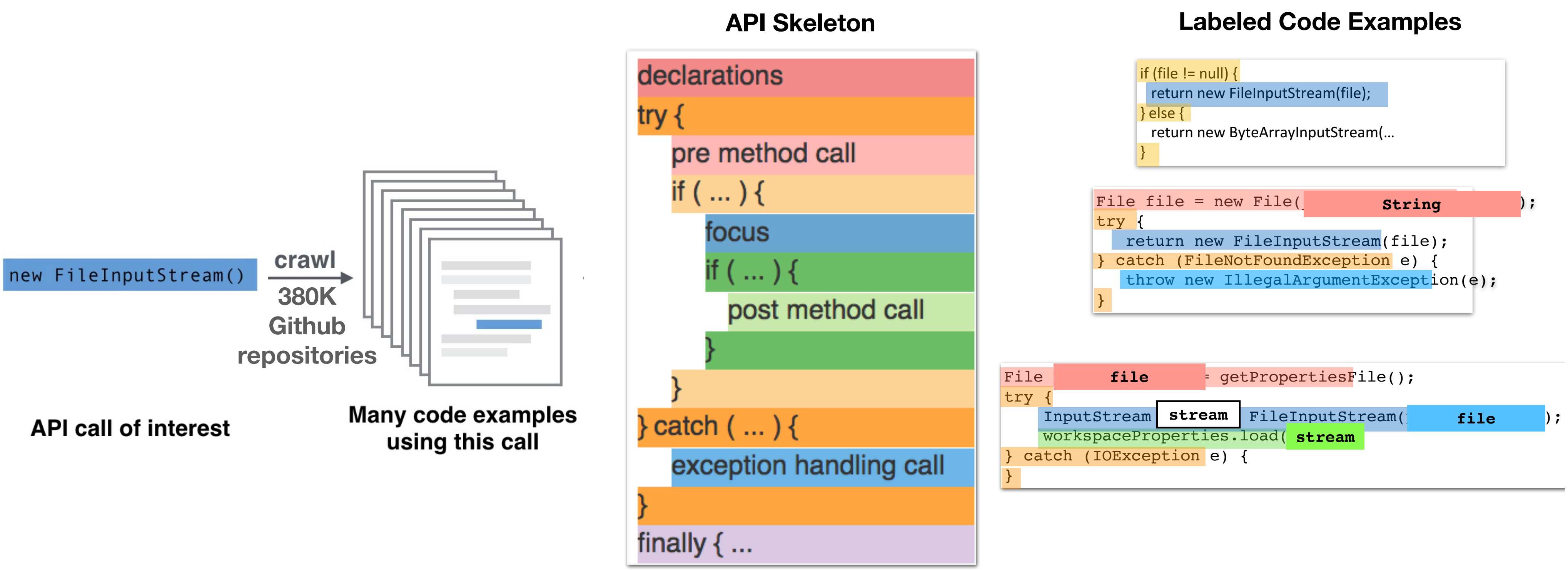
```
private void getLatestVersion() {
  // TODO Auto-generated method stub
  File temp = new File(Environment.getExternalStorageDirectory().toString() + "/pdTemp");
  try {
   List<File> listMain = IoUtils.extractZipResource(new FileInputStream(pdzZipPath), temp, true);
   if (listMain.size() != 0) {
    for (File f : listMain) {
     if (f.isDirectory()) folderName = f.getName();
     if (f.getAbsolutePath().toLowerCase().contains("droidparty_main.pd")) {
      foundmainPd = true;
      dpMainfileName = f.getName();
      InputStream is = new FileInputStream(f);
      BufferedReader reader = new BufferedReader(new InputStreamReader(is));
      String line;
      while ((line = reader.readLine()) != null) {
       String version;
       if (line.contains(" version: ")) {
        Log.d("LatestVersionLine", line);
        version = line.substring(line.lastIndexOf(":") + 1, line.length() - 1);
        this.latestVersion = Float.parseFloat(version);
        break;
       } else {
        version = "0";
        this.latestVersion = Float.parseFloat(version);
       }
      }
      reader.close();
      Log.d("LatestVersion", latestVersion + "");
      break;
     }
    }
    if (!foundmainPd) {
     closePd();
    }
   } else {
    closePd();
   }
  } catch (Exception e) {
   e.printStackTrace();
  }
 }
```

```
private void getLatestVersion() {
  // TODO Auto-generated method stub
  File temp = new File(Environment.getExternalStorageDirectory().toString() + "/pdTemp");
  try {
   List<File> listMain = IoUtils.extractZipResource(new FileInputStream(pdzZipPath), temp, true);
   if (listMain.size() != 0) {
    for (File f : listMain) {
     if (f.isDirectory()) folderName = f.getName();
     if (f.getAbsolutePath().toLowerCase().contains("droidparty_main.pd")) {
      foundmainPd = true;
      dpMainfileName = f.getName();
      InputStream is = new FileInputStream(f);
      BufferedReader reader = new BufferedReader(new InputStreamReader(is));
      String line;
      while ((line = reader.readLine()) != null) {
       String version;
       if (line.contains(" version: ")) {
        Log.d("LatestVersionLine", line);
        version = line.substring(line.lastIndexOf(":") + 1, line.length() - 1);
        this.latestVersion = Float.parseFloat(version);
        break;
       } else {
        version = "0";
        this.latestVersion = Float.parseFloat(version);
       }
      }
      reader.close();
      Log.d("LatestVersion", latestVersion + "");
      break;
     }
    }
    if (!foundmainPd) {
     closePd();
    }
   } else {
    closePd();
   }
  } catch (Exception e) {
   e.printStackTrace();
  }
 }
```

Labeled Code Examples

[Ko et al. 2004, Duala-Ekoko & Robillard 2012]

Code Canonicalization

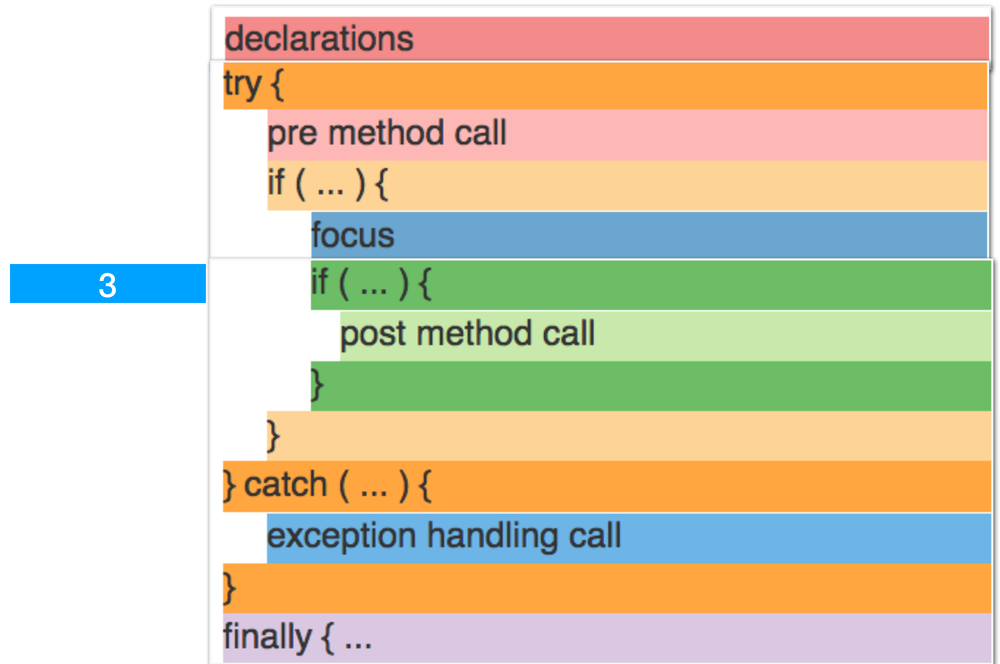


Examplore Interface

Mutual Alignment

Abstraction
API Skeleton

```
return new FileInputStream(file);
```




```
return new FileInputStream(file);
```

```
InputStream stream = new FileInputStream(file);
```

Examplore Interface

Mutual Alignment

Abstraction
API Skeleton

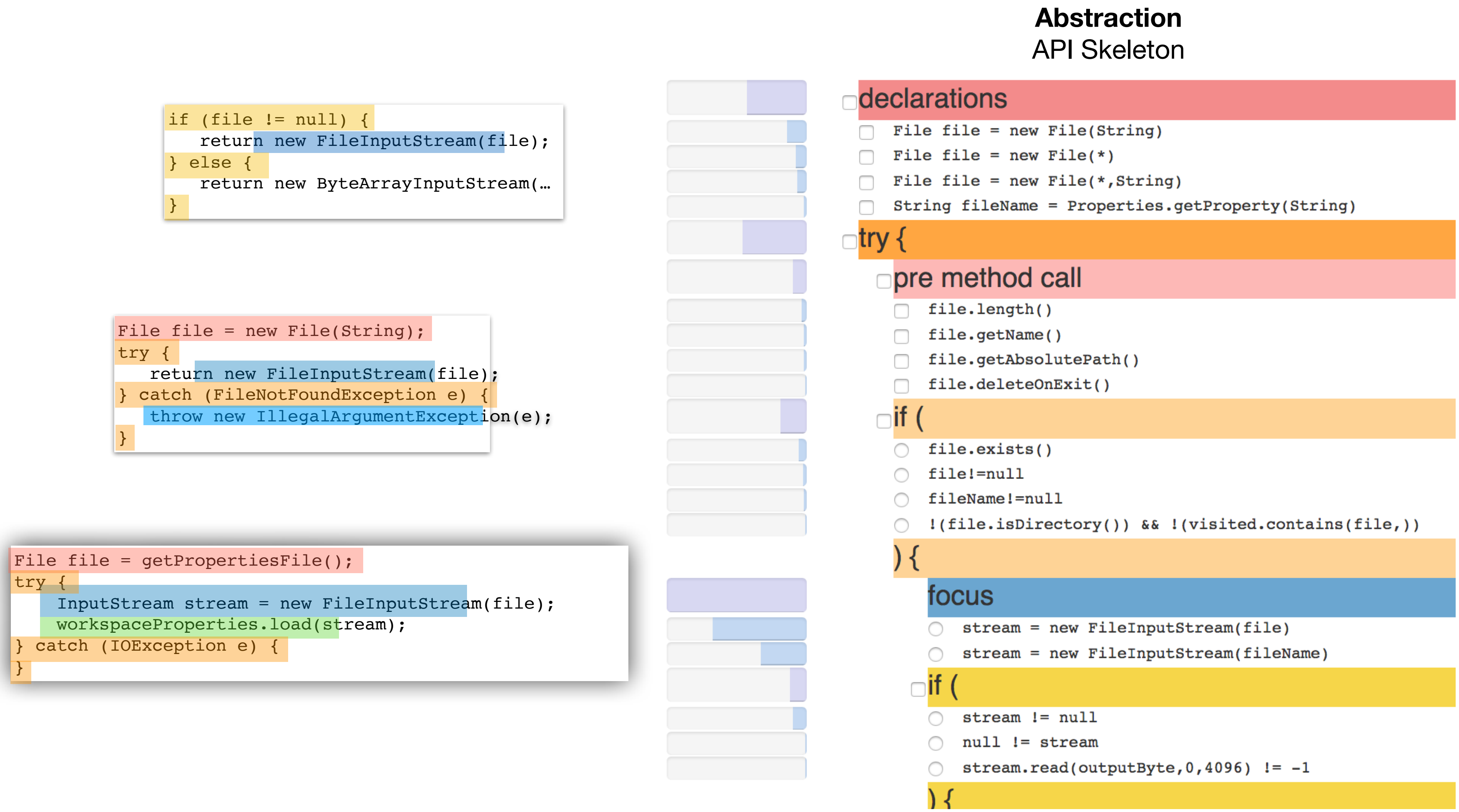
`File file = new File(String);`

`File file = getPropertiesFile();`

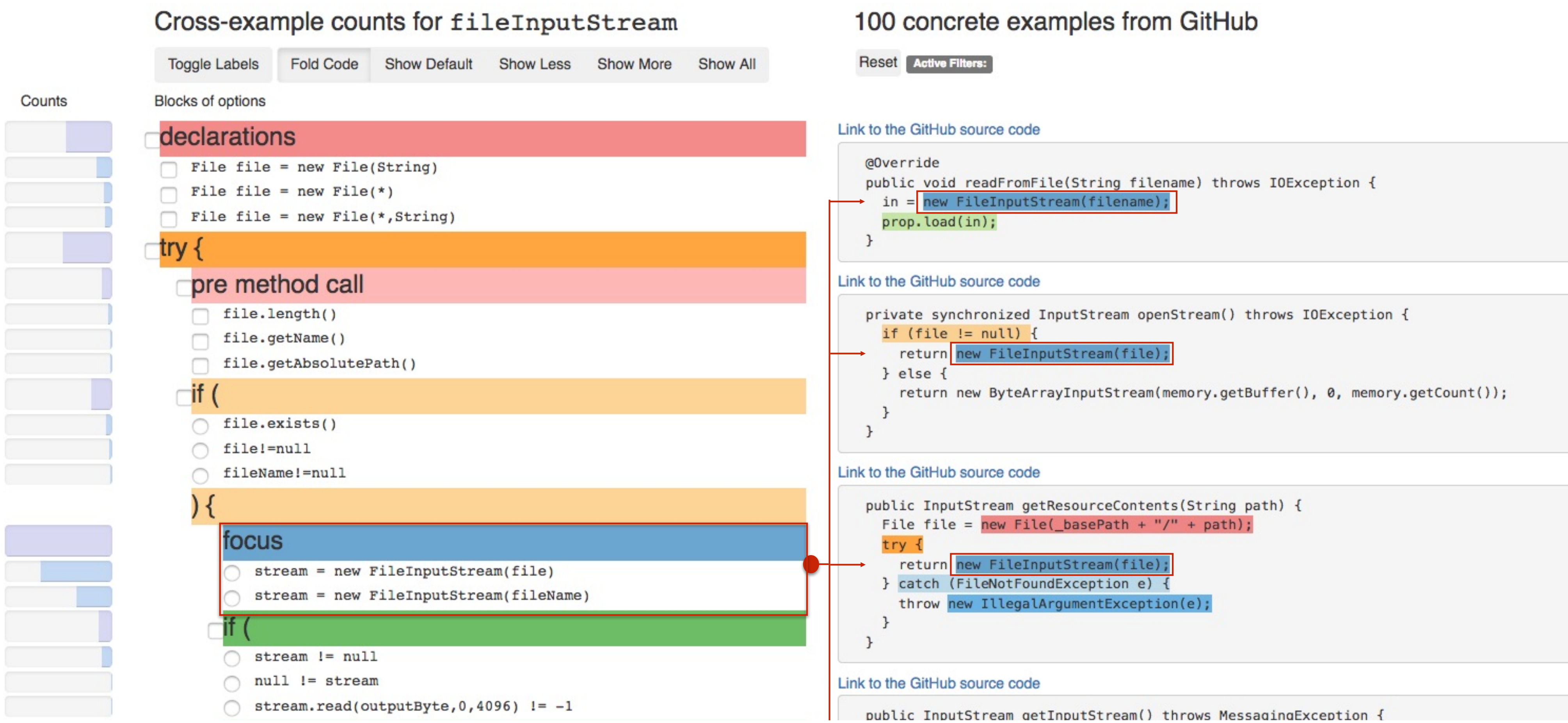
```
declarations
1 try {
1     pre method call
      if ( ... ) {
          focus
3             stream = new FileInputStream(file);
          if ( ... ) {
             post method call
          }
      }
  } catch ( ... ) {
      exception handling call
  }
  finally { ...
```

Examplore Interface

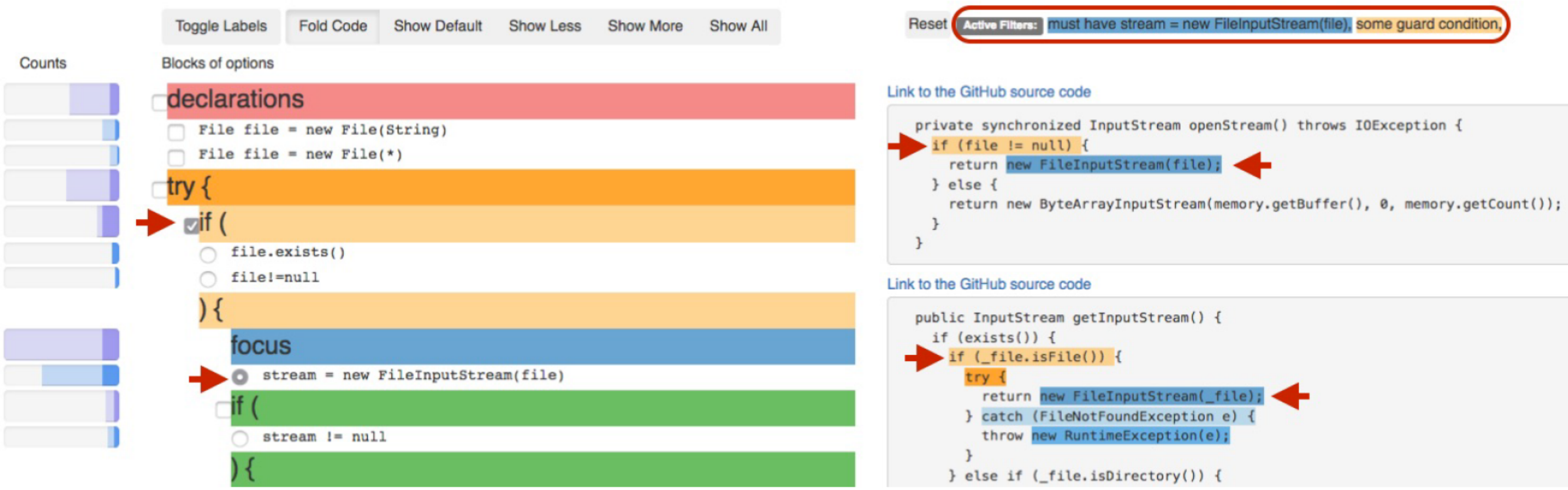
Mutual Alignment



Examplore Interface



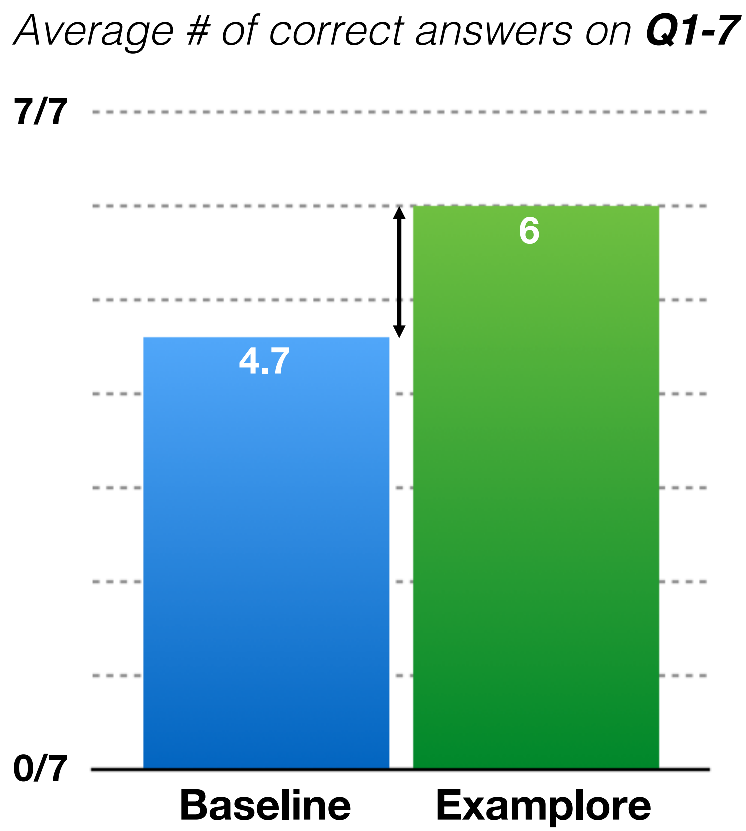
Examplore Interface



Tool is available at http://examplore.cs.ucla.edu:3000/

Lab Study Results

- Examplore users investigated many relevant examples.
- Baseline users often answered based on one example or by guessing.



Mean difference is statistically significant

(paired t-test: $t=3.02$, $df=15$, $p\text{-value}<0.01$)

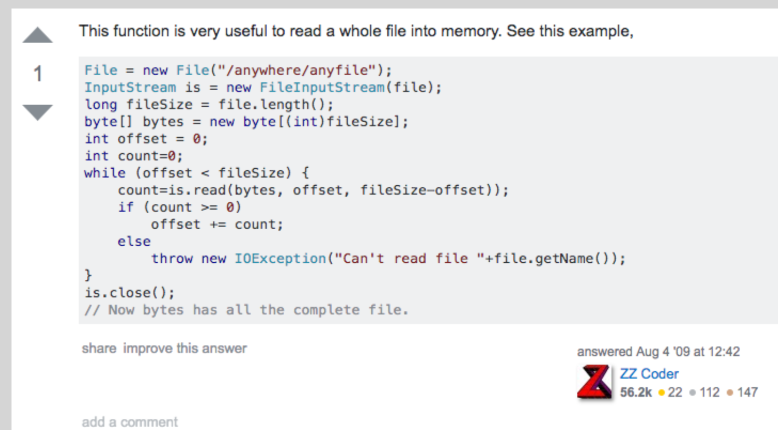
Lab Study Results

For **Q8**, 88% of participants gave valid comments about the StackOverflow answer.

The majority of participants' critiques…

- (Using the baseline) were about style and the mechanics of adaptation
- (Using Examplore) were about safety

- Q8. How might you **modify this code example on Stack Overflow** if you were going to copy and paste it into your own solution to the original prompt?



1

This function is very useful to read a whole file into memory. See this example,

```
File = new File("/anywhere/anyfile");
InputStream is = new FileInputStream(file);
long fileSize = file.length();
byte[] bytes = new byte[(int)fileSize];
int offset = 0;
int count=0;
while (offset < fileSize) {
    count=is.read(bytes, offset, fileSize-offset));
    if (count >= 0)
        offset += count;
    else
        throw new IOException("Can't read file "+file.getName());
}
is.close();
// Now bytes has all the complete file.
```

share improve this answer

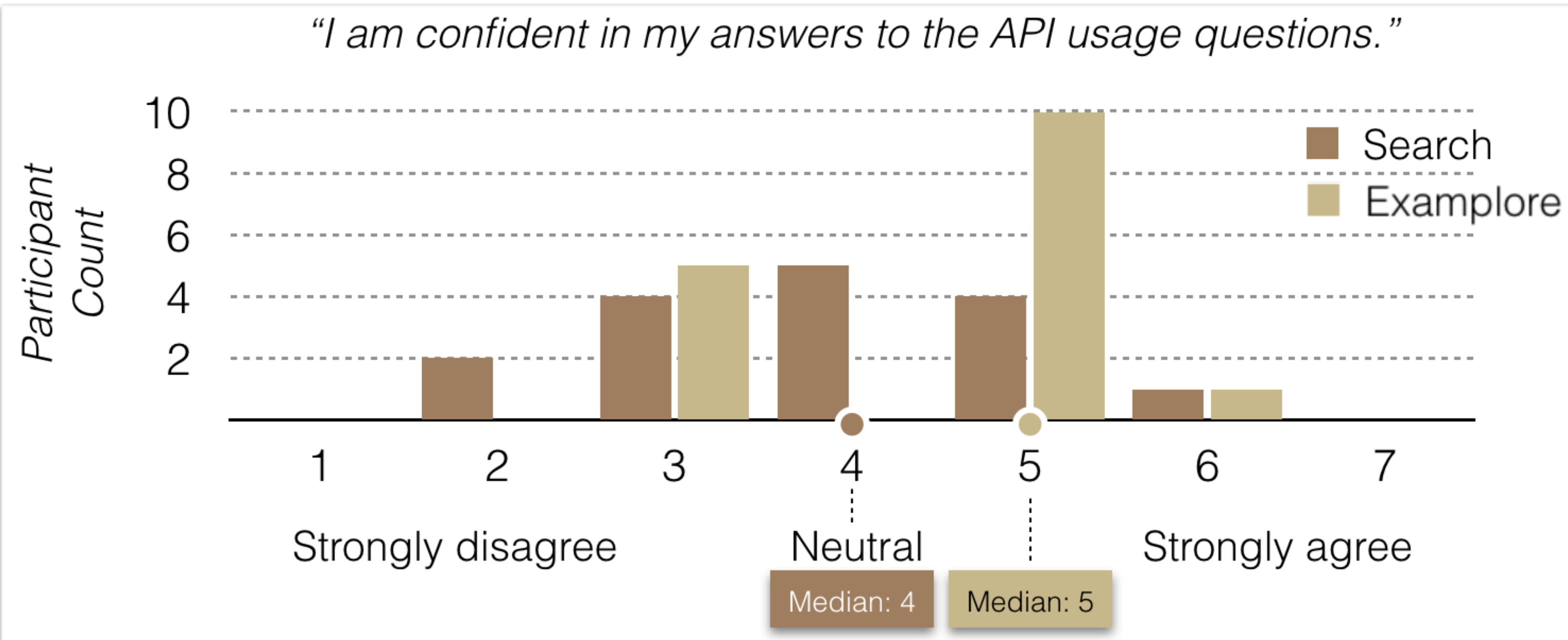
answered Aug 4 '09 at 12:42

ZZ Coder

56.2k ● 22 ● 112 ● 147

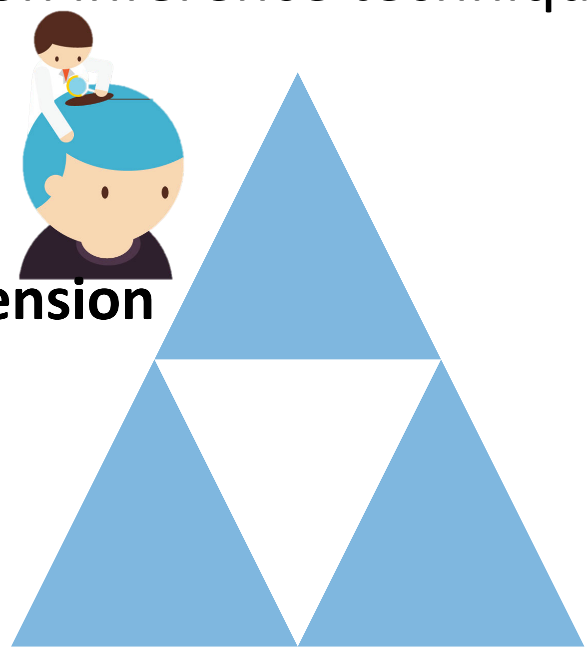
add a comment

Lab Study Results



Summary

It's time to **go beyond** measuring **precision** and **recall** of software specification inference techniques



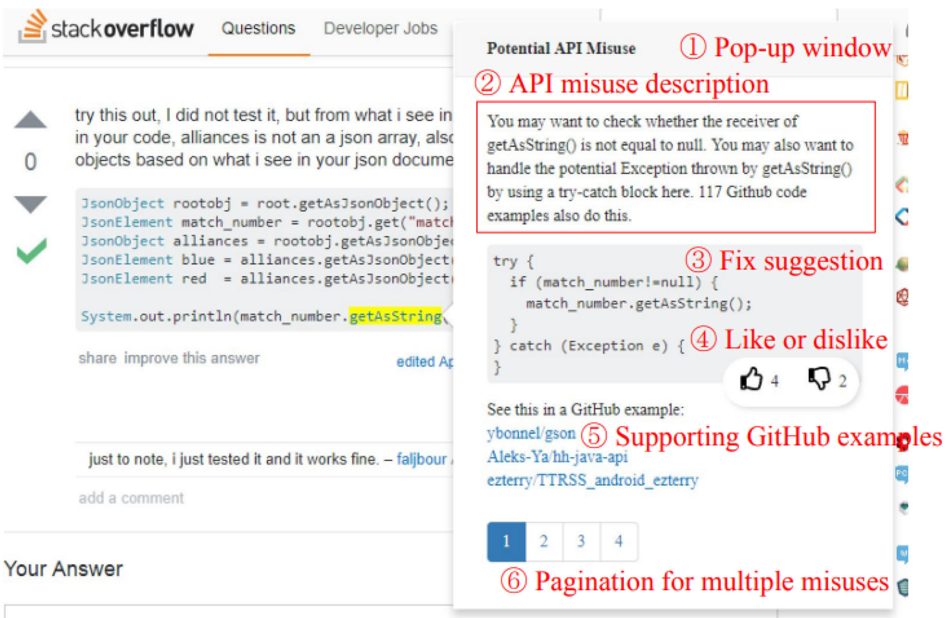
1. Comprehension

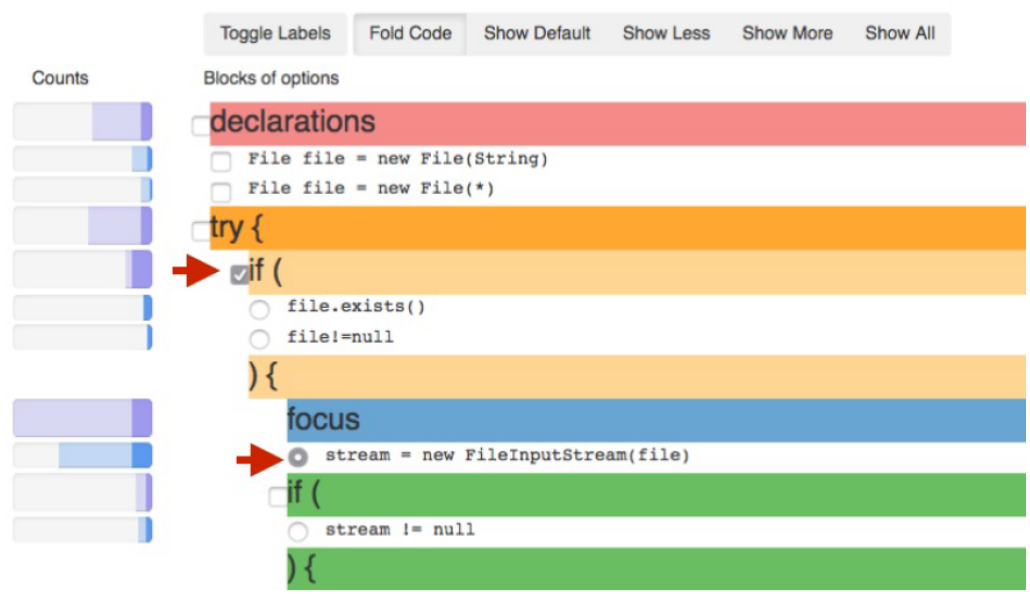
2. Interactive Navigation

3. Fit Developer Workflow

Collaborators: Tianyi Zhang, Elena Glassman, Bjoern Hartmann, Ganesha Upadhyaya, Hridesh Rajan, Anstasia Reinhart

ExampleCheck and Examplore





chrome web store

Tool is available at
http://examplore.cs.ucla.edu:3000/