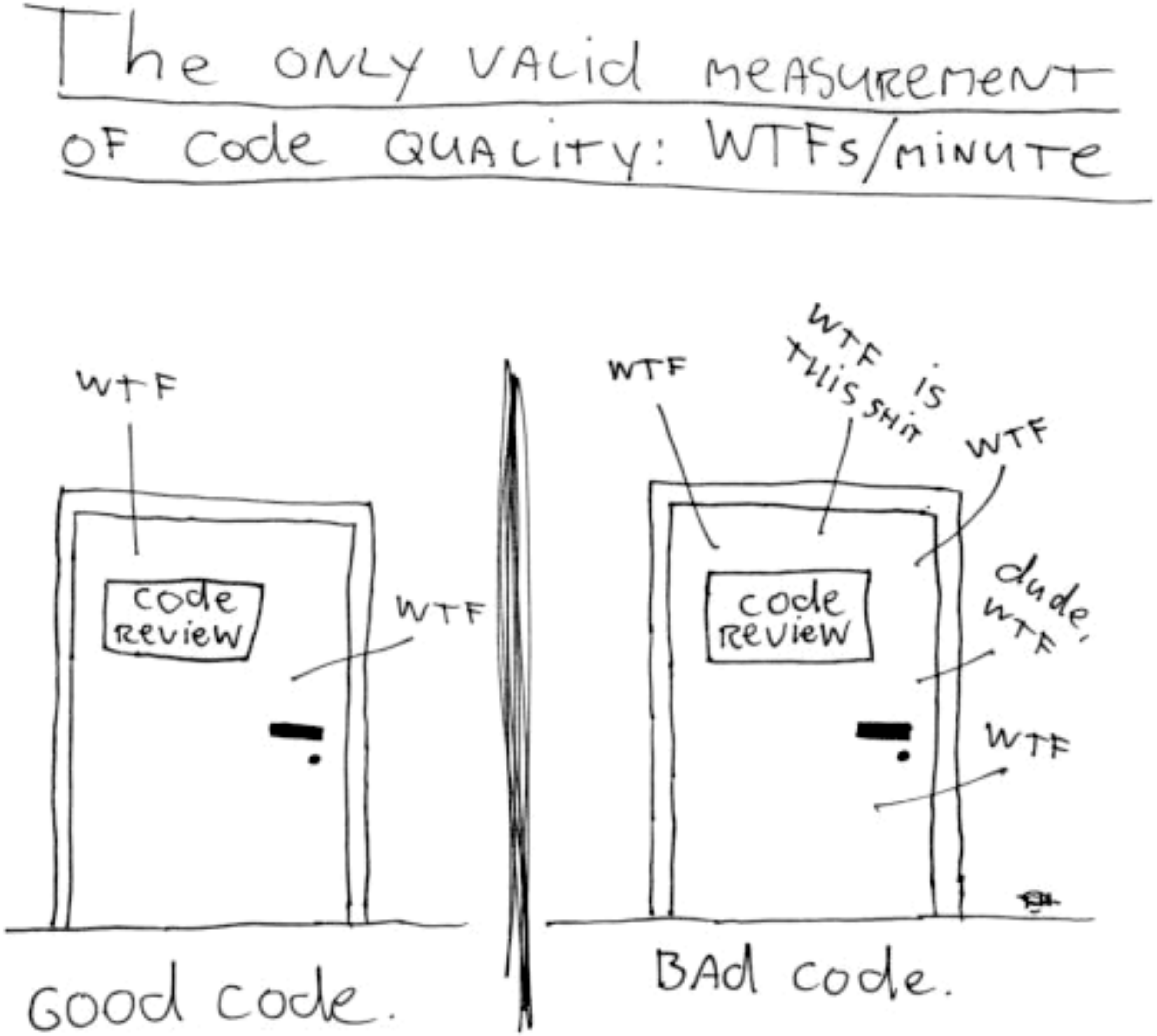
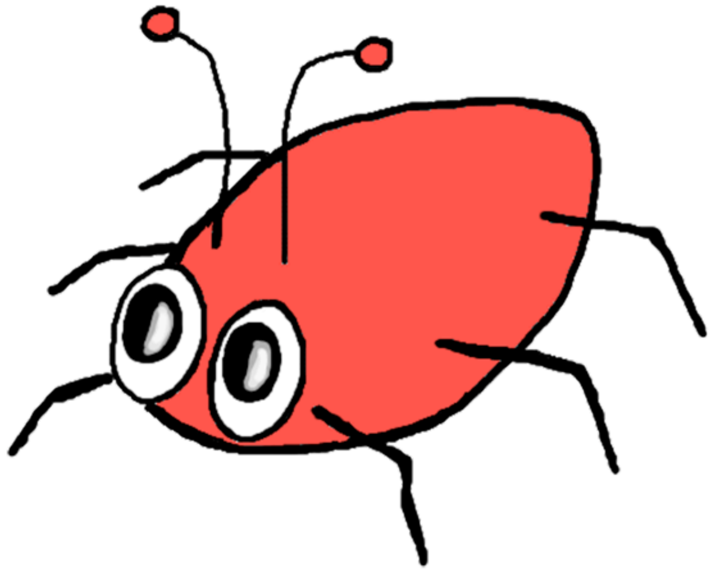
Effective use of FindBugs in large software development efforts



(c) 2008 Focus Shift/OSNews/Thom Holwerda - http://www.osnews.com/comics

EMERGING TECHNOLOGIES
FOR THE ENTERPRISE APRIL 10-11, 2012
PHILADELPHIA, PA

William Pugh
@wpugh



Code has bugs

- no perfect correctness or security
- you shouldn’t try to fix everything that is wrong with your code
- engineering effort is limited and zero sum
- how can you get the best return on the investment of engineering time using FindBugs

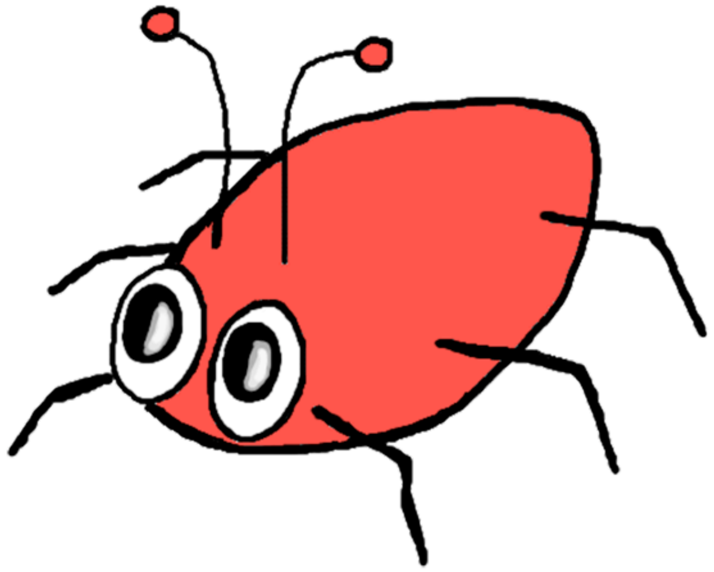
Defective Java Code

Learning from mistakes

- I'm the lead on FindBugs
  - static analysis tool for defect detection
  - more than a million downloads
- Spent a lot of time at Google
  - Found thousands of errors
    - not style issues, honest to god coding mistakes
    - but mistakes found weren't causing problems in production

FindBugs fixit @ Google May 2009

- 4,000 issues to review
  - Bug patterns most relevant to Google
- 8,000 reviews
  - 81+% must/should fix
  - many issues independently reviewed by multiple engineers



> 1,800 bugs filed
  > more than 600 fixed
> More than 1,500 issues removed in several days

Learned wisdom

- Static analysis typically finds mistakes (often just inconsistencies)
  - but some mistakes don't matter
  - need to find the intersection of stupid and important
- The bug that *matter* depend on context
- Static analysis, *at best*, might catch 5-10% of your software quality problems
  - 80+% for certain specific defects
  - but overall, not a magic bullet
- Used effectively, static analysis is cheaper than other techniques for catching the same bugs

Law of 2 feet

- Something I picked up from attending an unconference
- If you find yourself at a presentation where you aren’t getting anything
    - leave
    - and find a conversation you can gain from or contribute to.

Some bugs

What is wrong?

`Eclipse 3.7`

org.eclipse.update.internal.ui.views.FeaturesStateAction

```
  public void run() {
    try {
      if ((adapters == null) && (adapters.length == 0))
        return;
      IStatus status
        = OperationsManager
          .getValidator()
          .validatePlatformConfigValid();
      if (status != null)
        throw new CoreException(status);
      ...
```

What is wrong?

- Definitely no test cases for when `adapters` is null
- Probably no test cases for when `adapters` is empty
- Need to replace
  `(adapters == null) && (adapters.length == 0)`
  with
  `(adapters == null) || (adapters.length == 0)`
- If code has been in production, likely that `adapters` is never null in practice

A quick Java Puzzler
“The Joy of Sets”

```
public class ShortSet {
    public static void main(String args[]) {
        Set<Short> s = new HashSet<Short>();
        for (short i = 0; i < 100; i++) {
            s.add(i);
            s.remove(i - 1);
        }
        System.out.println(s.size());
    }
}
```

What Does It Print?

```
public class ShortSet {
    public static void main(String args[]) {
        Set<Short> s = new HashSet<Short>();
        for (short i = 0; i < 100; i++) {
            s.add(i);
            s.remove(i - 1);
        }
        System.out.println(s.size());
    }
}
```

(a) 1

(b) 100

(c) Throws exception

(d) None of the above

What Does It Print?

(a) `1`

(b) `100`

(c) Throws exception

(d) None of the above

The set contains `Short` values, but we're removing `Integer` values

Another Look

```
public class ShortSet {
    public static void main(String args[]) {
        Set<Short> s = new HashSet<Short>();
        for (short i = 0; i < 100; i++) {
            s.add(i);
            s.remove(i – 1); // int–valued expression
        }
        System.out.println(s.size());
    }
}
```

Another ‘nother Look

```
public class ShortSet {
    public static void main(String args[]) {
        Set<Short> s = new HashSet<Short>();
        for (short i = 0; i < 100; i++) {
            s.add(i);
            s.remove(i – 1); // int–valued expression
        }
        System.out.println(s.size());
    }
}
public interface Set<E>extends Collection<E> {
    public abstract boolean add(E e);
    public abstract boolean remove(Object o);
    ...
}
```

How Do You Fix It?

```
public class ShortSet {
    public static void main(String args[]) {
        Set<Short> s = new HashSet<Short>();
        for(short i = 0; i < 100; i++) {
            s.add(i);
            s.remove((short) (i – 1));
        }
        System.out.println(s.size());
    }
}
```

Moral

- **`Collection<E>.remove`** takes **`Object`**, not **`E`**
  - Also **`Collection.contains`**, **`Map.get`**
- Integral arithmetic always results in **`int`** or **`long`**
- Avoid mixing types
- Avoid **`short`**; prefer **`int`** and **`long`**
  - Arrays of **`short`** are the only compelling use case

Mismatched types

- Lots of places where you can pass in an object of the wrong type, and nothing happens
- comparing incompatible objects with equals

Map interface

```
public interface Map<K,V> {
 V put(K key, V value);
 V get(Object key);
 boolean containsKey(Object key);
 boolean containsValue(Object value);
 V remove(Object key);
 ...
 }
```

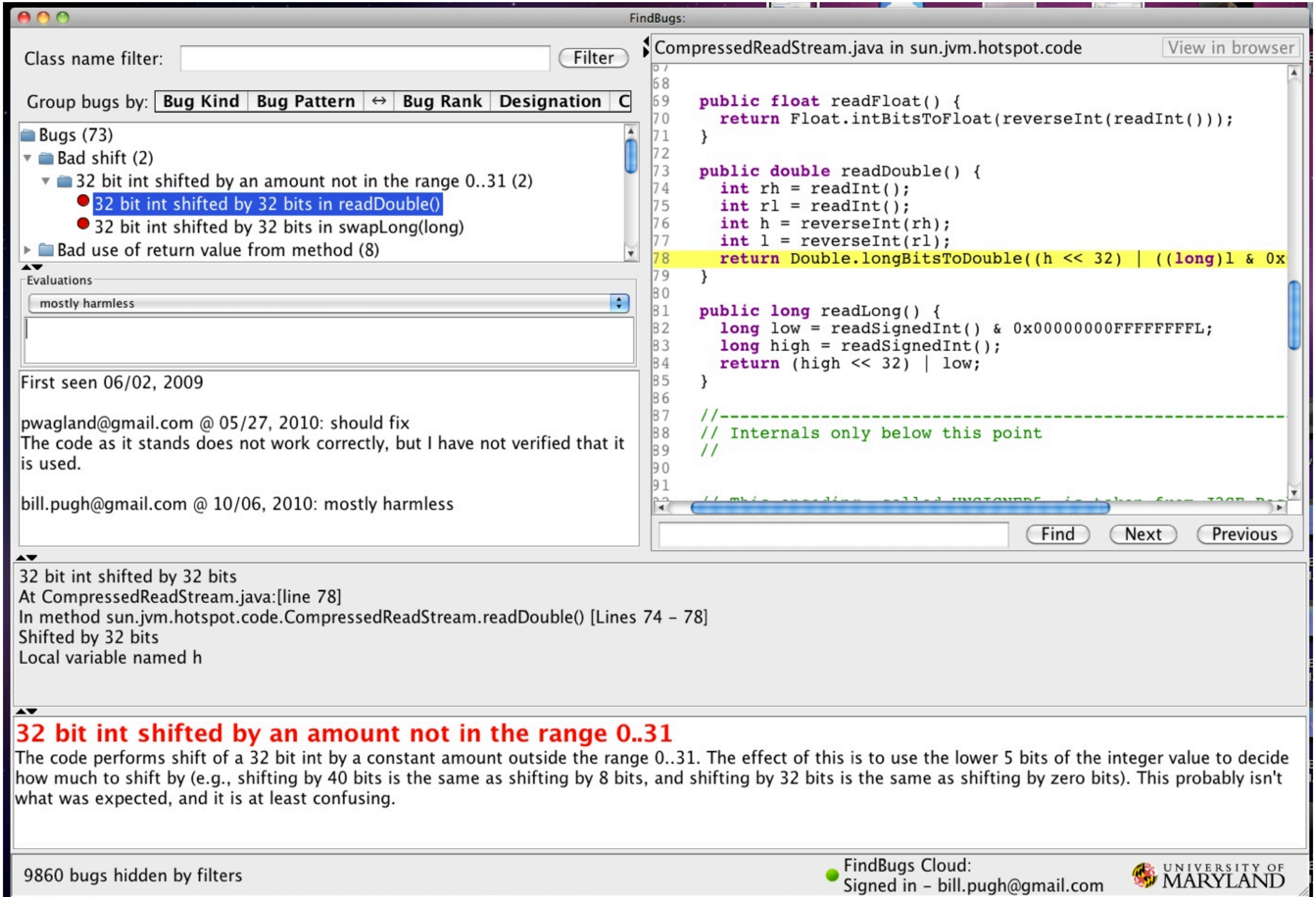
Map interface is mostly untyped

- It is type *safe* to pass any object to these methods
  - type parameter ignored
  - If it is an incompatible type, the call will do nothing
- It had to be this way for backwards compatibility
  - I’m getting to hate backwards compatibility

Comparing objects of different types

- Code that compares an instance of Foo with a String for equality
    - almost always wrong
    - might be OK if Foo.equals checks for a String being passed as an argument
    - Foo shouldn’t do this: break symmetry, and confusing as hell

FindBugs demo



Class name filter:

Group bugs by: Bug Kind | Bug Pattern | ↔ | Bug Rank | Designation | C

- Bugs (73)
  - Bad shift (2)
    - 32 bit int shifted by an amount not in the range 0..31 (2)
      - ● 32 bit int shifted by 32 bits in readDouble()
      - ● 32 bit int shifted by 32 bits in swapLong(long)
  - Bad use of return value from method (8)

Evaluations: mostly harmless

First seen 06/02, 2009

pwagland@gmail.com @ 05/27, 2010: should fix
The code as it stands does not work correctly, but I have not verified that it is used.

bill.pugh@gmail.com @ 10/06, 2010: mostly harmless

CompressedReadStream.java in sun.jvm.hotspot.code

```
68
69    public float readFloat() {
70      return Float.intBitsToFloat(reverseInt(readInt()));
71    }
72
73    public double readDouble() {
74      int rh = readInt();
75      int rl = readInt();
76      int h = reverseInt(rh);
77      int l = reverseInt(rl);
78      return Double.longBitsToDouble((h << 32) | ((long)l & 0x
79    }
80
81    public long readLong() {
82      long low = readSignedInt() & 0x00000000FFFFFFFFL;
83      long high = readSignedInt();
84      return (high << 32) | low;
85    }
86
87    //-----------------------------------------------------------
88    // Internals only below this point
89    //
90
91
92    // This encoding, called UNSIGNED5, is taken from J2SE Pa
```

32 bit int shifted by 32 bits
At CompressedReadStream.java:[line 78]
In method sun.jvm.hotspot.code.CompressedReadStream.readDouble() [Lines 74 – 78]
Shifted by 32 bits
Local variable named h

32 bit int shifted by an amount not in the range 0..31

The code performs shift of a 32 bit int by a constant amount outside the range 0..31. The effect of this is to use the lower 5 bits of the integer value to decide how much to shift by (e.g., shifting by 40 bits is the same as shifting by 8 bits, and shifting by 32 bits is the same as shifting by zero bits). This probably isn't what was expected, and it is at least confusing.

9860 bugs hidden by filters

● FindBugs Cloud:
Signed in – bill.pugh@gmail.com

FindBugs web start

- Go to http://findbugs.sourceforge.net/findbugs2.html
- Click on one of the links for communal reviews of FindBugs issues

Effective use of a static analysis tool

- Tune it to report only the kinds of issues you care about
- Run it automatically, alerting you when new serious issues are found
- Deal with issues where you don’t want to change the code
- Figure out how to deal to legacy bugs: broken code that has been in the codebase for a long time

What bugs matter to you?

- If you have a public static final field pointing to an array
  - anyone can change the contains of the array
- A big concern if you are concerned about untrusted code running in the same VM
  - a minor concern otherwise
- Are you concerned about internationalization, character encodings, etc?
  - lots of issues here, only matters in some applications

Compiler warnings

- compiler warnings are a similar issue
- At Google, they've spent some time thinking about the compiler warnings they care about
- Try to fix the ones they care about, globally disable the ones they don't care about

Running it automatically

- Most changes don’t introduce serious new issues detected by FindBugs (probably less than 2%)
- You don’t want developers to have to think about running it, or be blocked while it is running
  - their time and focus is too valuable; too little return
- But, some of the mistakes caught will cause developers to go on a frustrating hours long debugging hunt

How?

- Need better IDE integration
  - we’ve got some work to do here
- Need a way to know which issues are new and scary
- Run at unit test time, or at continuous build time
  - ... need to write a shim for launching it from a unit test...

Dealing with issues where you don’t want to change the code

- FindBugs is very accurate, certainly compared to many other tools
  - For rank 1-12 issues, Google engineers said they were “should fix” 81% of the time
- But sometimes, the warning doesn’t inspire you to want to change the code
- We have 55 such issues in the FindBugs code base
  - only 10 of them at rank 1-18

Dealing with “not a bug”

- Put an annotation in the source code
    - Careful: annotations can suppress future issues that shouldn’t be suppressed
    - In many circumstances, resistance to changing source code to suppress issues
- Store issues and evaluations in a central database
    - used by every major commercial static analysis tool

legacy bugs

- Understand whether the code is being executed now, and whether the buggy behavior is occurring now
  - code coverage from production?
- If the code isn't being executed, consider just deleting the code, or adding logging if it ever does get executed
- If you want to fix it, figure out the right behavior and write a test case to document it
  - *then* fix it

Maybe you shouldn't fix all old issues

- If a mistake was written into your code two years ago, and it hasn't caused any problems, maybe you shouldn't fix it.
  - Probably no test cases, code may not be used or understood
  - Changing the code to silence the warning without really understanding the code or having any test cases is dangerous
    - it just removes the WTF from the code.

Bug fix regressions

- Whenever you try to fix a bug, there is a chance that you will won't do so correctly
  - might make things worse, or only partially fix the problem
  - Estimates of incomplete/bad bug fixes range from 5-30%

Important concepts in FindBugs

- Ways to run FindBugs
- Bug attributes:
  - confidence, rank, category, kind, pattern
- Ways to filter and rank bugs
- Baseline bugs
- Bug clouds
- plugins

Running FindBugs

- Works on JVM classfiles
    - Some detectors produce poor results for some non-Java languages, such as Scala
- Runs on command line, ant, maven, Eclipse, Netbeans, IntelliJ, Jenkins, sonar, Fortify, Coverity

Bug attributes

- Each bug is an instance of a pattern
  - patterns are groups by category (e.g., internationalization) and kind (e.g., null pointer dereference)
- Each instance has a confidence (low, medium high)
  - priority in previous versions of FindBugs, but this confused people because priorities weren't comparable between different bug patterns

BugRank

- Each instance has a rank 1-20, with 1 being scariest
  - Scariest: rank 1-4
  - Scary: rank 5-9
  - troubling: rank 10-14
  - of concern: rank 15-20
- Scariest are issues most likely to cause significant and stealthy changes in behavior
  - roughly corresponds to the OMG level

Customizing bug rank

- Bug ranks can be and should be customized for production deployments
- can create a plugin that contains a bugrank.txt file, and add plugin to your deployement or project

Filtering Bugs

- You can filter bugs using either options to a command-line or ant task, or via a filter file
- Filter files can involve more complicated logic, including things such as "filter warnings of type X if they involving invoking method Y"
- Filters can be put into a plugin

Baseline bugs

- Easy way to show just new bugs
- Filter a bug report, excluding issues that are already present in another bug report
- Allows you to say: show me just the issues that weren't in the previous release

Comparing bugs across versions

- FindBugs using techniques that use the bug pattern, class, method, and other components of the issue to identify when two different analysis reports contain the same issue
    - it is confused by refactorings such as class and method renaming

Bug clouds

- Previously, we had provided a way for you to store evaluations of issues in the XML used to store the analysis results
  - but it was very hard to share results among a team
- We now provide bug clouds, where we store information about the first time an issue was seen, and any evaluations of the issue

Which bug cloud?

- We provide a free bug cloud, hosted on Google app engine, suitable for use on open source or other non-confidential projects
    - people have to sign in using open-id before anything is stored there.
- You can set up your own bug cloud on your own servers
    - At the moment, requires making some changes to the distro and rebuilding, should soon be possible to configure as separate plugin

Plugins

- FindBugs has had plugins for a long time, but we've really added lots of features
- A plugin might just consist of some xml files specifying various properties
- Plugins are loaded from the findbugs installation directory and from a .findbugs directory in the user's home directory
- in both, looks in subdirections plugin and optionalPlugin

Enabling plugins

- Plugins loaded from a plugin directory are enabled by default
  - those loaded from optionalPlugin are not
- You can set which plugins are enabled for a particular project

Some privacy and confidentiality issues

FindBugs update check

- FindBugs does an update check to see if there is a new version of FindBugs
  - doesn't report anything about the code being analyzed
  - but does report things like OS, Java version, locale, invocation mechanism (Ant, Maven, command line, GUI)
- You can install a plugin that completely blocks this check, or write your own plugin that reroutes the check to your own server

FindBugs communal cloud

- We are hosting a free server to record information about bugs
  - when the bug was first seen, and any evaluations of the issue by developers.
    - e.g., "On Jan 11th, Sam marked this as a "Should Fix" issue and said "...."
- Appropriate for open source and other non-confidential source code

FindBugs communal cloud privacy

- Source code is never uploaded
- You have to select the "FindBugs Communal Cloud", and log in with an open-id account, before anything is uploaded into the cloud
- You can remove the FindBugs communal cloud from your configuration if you are concerned

Defect density

- For Eclipse 3.0 (fairly typical)
  - Scariest: 30 per million
  - Scary: 160 per million LOC
  - Troubling: 480 per million LOC
  - Of concern: 6000 per million LOC

Understand your risk/bug environment

- What are the expensive risks?
- Is it OK to just pop up an error message for one web request or GUI event?
  - how do you ensure you don't show the fail whale to everyone?
- Could a failure destroy equipment, leak or loose sensitive/valuable data, kill people?

mistakes charactertistics

- Will you know quickly if it manifests itself?
- What techniques are good for finding it?
  - Is unit testing effective?
- Might a change in circumstances cause it to start manifesting itself?
- What is the cost of it manifesting itself?
- If is does manifest itself, will it come on slowly or in a tidal wave

Bugs in Google's code

- Google's code base contains thousands of "serious" errors
  - code that could *never* function in the way the developer intended
  - If noticed during code review, would definitely have been fixed
  - Most of the issues found by looking at Google's entire codebase have been there for months or years
- despite efforts, unable to find any causing noticeable problems in production

As issues/bugs age

- go up:
  - cost of understanding potential issues, deciding if they are bugs
  - cost and risk of changing code to remedy bugs
- goes down:
  - chance that bug will manifest itself as misbehavior

More efficient to look at issues early

- be prepared for disappointment when you look at old issues
- may not find many serious issues
- don't be too eager to "fix" all the old issues

Where bugs live

- code that is never tested
    - If code isn't unit or system tested, it probably doesn't work
- `throw new UnsupportedOperationException()` is vastly underrated
- if your current functionality doesn't need an equals method, and you don't want to write unit tests for it, make it throw `UnsupportedOperationException`
- Particularly an issue when you implement an interface with 12 methods, and your current use case only needs 2

Improving software quality

Improving software quality

- Many different things can catch mistakes and/or improve software quality
  - Each technique more efficient at finding some mistakes than others
  - Each subject to diminishing returns
  - No magic bullet
  - Find the right combination for you and for the mistakes that matter to you

Test, test, test...

- Many times FindBugs will identify bugs
    - that leave you thinking "Did anyone test this code?"
        - And you find other mistakes in the same vicinity
    - FindBugs might be more useful as an untested code detector than as a bug detector
- Overall, testing is far more valuable than static analysis
    - I'm agnostic on unit tests vs. system tests
    - But *no one* writes code so good you don't need to check that it does the right thing
        - I've learned this from personal painful experience

Dead code

- Many projects contain lots of dead code
  - abandoned packages and classes
  - classes that implement 12 methods; only 3 are used
- Code coverage is a very useful tool
  - but pushing to very high code coverage may not be worthwhile
  - you’d have to cover lots of code that never gets executed in production

Code coverage from production

- If you can sample code coverage from production, great
    - look for code executed in production but not covered in unit or system test

Cool idea

- If you can’t get code coverage from production
- Just get list of loaded classes
  - just your code, ignoring classes loaded from core classes or libraries
  - Very light weight instrumentation
- Log the data
  - could then ask queries such as “Which web services loaded the **`FooBar`** class this month?”

Using FindBugs to find mistakes

- FindBugs is accurate at finding coding mistakes
  - 75+% evaluated as a mistake that should be fixed
- But many mistakes have low costs
  - memory/type safety lowers cost of mistakes
  - If applied to existing production code, many expensive mistakes have already been removed
    - perhaps painfully
- Need to lower cost of using FindBugs to sell to some projects/teams

FindBugs integration at Google

- FindBugs has been in use for years at Google
- Finally turned on as a presubmit check at Google
- When you want to commit a change, you need a code review
    - now, FindBugs will comment on your code and you need to respond to newly introduced issues and discuss them with the person doing your code review

Questions?