Software Evolution

Thomas Fritz & Nils Grob

Many thanks to K. Kevic, H. Gall, R. Holmes and E. Baniassad, G. Murphy, D. Shepherd, M. Lanza, V. Razmov

Agenda

1. Introduction to Software Evolution
2. Evolution and Compatibility
3. Issue Tracking
4. Fixing a Bug / making a change

    Ensure to install Android Studio (in break if you have not done so)

Note:

- Jonas Blum will teach next week

Examinable skills

By the end of this lecture, you should be able to…

- Explain why evolution is difficult but inherent
- Describe three categories of reasons why useful software must evolve and identify what kind of reason motivates a given software change
- Reason about and argue whether a given change retains binary/contract compatibility
- Describe the role of issue tracking systems in the software development process
- Discuss the life cycle of a bug report, criteria for writing a good one and general steps for working on one
- Describe and perform the steps and activities to fix a bug and evolve an application

Software Maintenance / Evolution

Learning Objectives

Be able to:

- Explain why evolution is difficult but inherent and important
- Identify reasons for software change

Importance of Maintenance/Evolution

Maintenance Examples

Microsoft Windows XP

- Released 12/31/2001
- Service packs ended 8/30/2005
- Support ended 4/14/2009 (7.5 years)
- Extended support was still possible in 2016

Red Hat Enterprise Linux 3

- Released 10/23/2003
- End of life cycle 10/31/2010
- End of extended support 01/30/2014

Bank systems…

Software Maintenance/Evolution

Producing new (versions of) software under the constraints of existing software

- aka “Brownfield development”
- Backwards compatibility is often assumed / required
- Legacy Software: “software which is vital to our organization, but we don’t know what to do with it” (Bennett and Rajlich)

Can comprise all phases of the lifecycle, starting with requirements gathering

- Another turn of the spiral

Similar to development, but HARDER!

Software change

Software change is inevitable

- New requirements emerge when the software is used
- The business environment changes
- Errors must be repaired
- New computers and equipment is added to the system
- The performance or reliability of the system may have to be improved

A key problem for organisations is implementing and managing change to their *existing* software systems.

Y2K Example

Memory space used to be a problem, so, store 2-digit years

- Rollover problem: ascending numbering assumption becomes invalid

Mitigation efforts cost ~$300 billion worldwide

Valuable surge in IT modernization

- major issue for business: enterprise architecture

Computerworld: http://goo.gl/1ABH2

Software Evolution

Organizations have huge investments in their software systems - they are critical business assets.

To maintain the value of these assets to the business, they must be changed and updated.

The majority of the software budget in large companies is devoted to evolving existing software rather than developing new software.

Lehman's laws

Observations (~laws) on large systems developed by large organizations

Continuing change

A program that is used in a real-world environment necessarily must change or become progressively less useful in that environment

Increasing complexity

As an evolving program changes, its structure tends to become more complex. Extra resources must be devoted to preserving and simplifying structure.

Declining quality

The quality of systems will appear to be declining unless they are adapted to changes in their operational environment

....

Evolution is hard

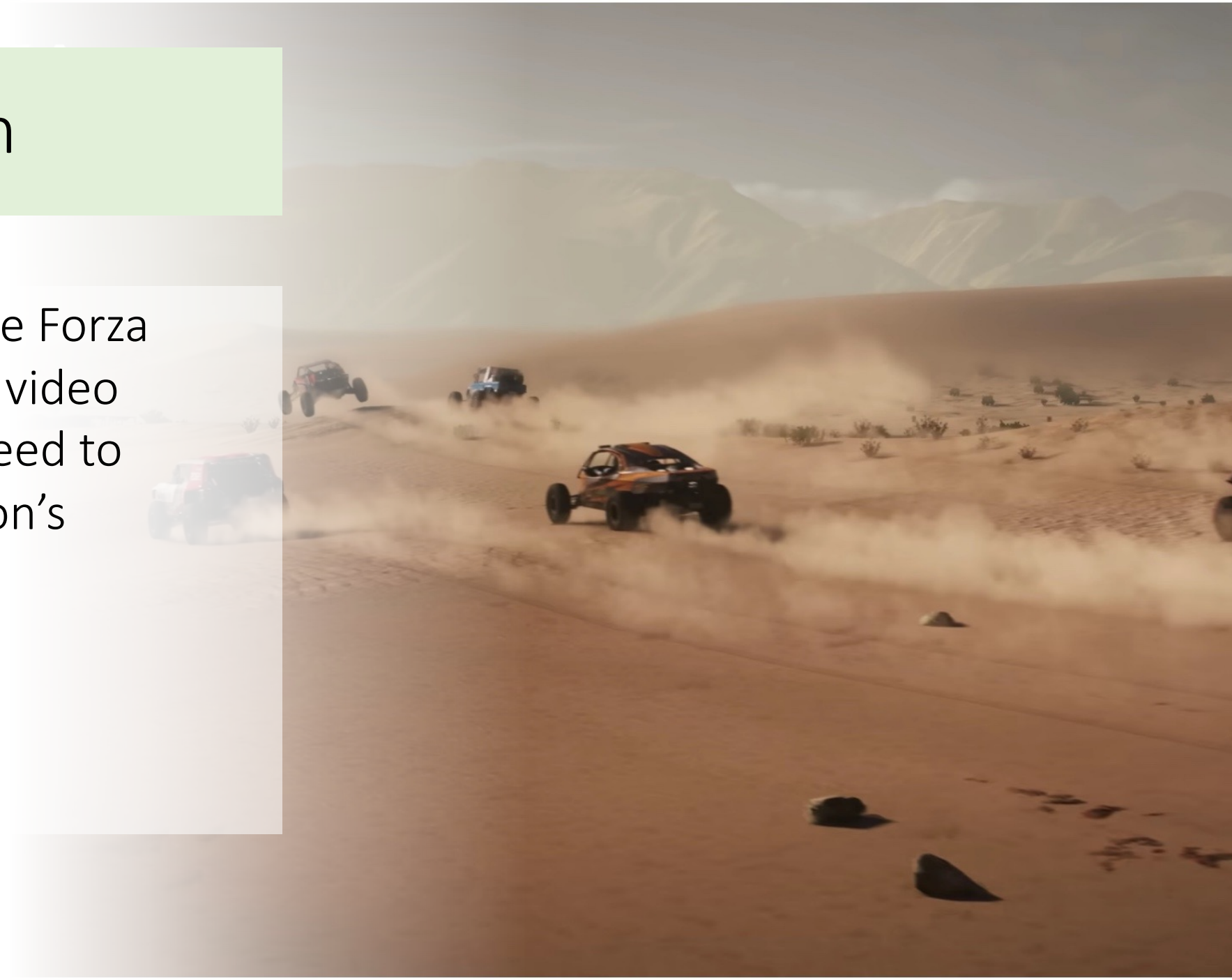
- Systems not robust under change
- Lack of traceability (e.g. between requirements and code)
- Poor documentation of code, of design process and rationale and of system evolution
- “Stupid” code features may not be so stupid.
  - work-arounds of artificial constraints may no longer be documented (e.g. OS bugs, memory limits, etc.)
- Poor management attitudes and culture
  - Maintenance is not high-profile
  - It is just patching code
  - Easier/less important than design

```
...  ...  @@ -51,10 +51,12 @@ public void onModuleLoad() {
51   51       try {
52   52         displayset.add( tabMe.renderTable( dSMngr.getDataSet( (long) 1 ) ));
53   53       } catch (DataSetNotPresentException e) {
54        -       // TODO Auto-generated catch block
     54   +       // TODO: Some kind of intelligent response to a missing DataSet
55   55         e.printStackTrace();
56   56       }
57   57
     58   +
     59   +     // TODO: What does this hideous block of code actually do?
58   60       HorizontalPanel buttonPanel = new HorizontalPanel();
59   61       buttonPanel.setHorizontalAlignment(HasHorizontalAlignment.ALIGN_CENTER);
60   62       root.add(buttonPanel, 0, 50);
...  ...  @@ -80,18 +82,33 @@ public void onFinish(IUploader uploader) {
80   82                 }
81   83               });
82   84             }
83        -       });
     85   +       });
```

Class Question

If we build a game like Forza Horizon 5 (car racing video game), do we ever need to change the application's source code?

When? Why?



Reasons for evolutionary changes

Corrective

- correct faults in system behaviour
- caused by errors in coding, design or requirements

Adaptive

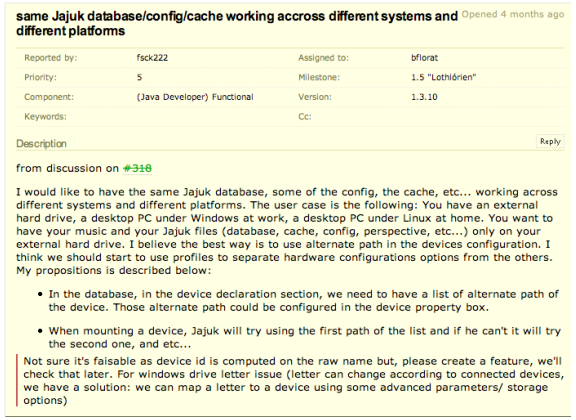
- due to changes in operating environment
- e.g., different hardware or operating system

Perfective

- due to changes in requirements
- often triggered by organizational, business or user learning

Class Exercise – Evolutionary Changes [https://bit.ly/3UXDtXr]

For each of the three tasks / issues of open source software systems, determine whether the requested change is corrective, adaptive, or perfective.



same Jajuk database/config/cache working accross different systems and different platforms Opened 4 months ago

Reported by:	fsck222	Assigned to:	bflorat
Priority:	5	Milestone:	1.5 "Lothlórien"
Component:	(Java Developer) Functional	Version:	1.3.10
Keywords:		Cc:	

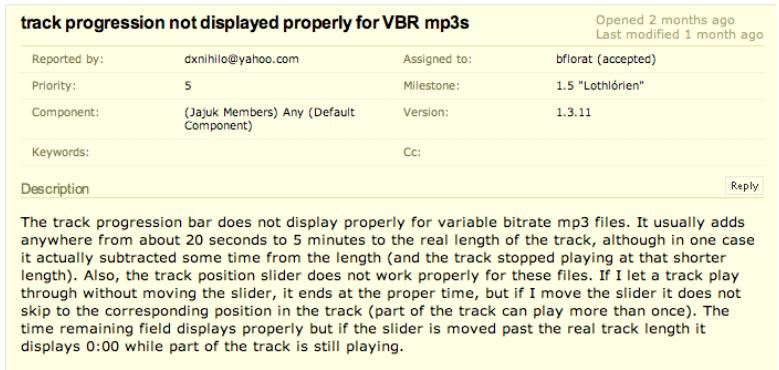
Description Reply

from discussion on ~~#318~~

I would like to have the same Jajuk database, some of the config, the cache, etc... working across different systems and different platforms. The user case is the following: You have an external hard drive, a desktop PC under Windows at work, a desktop PC under Linux at home. You want to have your music and your Jajuk files (database, cache, config, perspective, etc...) only on your external hard drive. I believe the best way is to use alternate path in the devices configuration. I think we should start to use profiles to separate hardware configurations options from the others. My propositions is described below:

- In the database, in the device declaration section, we need to have a list of alternate path of the device. Those alternate path could be configured in the device property box.
- When mounting a device, Jajuk will try using the first path of the list and if he can't it will try the second one, and etc...

> Not sure it's faisable as device id is computed on the raw name but, please create a feature, we'll check that later. For windows drive letter issue (letter can change according to connected devices, we have a solution: we can map a letter to a device using some advanced parameters/ storage options)

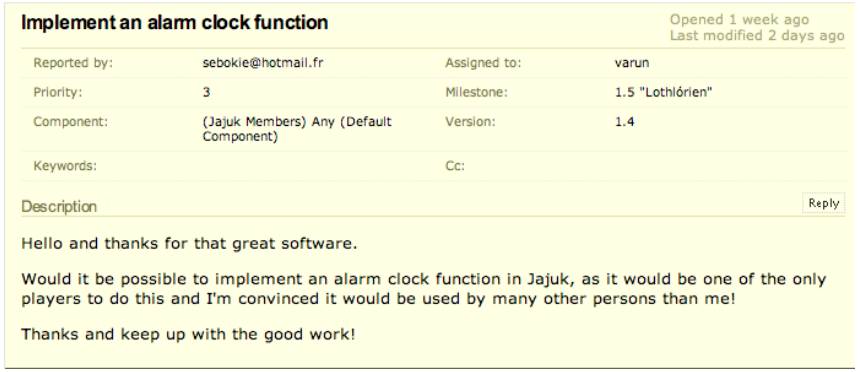


track progression not displayed properly for VBR mp3s Opened 2 months ago Last modified 1 month ago

Reported by:	dxnihilo@yahoo.com	Assigned to:	bflorat (accepted)
Priority:	5	Milestone:	1.5 "Lothlórien"
Component:	(Jajuk Members) Any (Default Component)	Version:	1.3.11
Keywords:		Cc:	

Description Reply

The track progression bar does not display properly for variable bitrate mp3 files. It usually adds anywhere from about 20 seconds to 5 minutes to the real length of the track, although in one case it actually subtracted some time from the length (and the track stopped playing at that shorter length). Also, the track position slider does not work properly for these files. If I let a track play through without moving the slider, it ends at the proper time, but if I move the slider it does not skip to the corresponding position in the track (part of the track can play more than once). The time remaining field displays properly but if the slider is moved past the real track length it displays 0:00 while part of the track is still playing.



Implement an alarm clock function Opened 1 week ago Last modified 2 days ago

Reported by:	sebokie@hotmail.fr	Assigned to:	varun
Priority:	3	Milestone:	1.5 "Lothlórien"
Component:	(Jajuk Members) Any (Default Component)	Version:	1.4
Keywords:		Cc:	

Description Reply

Hello and thanks for that great software.

Would it be possible to implement an alarm clock function in Jajuk, as it would be one of the only players to do this and I'm convinced it would be used by many other persons than me!

Thanks and keep up with the good work!

What is the reason for this change?

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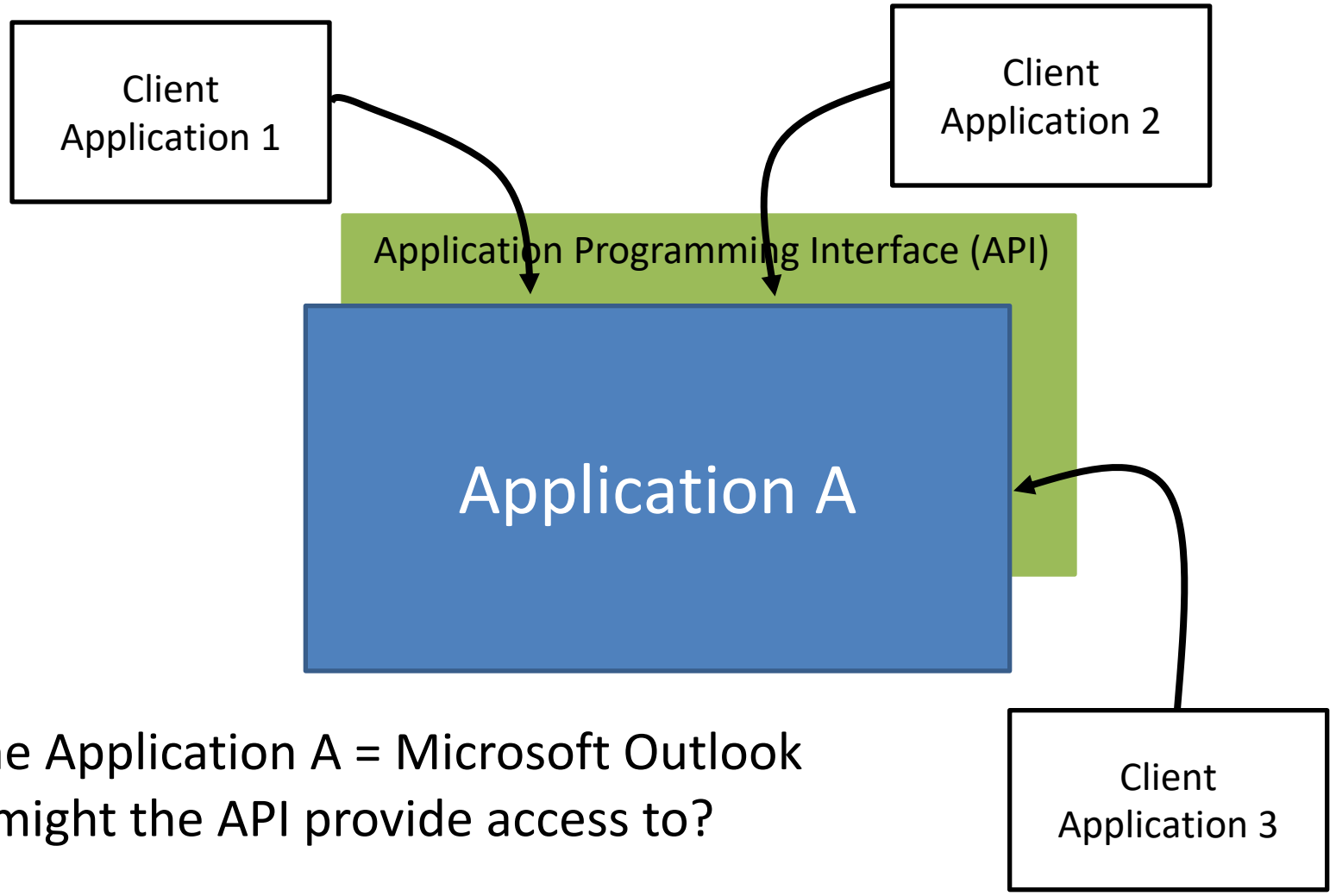
Evolution and Compatibility

Learning Objectives

Be able to:

- Reason about binary and contract compatibility of a change

Evolution and Compatibility



Imagine Application A = Microsoft Outlook
What might the API provide access to?
Why?

API (Java perspective)

e.g., Moyosoft Java Outlook Connector

```
public class SendMail {
   public static void main(String[] args) {
      try {
         // Outlook application
         Outlook outlookApplication = new Outlook();

         // Get the Outbox folder
         OutlookFolder outbox = outlookApplication.getDefaultFolder(
                                    FolderType.OUTBOX);
         // Create a new mail in the outbox folder
         OutlookMail mail = (OutlookMail) outbox.createItem(ItemType.MAIL);
         // Set the subject, destination and contents of the mail
         mail.setSubject("Hello world !");
         mail.setTo("your_email@test.com");
         mail.setBody("This is a test message.");
         // Send the mail
         mail.send(); ...
```

Evolving a Java-based API – binary compatibiltiy

Evolving a Java-based API

What kind of changes to the Java API code can we make to maintain **binary compatibility** so that existing (already compiled) applications using the API do not break?

1. Add a new (Java) package to the API?
2. Change name of a public method in a public class?
3. Change the name of a parameter to a method?
4. Re-order methods in a class declaration?
5. Add an unchecked exception thrown to an API method?
6. Change an API method from public access to protected access?
7. Add API field?

See http://wiki.eclipse.org/Evolving_Java-based_APIs_2 (rather than memorizing, try to understand the basic kinds of changes)

API Contract Compatibility

API changes must not invalidate formerly legal Client code.

Consider the following API method specification.

```
/** Returns the list of children of this widget.
  * @return a non-empty list of widgets
  */
Widget[] getChildren();
```

API Contract Compatibility I

What if that specification was changed in a revised API to allow an empty list of widgets to be returned?

```
/** Returns the list of children of this  widget.
  * @return a list of widgets
  */
Widget[] getChildren();
```

Could this change break a client who calls `getChildren()`? Why or why not?

API Contract Compatibility II

What about this one?

```
/** Removes the given widgets from this widget's list of children.
  * @param widgets a non-empty list of widgets
  */
void remove(Widget[] widgets);
```

changes to

```
/** Removes the given widgets from this widget's list of children.
  * @param widgets a list of widgets
  */
void remove(Widget[] widgets);
```

API Contract Compatibility..

Method pre-conditions	Strengthen	Breaks compatibility for callers
	Weaken	Contract compatible for callers
Method post-conditions	Strengthen	Contract compatible for callers
	Weaken	Breaks compatibility for callers

For more, see: http://wiki.eclipse.org/index.php/Evolving_Java-based_APIs
This is just part of the story of contract compatibility as the compatibility depends on the role of the client code.

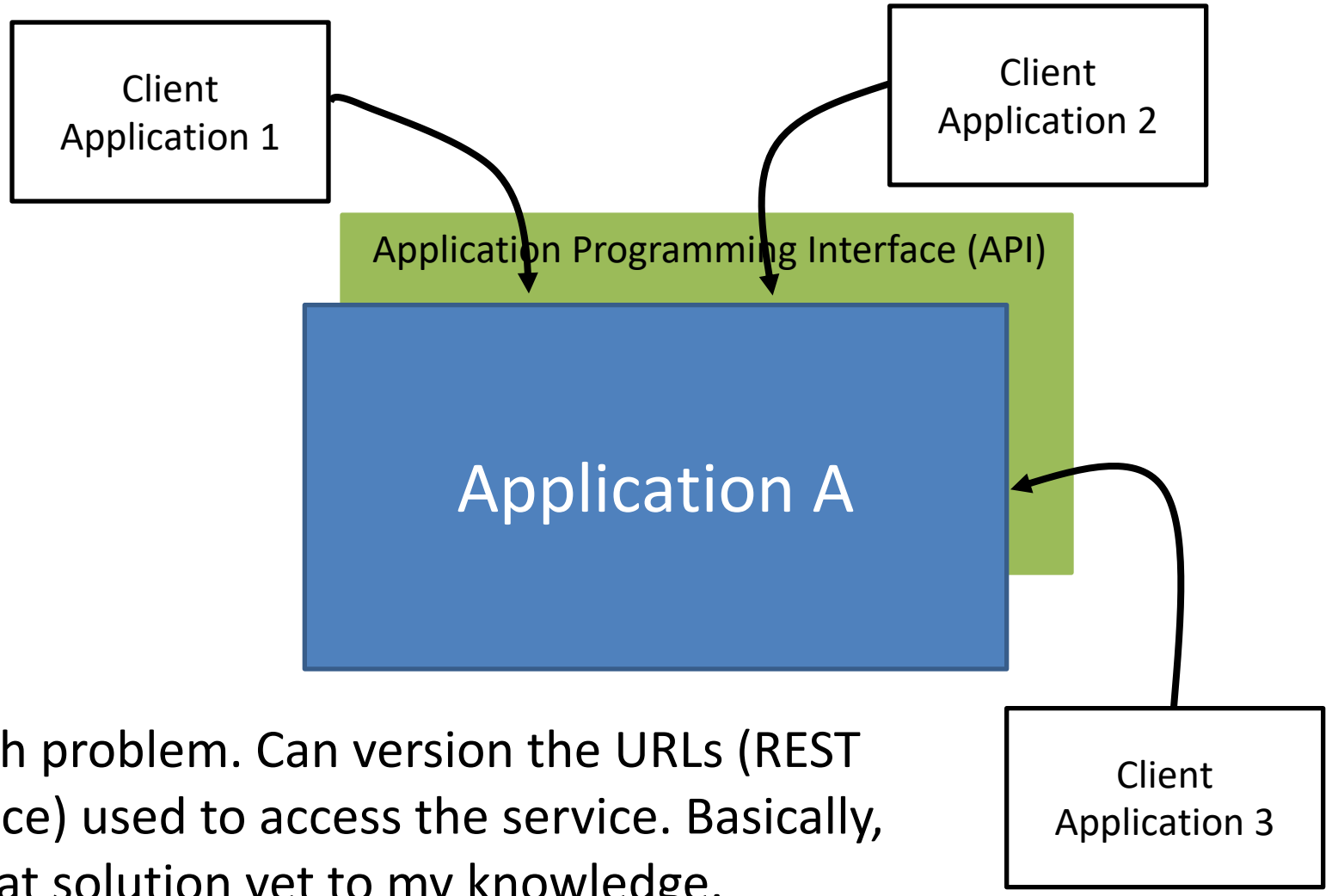
Coping with API evolution

What if you need to upgrade part of an API and it breaks compatibility?

a) add new API elements alongside the old
e.g., search() and search2()

b) deprecate the old “version” of the API

What if the API is to a web service?



A tough problem. Can version the URLs (REST interface) used to access the service. Basically, no great solution yet to my knowledge.

Issue Trackers (Tracking Evolution)

Learning Objectives

Be able to:

- Describe the role of issue tracking systems
- Discuss the life cycle of a bug report, criteria for writing a good one and general steps for working on one

Class Question

Which issue trackers do you know and/or have you used?

Why are issue trackers useful?

Issue Tracking Systems

Manage development requests (also called bug reports, work items, change requests, change tasks)

Maintain a list of bugs in the software

- In a database called the bug repository

Assign responsibility for each bug, feature, or task

Organize the work to be done

- Life cycle of a bug report

Break up the work into “releases” or other deadlines

Issues / Bug Reports / Work Items

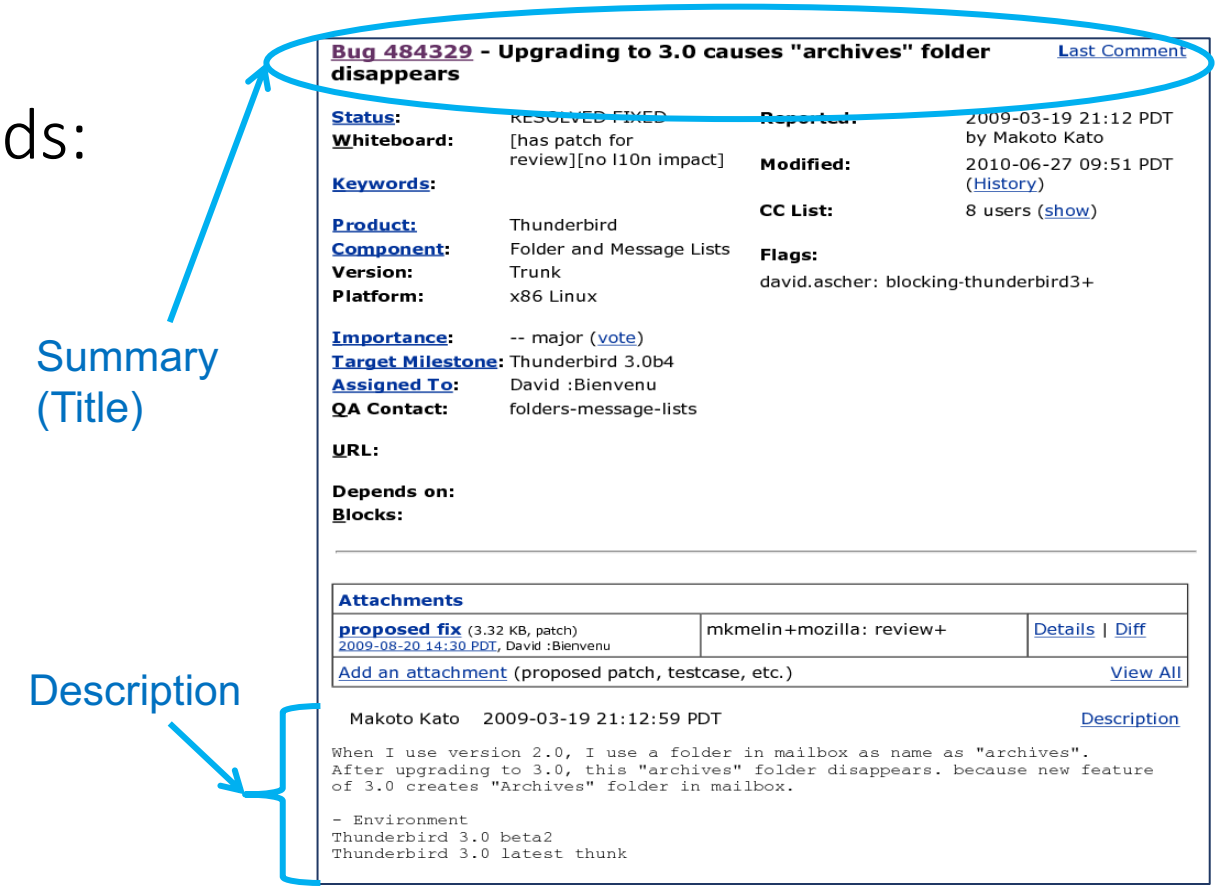
Are often the major piece of information in software development teams

- Contain the rationale for changes (provide documentation)
- Contain the links to related documents
- Contain information on the people who are involved
- ….

Anatomy of a bug report

A bug report has the following fields:

Title (also called Summary)
Description
Status
Assignee
Priority
Target Milestone
...
Comments



https://bugzilla.mozilla.org/page.cgi?id=fields.html

Summary of Bug Report Writing Guidelines (Mozilla)

- Be precise
- Be clear - explain it so others can reproduce the bug
- One bug per report
- No bug is too trivial to report - small bugs may hide big bugs
- Clearly separate fact from speculation

Based on:
https://developer.mozilla.org/en/Bug_writing_guidelines

Guidelines cont’d

A good *summary (title)* should

- quickly and uniquely identify a bug report
- explain the problem, not your suggested solution
- Good: "Cancelling a File Copy dialog crashes File Manager”
- Bad: "Software crashes”
- Bad: "Browser should work with my web site“

A good *description* should include

- Enough context
- Overview, steps to reproduce, actual results, expected results
- Survey study found most helpful information to be: Steps to reproduce, stack traces, test cases

T.Zimmerman et al., “*What makes a good bug report*”, IEEE Transactions on Software Engineering, vol. 36, No. 5, Sep./Oct. 2010

Role of bug report comments

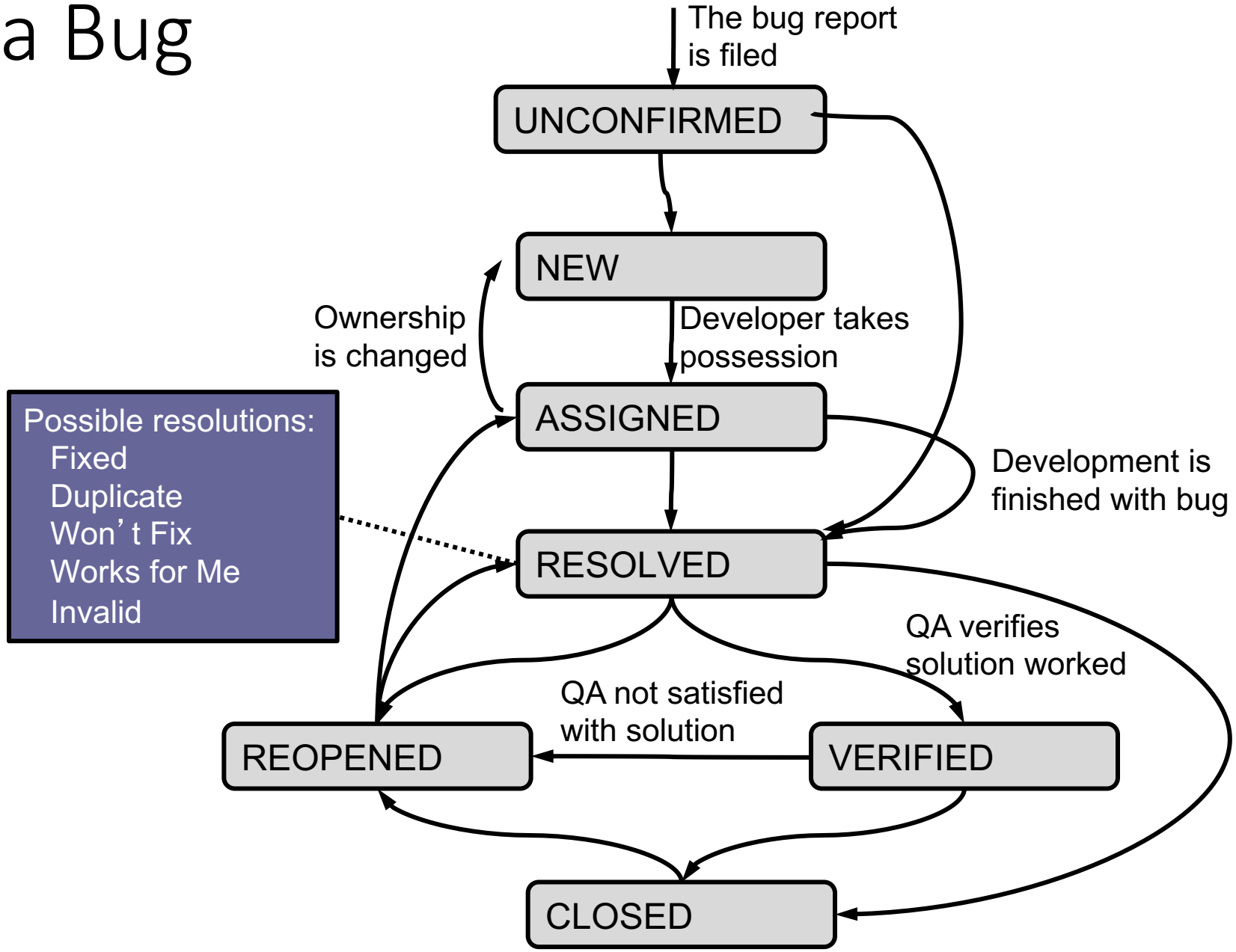
Discussion among reporters and developers

Might be the only way of communication for a distributed development team (different locations, time zones)

Even when the developers have a mean of communicating face-to-face, it provides a way of documenting the history of the development process and the rationale.

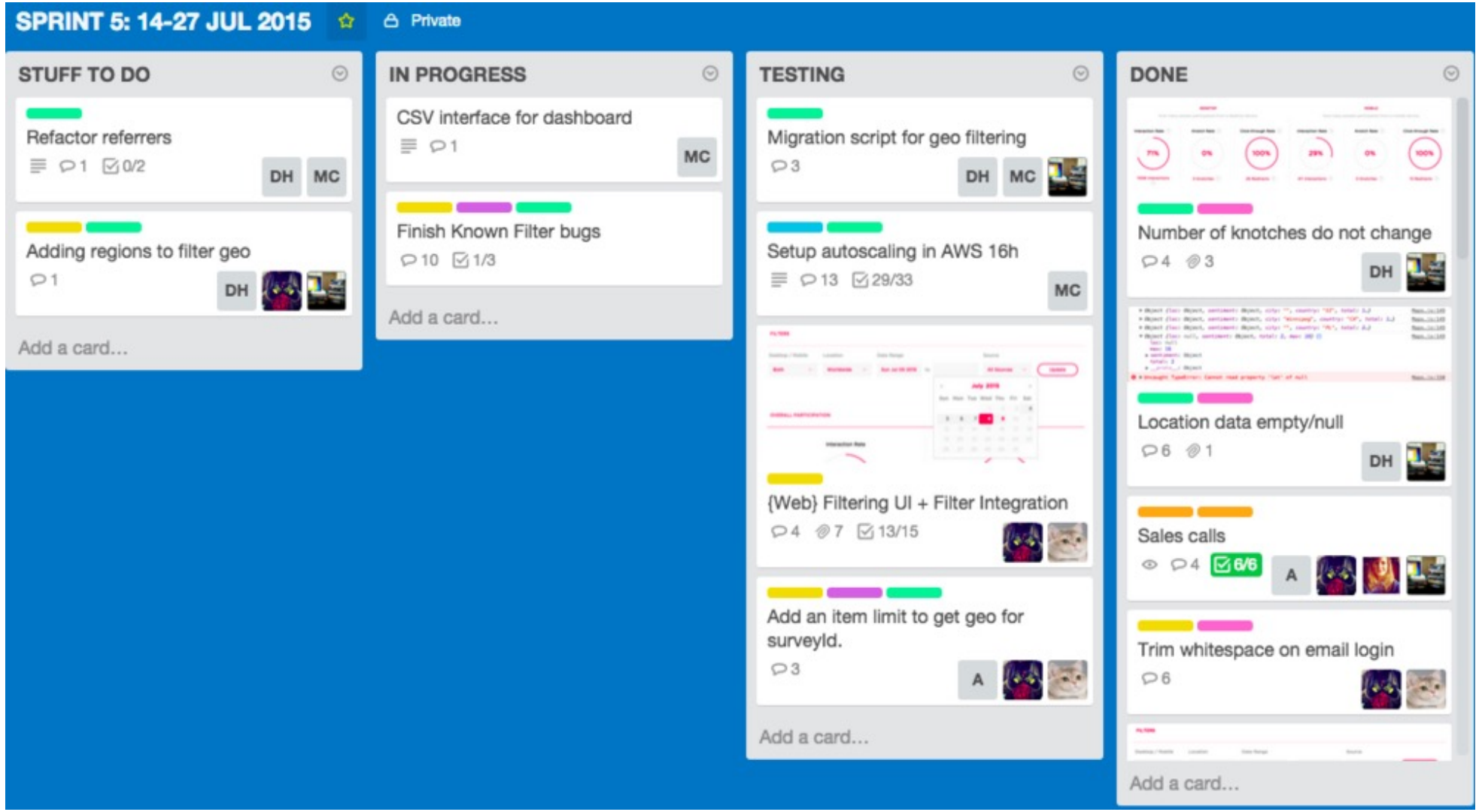
- e.g. why it was decided to fix a bug in a certain way.

Life Cycle of a Bug

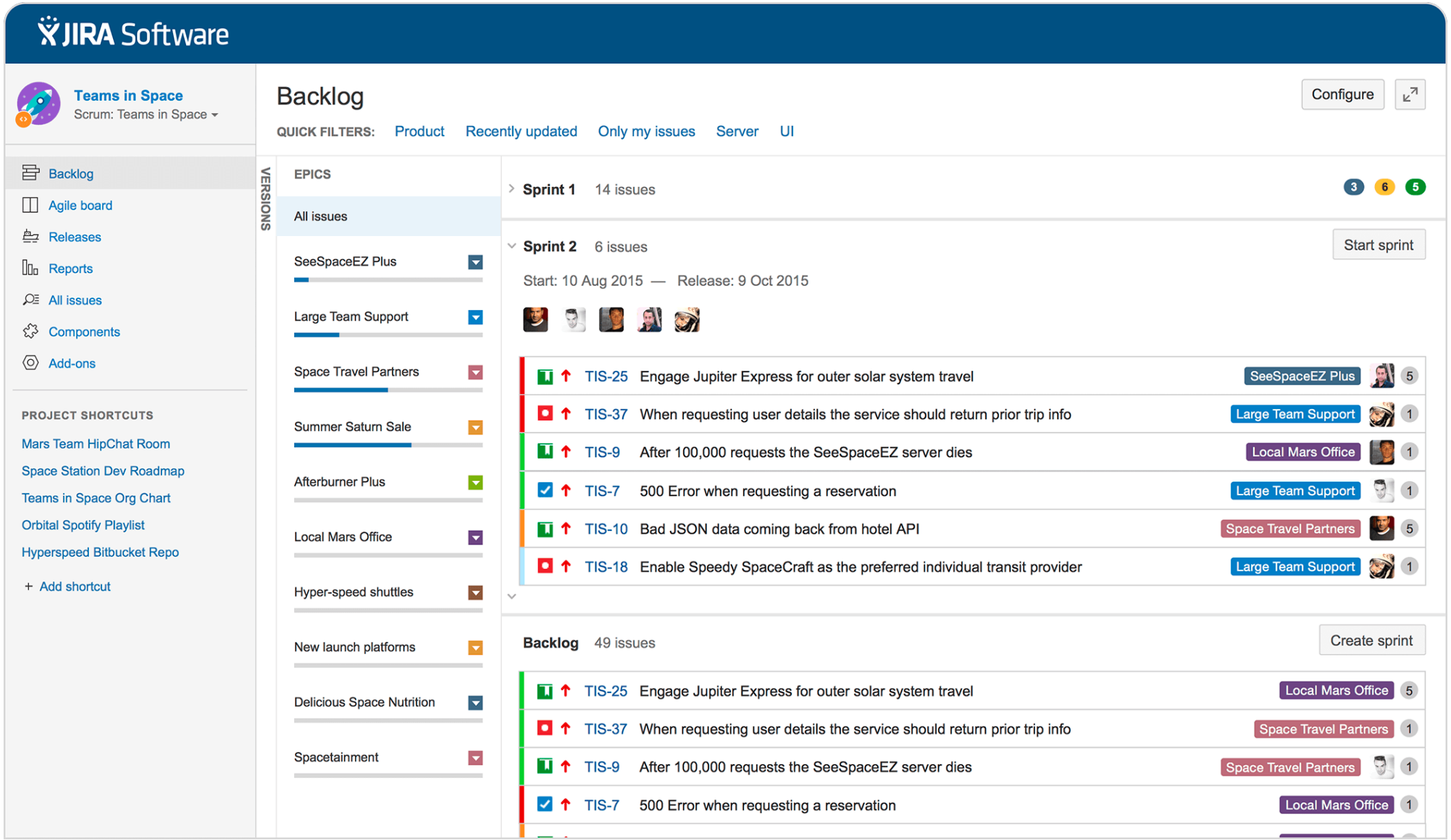


Based on:
http://www.bugzilla.org/docs/2.16/html/how.html#lifecycle-image

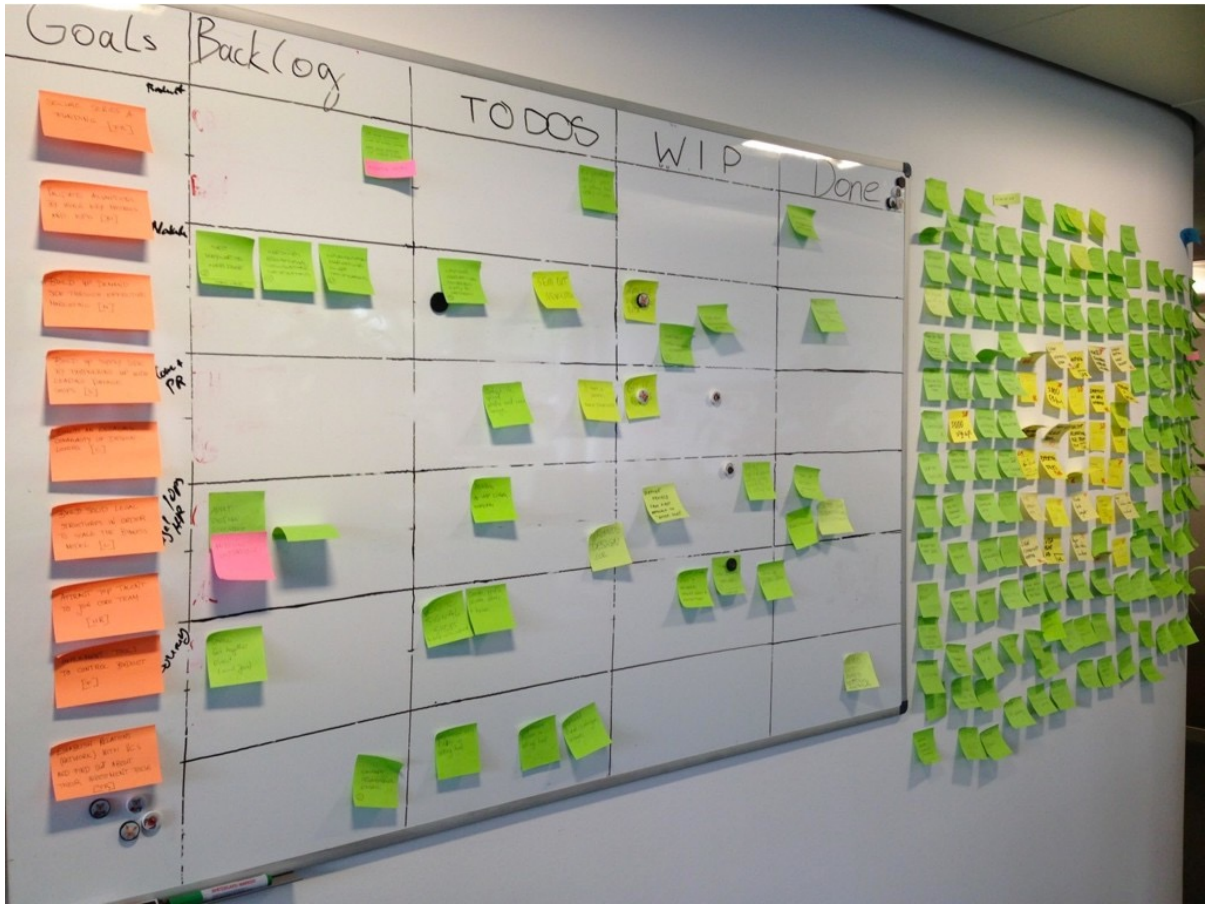
Recap: User stories and sprint (dashboard)



Many issues/bugs



Keeping track of issues



Fixing a bug / making a change

Learning Objectives

Be able to:

- Describe the steps and activities for fixing a bug

Class Questions:
1. How do you perform a change task?
2. What do you spend time on when fixing a bug?

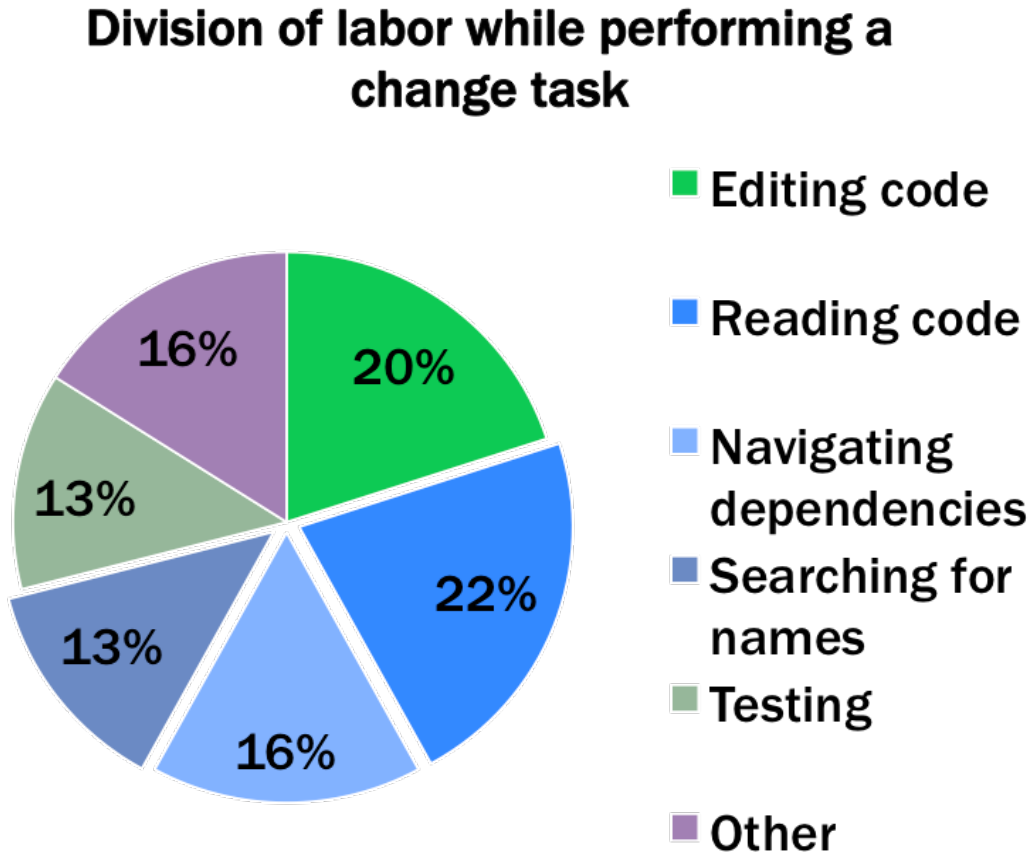
Summary:
Application crash on clicking the SAVE button while creating a new user.

Description:
Application crash on clicking the SAVE button while creating a new user, hence unable to create a new user in the application

Steps to reproduce:
1) Logon into the application
2) Navigate to the Users Menu > New User
3) Filled all the user information fields
4) Clicked on 'Save' Button
5) Seen an error page "ORA1090 Exception: Insert values Error…"
6) See attached logs for more information and also attached screenshot

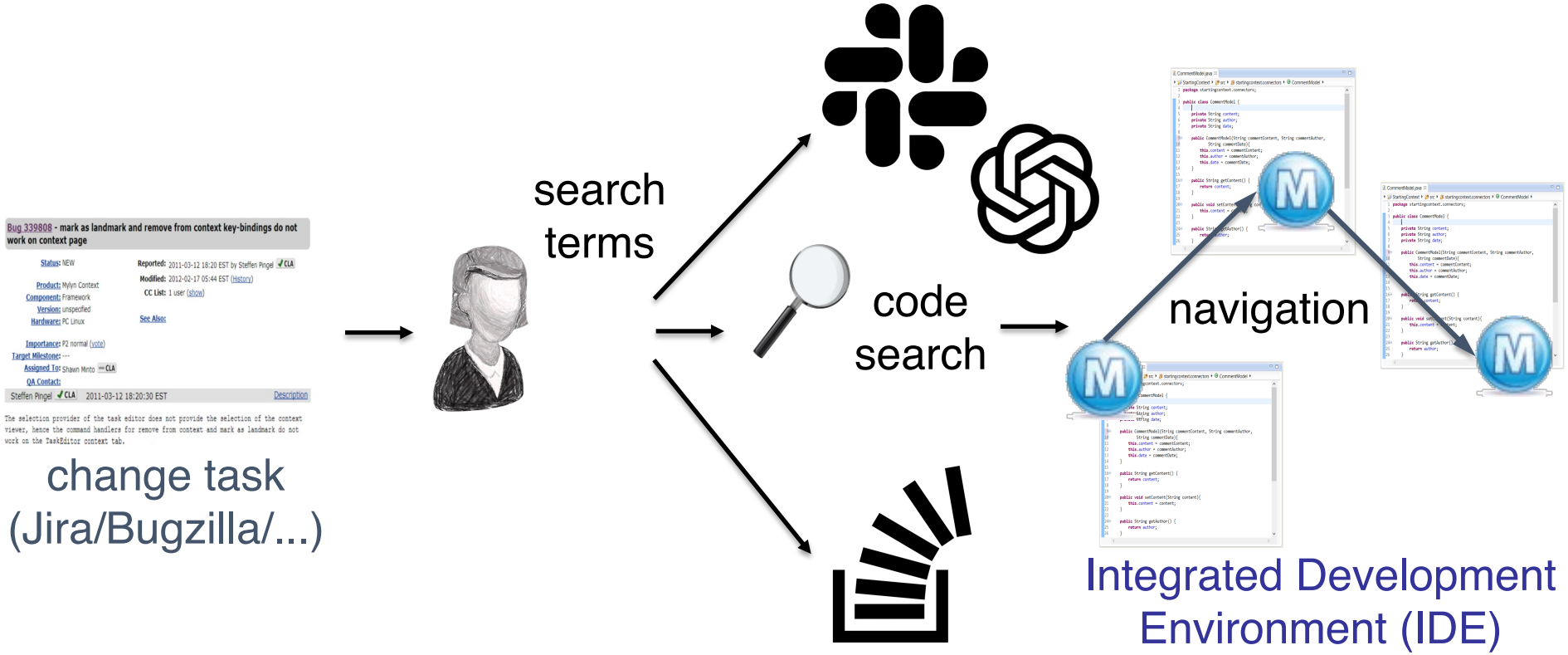
http://www.softwaretestinghelp.com/sample-bug-report/

Time spend during change tasks



Amy J. Ko, Htet Aung, and Brad A. Myers. Eliciting design requirements for maintenance-oriented ides: a detailed study of corrective and perfective maintenance tasks. ICSE ’05.

Working on a change task…



…eventually editing

Working on a change task

Problems/Difficulties:

- Too much code to understand/read all
- Language mismatch: bug reports (NL) ≠ source code
- Crosscutting concerns: code is often tangled and scattered

…

To localize and edit relevant code…

- Identify good search terms
- Take advantage of tool support, e.g. code search, structural navigation support, breakpoints (debugging)
- Take advantage of information provided in bug reports, such as stack traces, and on Q&A forums, such as stackoverflow

Fixing a bug IN ACTION

Learning Objectives

Be able to:

- Perform the steps to successfully fix a small bug

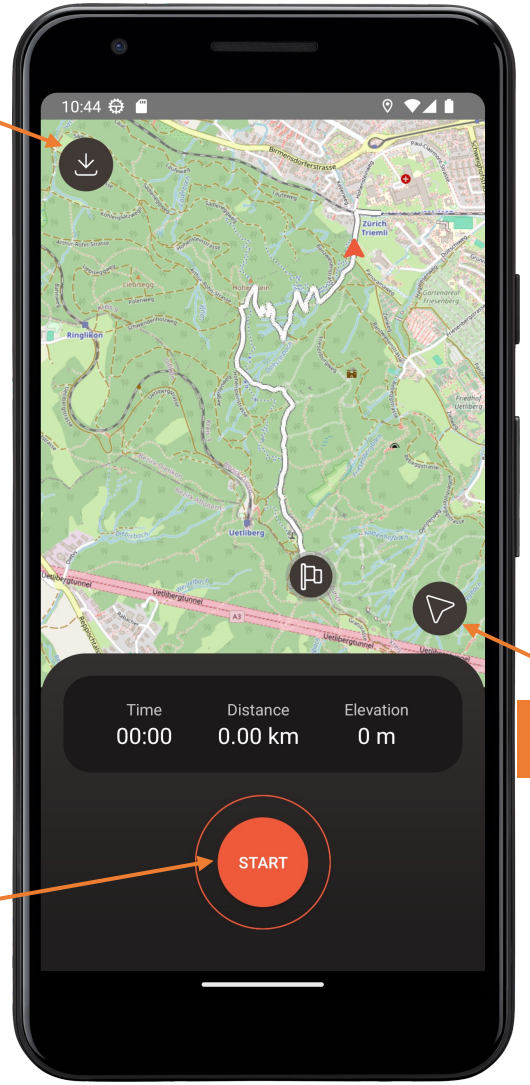
Software Evolution Task – Setup

1. Install and use **JAVA 17** on your machine
2. Download and Install Android Studio on your machine https://developer.android.com/studio/install
3. Open Android Studio and finish the setup procedure, by going through the setup wizard and selecting all default options
4. Download the file **gps-alarm.zip** from OLAT
5. Unzip the file, open Android Studio, under projects click "Open" and select the folder which you have unzipped before
6. Click on the green run button on the top right, select “gps-alarm-se2024-evolution-task.app.main” as the module, press “Run” & the app should start in the emulator (if the green button does not appear, restart Android Studio, if there is an error stating “SDK location not found” click the elephant with the blue arrow “Sync Project with Gradle Files”)
7. On top tool bar in the emulator window click on the three dots (extended controls). Then under location/routes click on "Import GPX/KML" and select the GPXfile under **app/src/main/assets/uetliberg_with_timestamps.gpx**

Software Evolution Task – Current Application

App description:

- *GPSAlarm* is an Android app which assists users on their hiking tracks.
- A user can import a GPX route and then start the monitoring during the hike.
- The app requests the live GPS data from the device and warns the users if they leave the track.

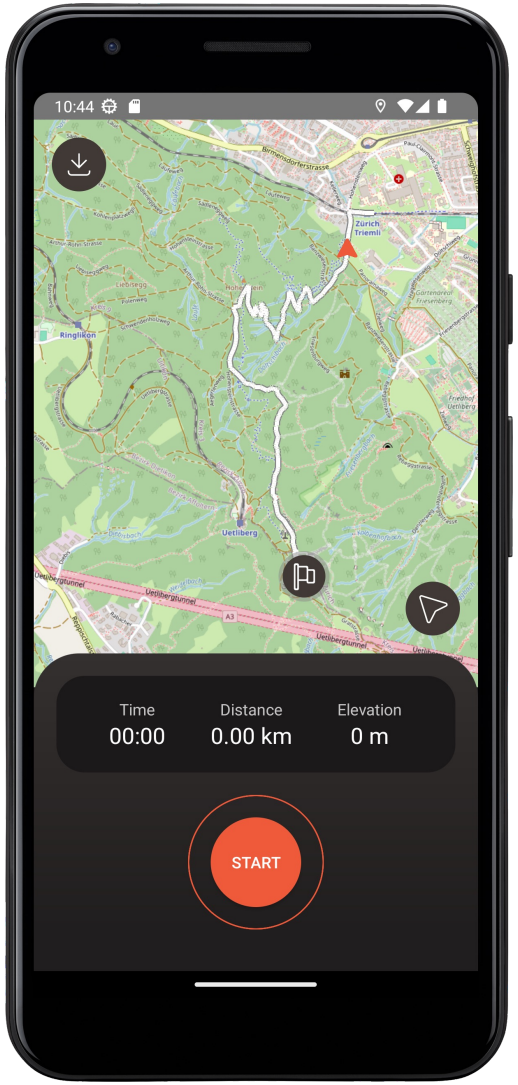


Software Evolution Task – Bug Fix (10 min)

There's a bug in the app which causes it to crash as soon as one clicks on the Start button.

Task: Reproduce the bug in the emulator. Find it in the codebase and finally fix the bug.

Hint: The stack trace of an exception can be found by opening the logcat output (bottom left cat icon in Android Studio)



Software Evolution Task – Steps to fix the bug

1. Reproduce the bug
2. Understand the bug:
   - Debugging
   - Inspecting code
3. Fix the bug
4. Test the bugfix

Software Evolution Task – Steps to fix the bug

1. Reproduce the bug
2. Understand the bug:
   - Debugging
   - Inspecting code

```
E FATAL EXCEPTION: main
  Process: ch.nilsgrob.android.gpsalarm, PID: 8396
  java.lang.NullPointerException: Attempt to read from field 'double android.location.Location.mLatitudeDegrees' on a null object reference in method 'float android.location.Location.distanceTo(android.location.Location)
      at android.location.Location.distanceTo(Location.java:196)
      at ch.nilsgrob.android.gpsalarm.core.model.Route.onLocationChanged(Route.java:14)
      at ch.nilsgrob.android.gpsalarm.core.model.RouteLiveData.updateLocation(RouteLiveData.java:18)
      at ch.nilsgrob.android.gpsalarm.core.location.GpsAlarmLocationListener.onLocationChanged(GpsAlarmLocationListener.java:34)
      at android.location.LocationListener.onLocationChanged(LocationListener.java:63)
      at android.location.LocationManager$LocationListenerTransport$1.operate(LocationManager.java:3234)
      at android.location.LocationManager$LocationListenerTransport$1.operate(LocationManager.java:3231)
      at com.android.internal.listeners.ListenerExecutor.lambda$executeSafely$0(ListenerExecutor.java:127)
      at com.android.internal.listeners.ListenerExecutor$$ExternalSyntheticLambda0.run(Unknown Source:8)
      at android.os.Handler.handleCallback(Handler.java:942)
      at android.os.Handler.dispatchMessage(Handler.java:99)
      at android.os.Looper.loopOnce(Looper.java:201)
      at android.os.Looper.loop(Looper.java:288)
      at android.app.ActivityThread.main(ActivityThread.java:7898) <1 internal line>
      at com.android.internal.os.RuntimeInit$MethodAndArgsCaller.run(RuntimeInit.java:548)
      at com.android.internal.os.ZygoteInit.main(ZygoteInit.java:936)
```

Software Evolution Task – Bug Fix Solution

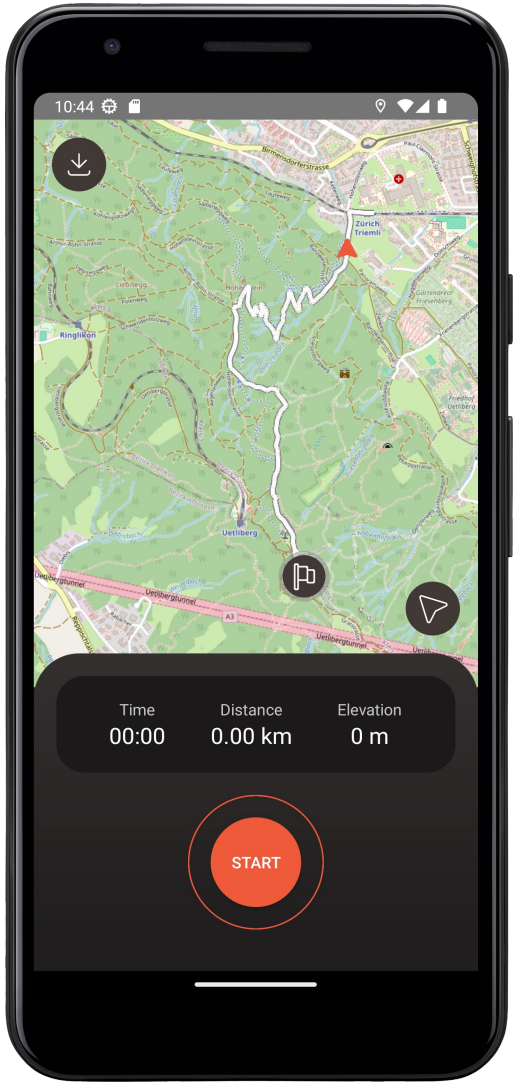
Missing null check in *GpsAlarmLocationListener* class

```
public class GpsAlarmLocationListener implements LocationListener {

   private IPerimeter perimeter;
   private Context ctx;
   private RouteLiveData routeLiveData;
   private Location lastChangedLocation;

   public GpsAlarmLocationListener(Context ctx, TrackPerimeter aPerimeter, RouteLiveData aRoute) {
      this.ctx = ctx;
      this.perimeter = aPerimeter;
      this.routeLiveData = aRoute;
   }


   @Override
   public void onLocationChanged(@NonNull Location location) {
      Log.d("GPS_ALARM_LOCATION_LISTENER", "updated locations");
      triggerAlarmIfOutOfPerimeter(location);
      routeLiveData.updateLocation(location, lastChangedLocation);
      lastChangedLocation = location;
   }
```

```
public class GpsAlarmLocationListener implements LocationListener {

   private IPerimeter perimeter;
   private Context ctx;
   private RouteLiveData routeLiveData;
   private Location lastChangedLocation;

   public GpsAlarmLocationListener(Context ctx, TrackPerimeter aPerimeter, RouteLiveData aRoute) {
      this.ctx = ctx;
      this.perimeter = aPerimeter;
      this.routeLiveData = aRoute;
   }


   @Override
   public void onLocationChanged(@NonNull Location location) {
      Log.d("GPS_ALARM_LOCATION_LISTENER", "updated locations");
      triggerAlarmIfOutOfPerimeter(location);
      if (lastChangedLocation != null) routeLiveData.updateLocation(location, lastChangedLocation);
      lastChangedLocation = location;
   }
```

Software Evolution Task – Feature (25min)

- Currently when the user leaves the track only some text appears in the app, which can be overlooked/missed easily
- Open feature request: As a user I want the phone to vibrate and/or play a sound when I leave the track (and alarm is triggered)
- **Task: implement the feature request**
- **Hints:**
  - Read the documentation of the corresponding API
    - Media Player API (Sound)
    - Haptics API (Vibration) (more tricky since it requires physical device to test)
  - Inspect how the current ToastAlarm is implemented
  - A sound effect for testing purposes is located at: *app/src/main/res/raw/alarm_sound.mp3*



Software Evolution Task – Steps to implement feature

1. Understand the requirements
2. Understand how to use the API
   - Read the docs
   - Ask ChatGPT
   - Read sample code
3. Implement the feature
   - Follow existing conventions
4. Test the feature

Software Evolution Task – possible solution: sound

core/alarm/SoundAlarm.java

```
package ch.nilsgrob.android.gpsalarm.core.alarm;

import android.content.Context;
import android.media.MediaPlayer;

import ch.nilsgrob.android.gpsalarm.R;

public class SoundAlarm implements IAlarm {
    @Override
    public void trigger(Context ctx) {
        MediaPlayer mediaPlayer = MediaPlayer.create(ctx, R.raw.alarm_sound);
        mediaPlayer.start();
        mediaPlayer.setOnCompletionListener(MediaPlayer::release);
    }
}
```

core/location/GpsAlarmLocationListener.java

```
private void triggerAlarmIfOutOfPerimeter(Location location){
    boolean shouldTriggerAlarm = !perimeter.isCurrentGPSLocationInPerimeter(location);
    if (shouldTriggerAlarm){
        new ToastAlarm().trigger(this.ctx);
        new SoundAlarm().trigger(this.ctx);
    }
}
```

Software Evolution Task – possible solution: vibration

core/alarm/VibrationAlarm.java

```
package ch.nilsgrob.android.gpsalarm.core.alarm;

import android.content.Context;
import android.os.Build;
import android.os.VibrationEffect;
import android.os.Vibrator;

import androidx.annotation.RequiresApi;

public class VibrationAlarm implements IAlarm {

    @RequiresApi(api = Build.VERSION_CODES.O)
    @Override
    public void trigger(Context ctx) {
        Vibrator vibrator = ctx.getSystemService(Vibrator.class);
        if (vibrator == null) return;

        long[] timings = new long[]{50, 50, 50, 50, 50, 100, 350, 25, 25, 25, 25, 200};
        int[] amplitudes = new int[]{33, 51, 75, 113, 170, 255, 0, 38, 62, 100, 160, 255};
        int repeatIndex = -1; // Do not repeat.

        VibrationEffect vibrationEffect = VibrationEffect.createWaveform(timings, amplitudes, repeatIndex);

        vibrator.vibrate(vibrationEffect);
    }
}
```

core/location/GpsAlarmLocationListener.java

```
private void triggerAlarmIfOutOfPerimeter(Location location){
    boolean shouldTriggerAlarm = !perimeter.isCurrentGPSLocationInPerimeter(location);
    if (shouldTriggerAlarm){
        new ToastAlarm().trigger(this.ctx);
        // Only execute on devices which support this API
        if (Build.VERSION.SDK_INT >= Build.VERSION_CODES.O) {
            new VibrationAlarm().trigger(this.ctx);
        }
    }
}
```

Quiz

Quiz

1. You are maintaining code for a system that other companies are using.

```
public class Employee {
  private float commission;
  private float getCommission() {..}
  public float calculateSalary(float companyProfit, int numberOfEmployees) {..}
```

Now you are changing the code and make the following modifications. Please state for each of the following statements whether it is true/correct or false/incorrect.

```
public class Employee {
  private float commission;
  public float calculateSalary(float profit, int employeesCount) {..}}
```

a) The change does not break binary compatibility.

b) The renaming of the parameters in the “calculateSalary” method breaks binary compatibility.

c) Removing the “getComission” method breaks binary compatibility.

d) Regardless of compatibility, before removing the method getCommission, it should be marked as deprecated for some time.

Quiz

2. Assess whether the following statement is true/correct or false/incorrect:

Changing the access level of a field from public to protected breaks binary compatibility. [True]

Quiz

3. Your team plans to deprecate certain features in your software API that have become obsolete due to technological advancements. You aim to ensure that the deprecation process is clear to clients and does not immediately disrupt their current implementations. For each of the following statements, select whether it is true or false.

a) Marking an API method as deprecated provides a warning to developers but does not prevent the method's usage.

b) Marking an API method as deprecated immediately results in binary incompatibility (i.e. it breaks binary compatibility).

Quiz

4. You are using a version control system, where after making local commits, you push your changes to a shared repository. This version control system you are using is:

a) A centralized version control system.

b) A distributed version control system.

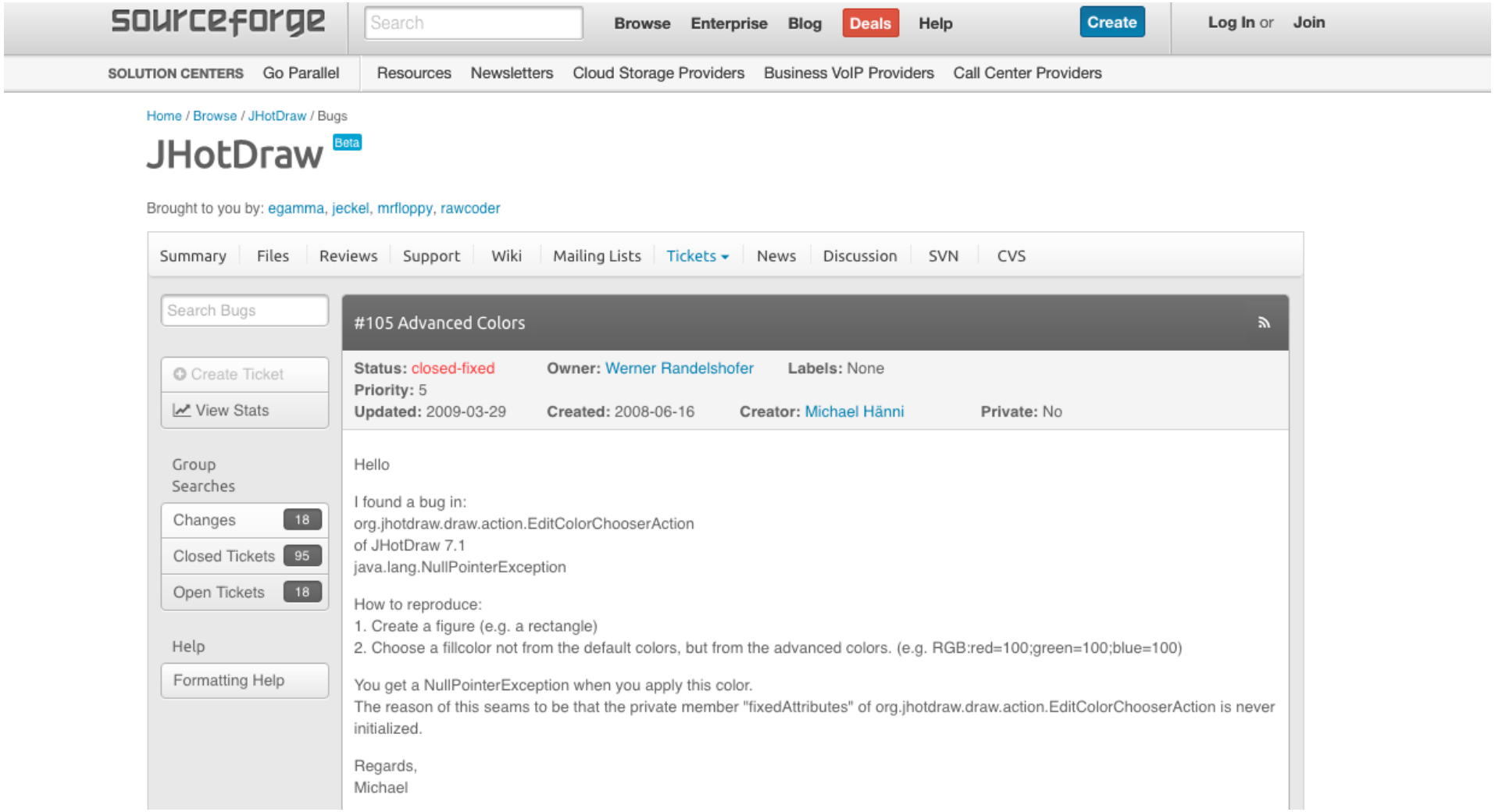
Fixing ANOTHER bug IN ACTION (by yourself)

Learning Objectives

Be able to:

- Perform the steps to successfully fix a small bug

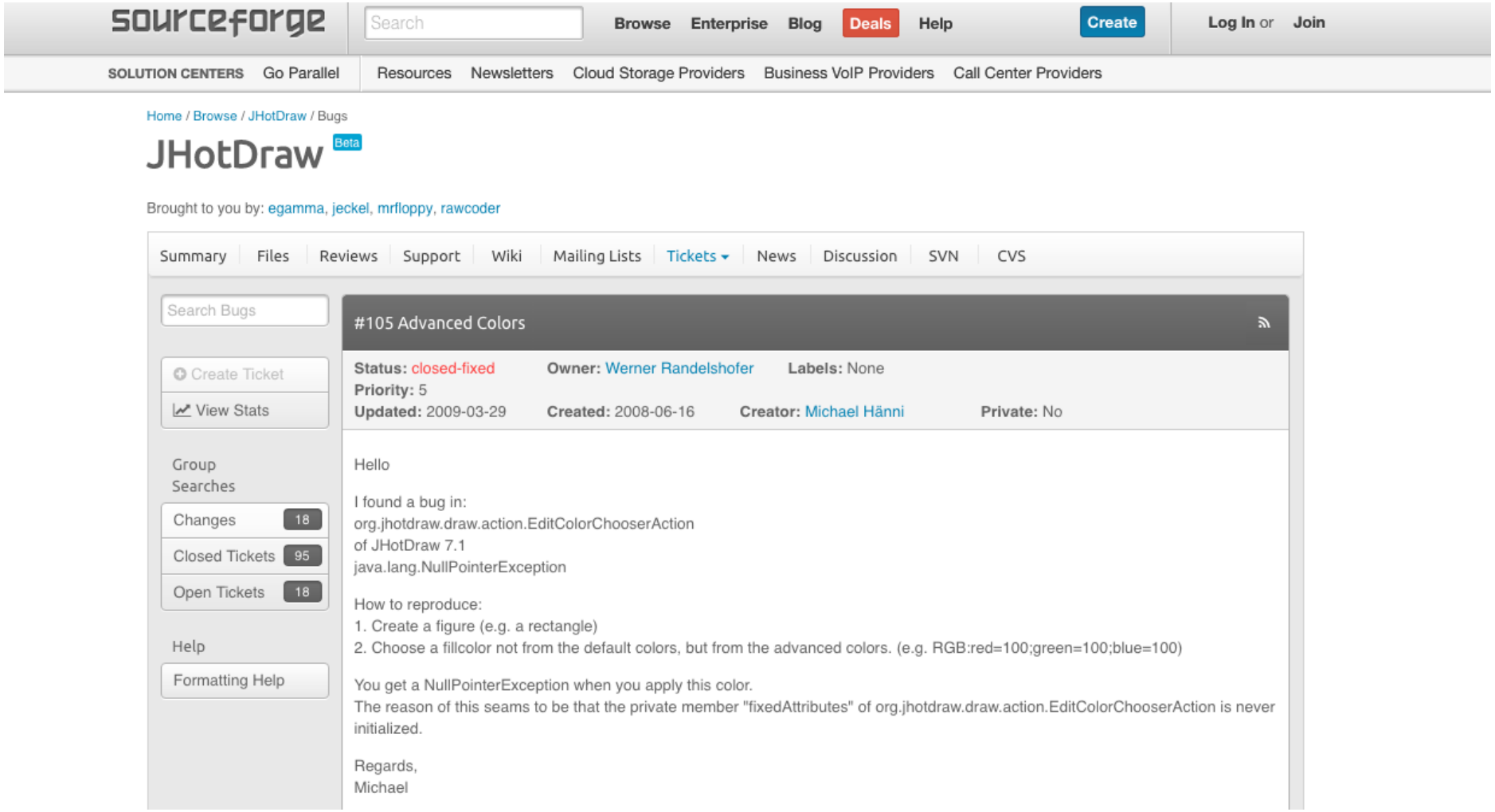
Evolution in action



https://sourceforge.net/p/jhotdraw/bugs/105/

https://sourceforge.net/p/jhotdraw/bugs/search/?q=status%3Awont-fix+or+status%3Aclosed-invalid+or+status%3Aclosed-later+or+status%3Aclosed-duplicate+or+status%3Aclosed-accepted+or+status%3Aclosed-remind+or+status%3Aclosed+or+status%3Aclosed-fixed

What kind of task? Corrective / adaptive / perfective



https://sourceforge.net/p/jhotdraw/bugs/105/

Evolution in action (~ 15mins, by yourself)

1. Download jHotDraw from OLAT
   - JHotDraw7.zip
2. Open VS Code, Eclipse (or the IDE of your choice)
3. Import JHotDraw
   - In VS Code: File > Open Folder…
     - Make sure to have the JDK set properly
   - In Eclipse: Package Explorer > Import > General > Projects from Folder or Archive > Archive

Evolution in action (~ 15mins, by yourself)

4. Adjust JRE (JHotDraw7)
   - In Eclipse: go to Help > Search > “Assigning the default JRE for the workbench”, click on “Java > Installed JREs”, select 1.8
   - In VS Code: make sure to configure runtime for projects and it’s at 1.8 (Command Palette Shift + Command + P) “Java: Configure Java Runtime”

     to install a new JDK use “Java: Install New JDK” in Command Palette

Evolution in action (~ 15mins, by yourself)

5. Run JHotDraw

   In VS Code: Run > Run without Debugging;

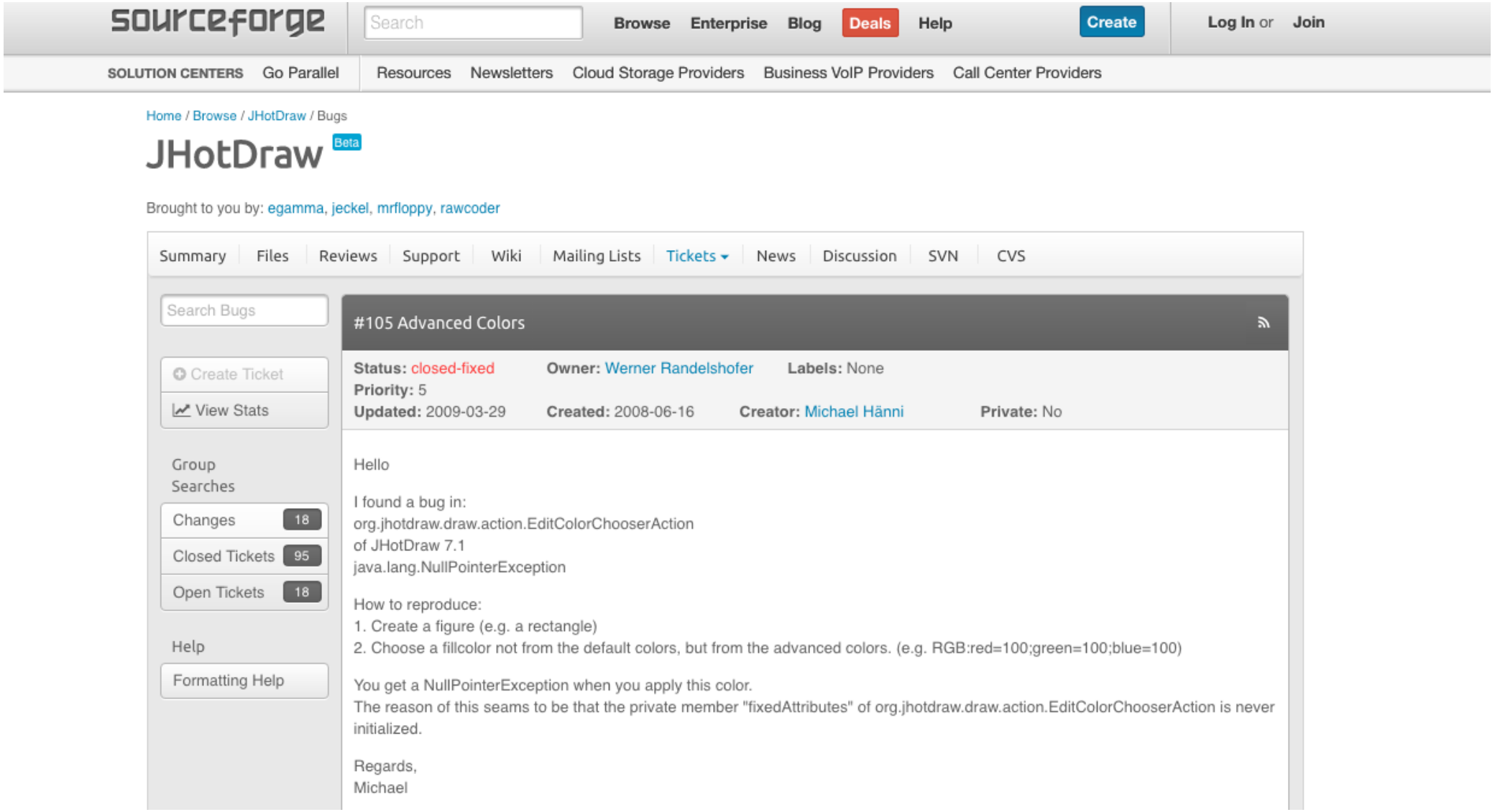
   In Eclipse: Run As > Java Application;

   Select **Main** class org.jhotdraw.samples.draw

6. Fix the bugs

→ What are the steps you took to fix the bug, where is it, and how did you fix it?

Fix the bug: first steps?



Evolution in action: first steps

Steps

1. Reproduce the bug
    a) Create a figure
    b) Choose advanced fill color
2. Examine Exception in Console
3. Set breakpoint → debug → inspect values

    / search for possible classes