

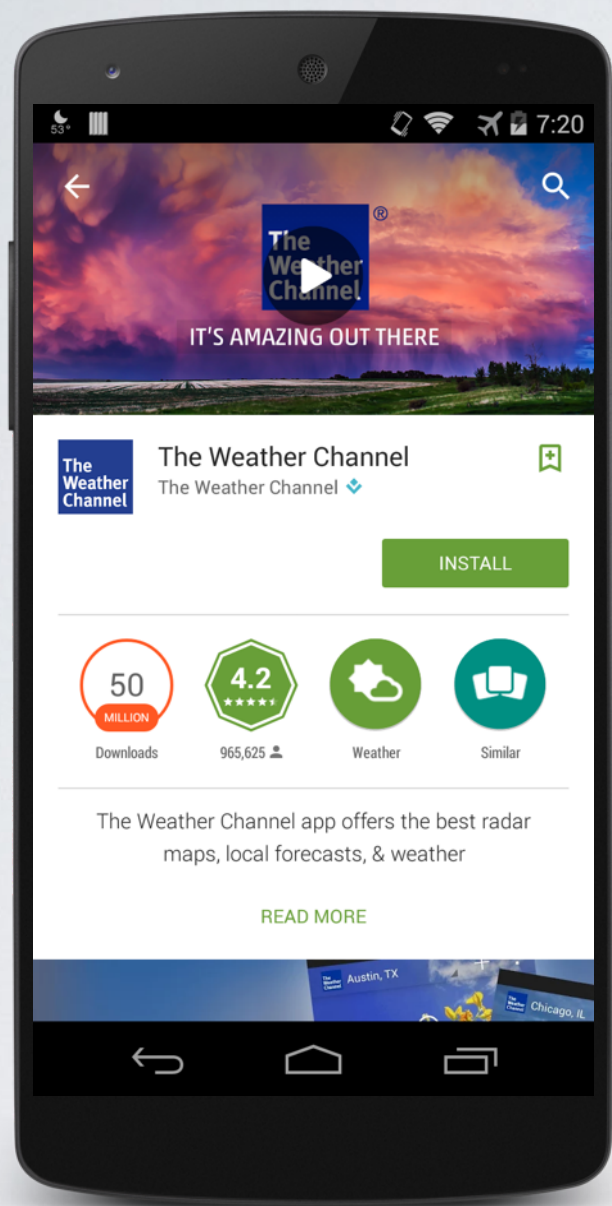


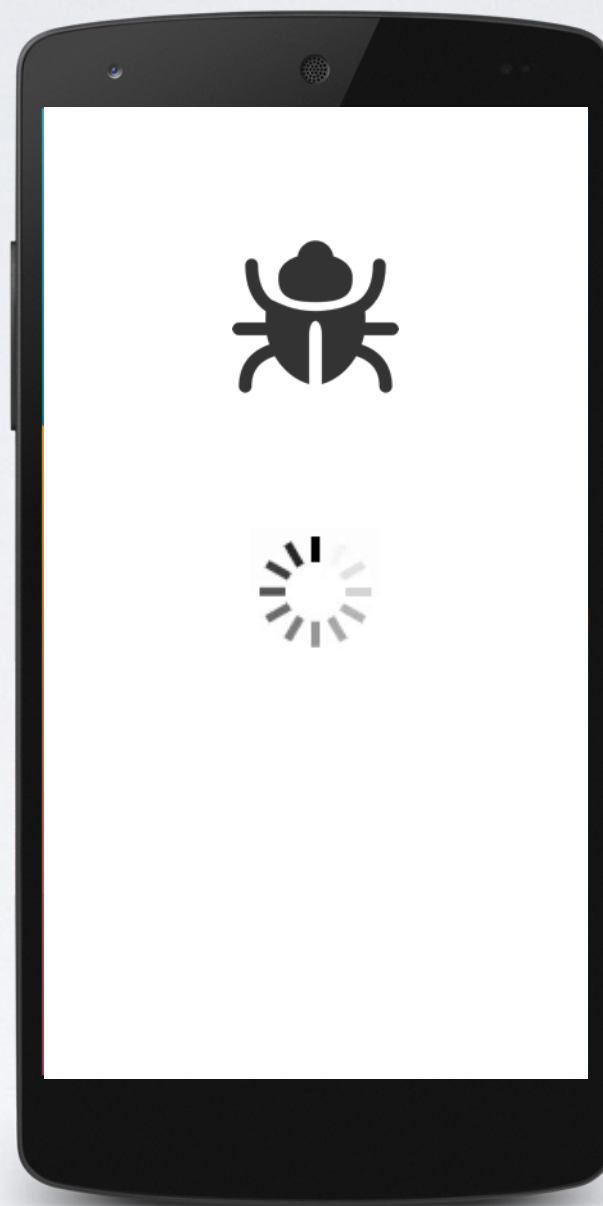
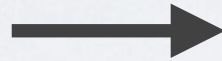
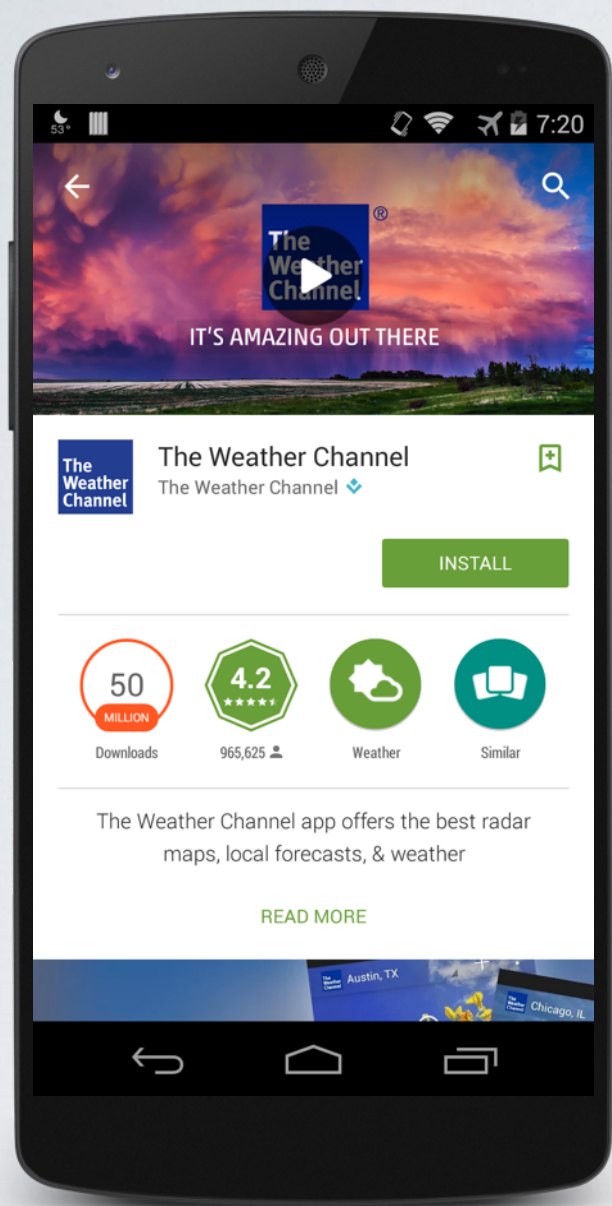
College of William & Mary - SEMERU - Department of Computer Science

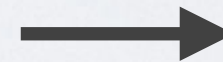
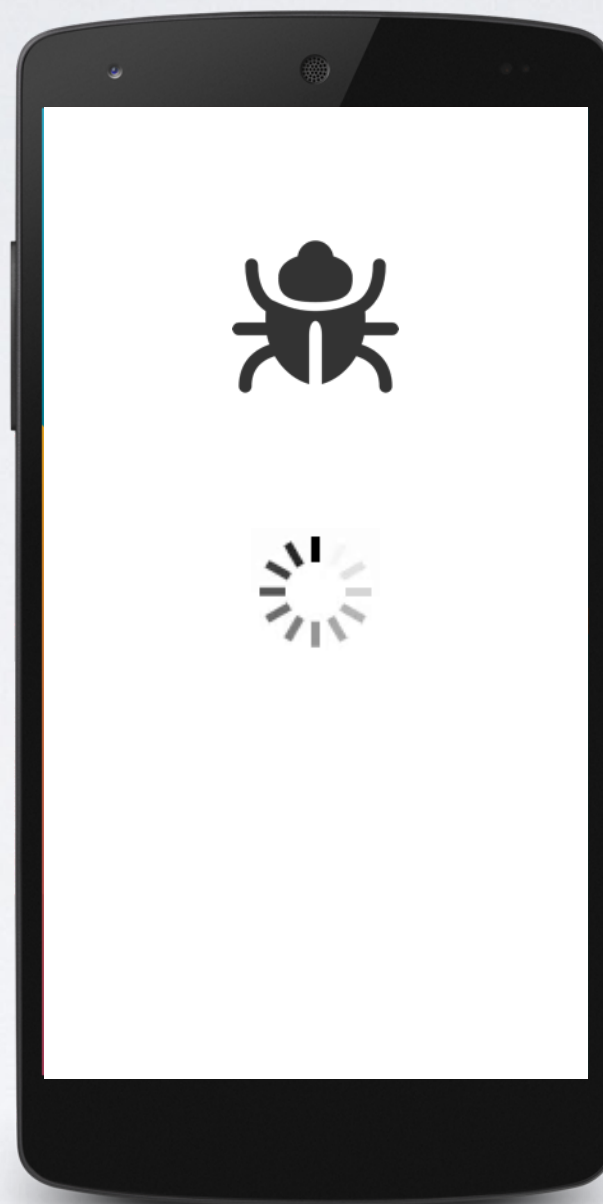
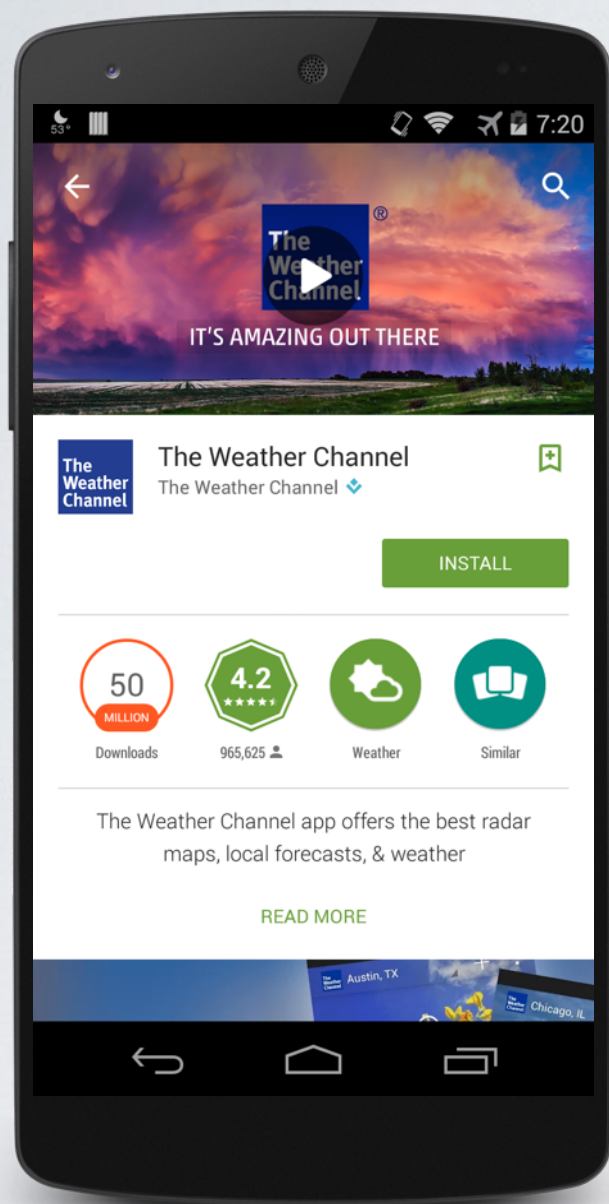
FUSION: A Tool for Facilitating and Augmenting Android Bug Reporting

Kevin Moran,
Mario Linares-Vásquez,
Carlos Bernal-Cárdenas,
and Denys Poshyvanyk

ICSE | 6
Austin, TX
Doctoral Symposium
Wednesday, May 18th, 2016







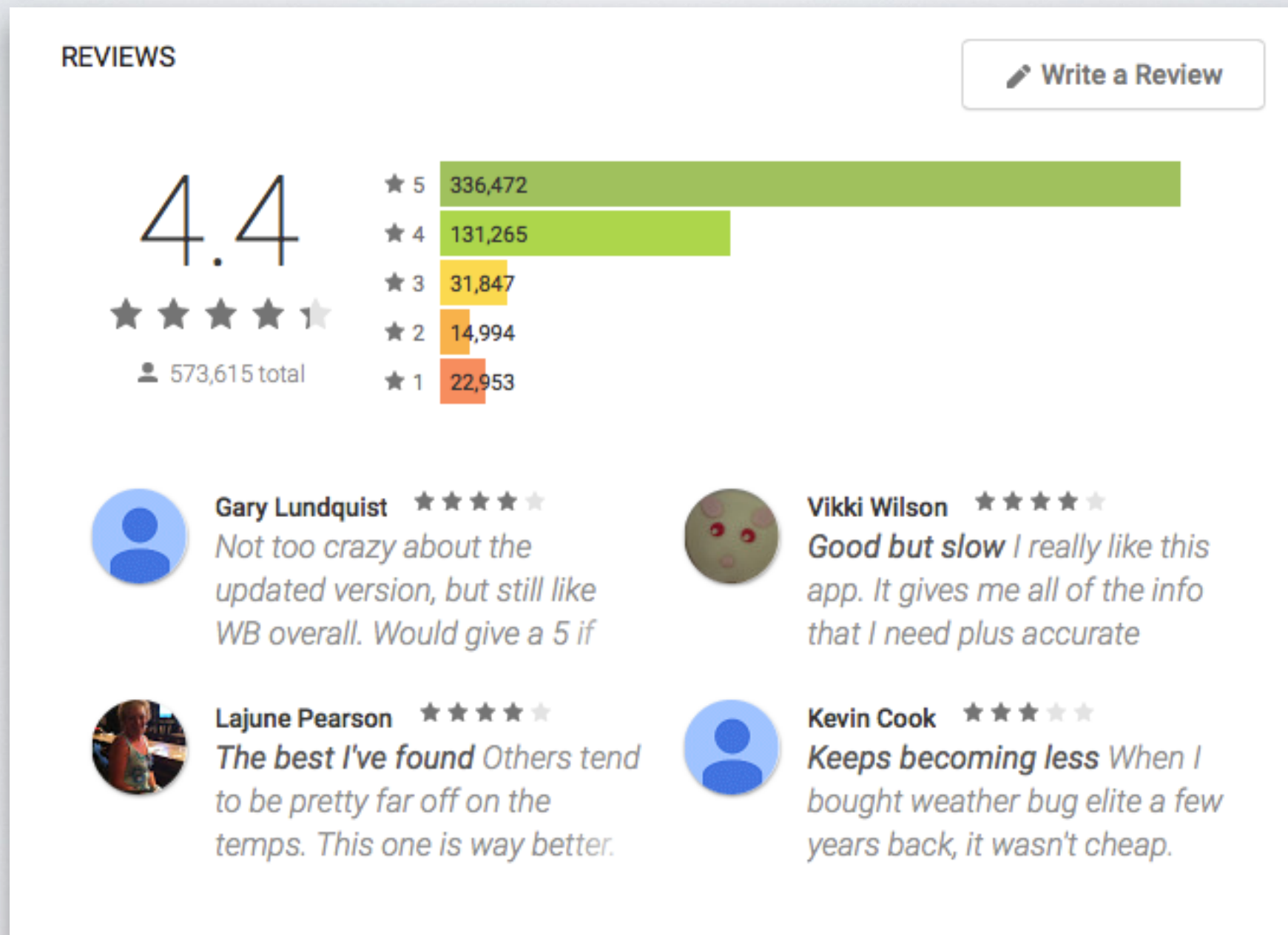
“If dissatisfied with the performance of a mobile app, 48 percent of users would be less likely to use the app again.”

“Dynatrace Mobile App Survey Report” - https://info.dynatrace.com/rs/compuware/images/Mobile_App_Survey_Report.pdf

Software maintenance, specifically the prompt resolution of bug reports, is extremely important to an application's success.



EXISTING ISSUE TRACKERS & USER REVIEWS





EXISTING ISSUE TRACKERS & USER REVIEWS

REVIEWS

Write a Review

code.google.com

android
Android Open Source Project - Issue Tracker

Project Home Issues

Search projects

GitHub, Inc.

dschuermann / document-viewer

Watch 12 Star 57 Fork 24

Missing fonts? #51

Open mase76 opened this issue on Sep 12 · 0 comments

mase76 commented on Sep 12

The german pdf manuals from gnupg.org are unreadable. Seems that there are missing fonts.

Write Preview

Leave a comment

Attach images by dragging & dropping or selecting them.

Comment

Labels

None yet

Milestone

No milestone

Assignee

No one assigned

Notifications

Subscribe

You're not receiving notifications from this thread.

1 participant

Mozilla Foundation

Bugzilla@Mozilla

Home New Browse Search [help] Reports Product Dashboard

Bug List: (9 of 281) First Last Prev Next Show last search results

Bug 935502 - blurred text when scrolling to fast

Status: UNCONFIRMED

Whiteboard:

Keywords:

Product: Firefox for Android (show info)

Component: Graphics, Panning and Zooming (show other bugs) (show info)

Version: unspecified

Platform: ARM Android

Importance: -- normal (vote)

Target Milestone: ---

Assigned To: Nobody; OK to take it and work on it

QA Contact:

Mentors:

URL:

Depends on:

Blocks: Show dependency tree / graph

Reported: 2013-11-06 06:19 PST by desiradaniel2007

Modified: 2013-11-07 06:55 PST (History)

CC List: 3 users (show)

See Also:

Crash Signature:

Project Flags:

Tracking Flags:

Attachments

Add an attachment (proposed patch, testcase, etc.)

desiradaniel2007 2013-11-06 06:19:17 PST

Description

When scrolling through text very quickly, causes the text to blur for a couple of seconds. I have reproduced

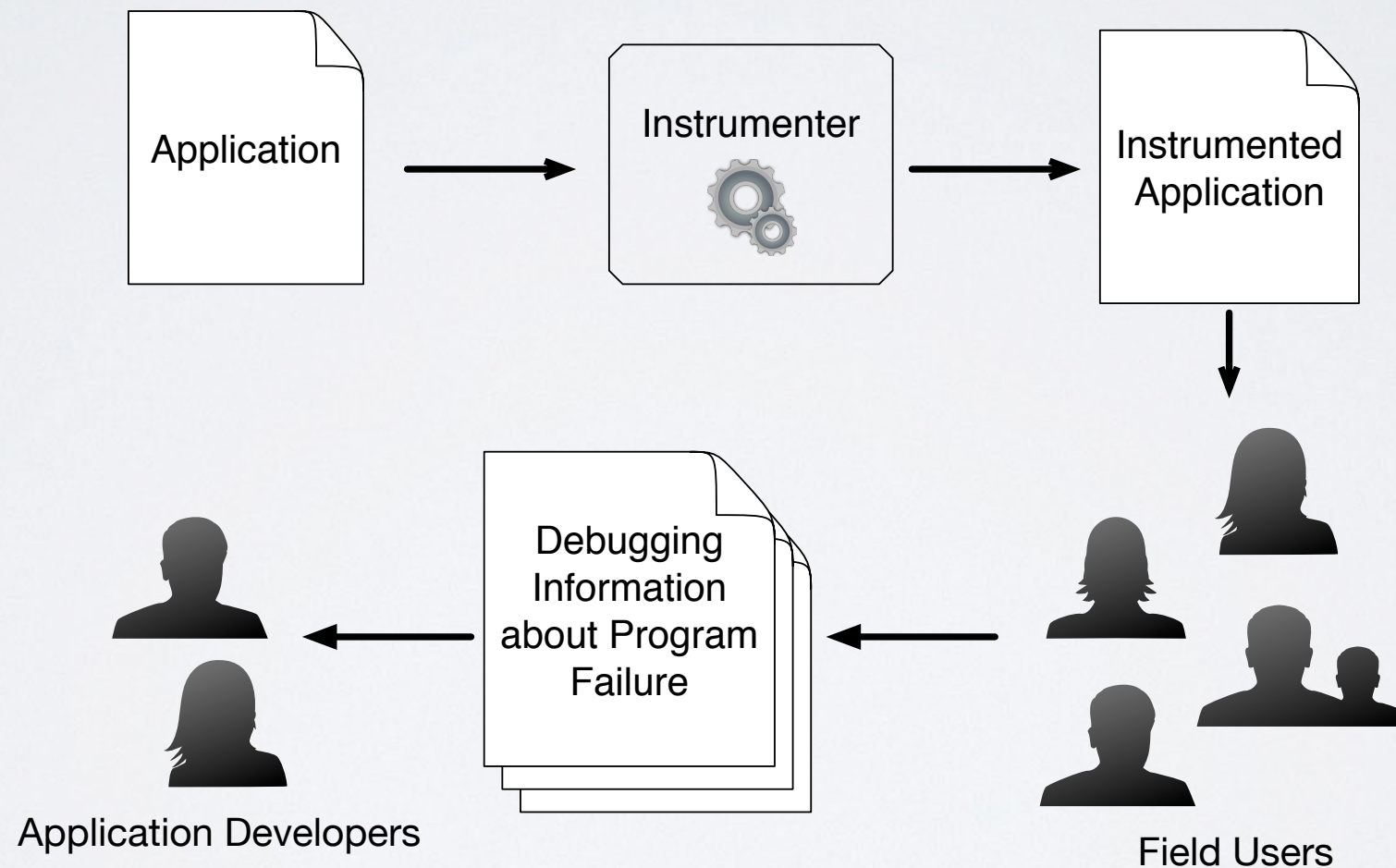
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Status API Training Shop Blog About



IN-FIELD FAILURE REPRODUCTION

- Allows for in-house debugging of field failures^[1].



James Clause and Alessandro Orso. 2007. A Technique for Enabling and Supporting Debugging of Field Failures. In Proceedings of the 29th international conference on Software Engineering (ICSE '07)



IN-FIELD FAILURE REPRODUCTION



Google play

ANDROID DEVELOPER CONSOLE

```
E/AndroidRuntime( 2909): FATAL EXCEPTION: AsyncTask #2
E/AndroidRuntime( 2909): Process: com.as.anagramsolver, PID: 2909
E/AndroidRuntime( 2909): java.lang.RuntimeException: An error occurred while executing doInBackground()
E/AndroidRuntime( 2909):     at android.os.AsyncTask$3.done(AsyncTask.java:300)
E/AndroidRuntime( 2909):     at java.util.concurrent.FutureTask.finishCompletion(FutureTask.java:355)
E/AndroidRuntime( 2909):     at java.util.concurrent.FutureTask.setException(FutureTask.java:222)
E/AndroidRuntime( 2909):     at java.util.concurrent.FutureTask.run(FutureTask.java:242)
E/AndroidRuntime( 2909):     at android.os.AsyncTask$SerialExecutor$1.run(AsyncTask.java:231)
E/AndroidRuntime( 2909):     at java.util.concurrent.ThreadPoolExecutor.runWorker(ThreadPoolExecutor.java:1112)
E/AndroidRuntime( 2909):     at java.util.concurrent.ThreadPoolExecutor$Worker.run(ThreadPoolExecutor.java:587)
E/AndroidRuntime( 2909):     at java.lang.Thread.run(Thread.java:841)
E/AndroidRuntime( 2909): Caused by: android.database.sqlite.SQLiteException: near "ez": syntax error (code 1): , while compiling: SELECT w
ord FROM English WHERE aword=' 'ez'
E/AndroidRuntime( 2909):     at android.database.sqlite.SQLiteConnection.nativePrepareStatement(Native Method)
E/AndroidRuntime( 2909):     at android.database.sqlite.SQLiteConnection.acquirePreparedStatement(SQLiteConnection.java:889)
E/AndroidRuntime( 2909):     at android.database.sqlite.SQLiteConnection.prepare(SQLiteConnection.java:500)
E/AndroidRuntime( 2909):     at android.database.sqlite.SQLiteSession.prepare(SQLiteSession.java:588)
E/AndroidRuntime( 2909):     at android.database.sqlite.SQLiteProgram.(SQLiteProgram.java:58)
E/AndroidRuntime( 2909):     at android.database.sqlite.SQLiteQuery.(SQLiteQuery.java:37)
E/AndroidRuntime( 2909):     at android.database.sqlite.SQLiteDirectCursorDriver.query(SQLiteDirectCursorDriver.java:44)
E/AndroidRuntime( 2909):     at android.database.sqlite.SQLiteDatabase.rawQueryWithFactory(SQLiteDatabase.java:1314)
E/AndroidRuntime( 2909):     at android.database.sqlite.SQLiteDatabase.rawQuery(SQLiteDatabase.java:1253)
E/AndroidRuntime( 2909):     at com.as.anagramsolver.DictionaryDBCcreator.rawQueryResults(DictionaryDBCcreator.java:189)
E/AndroidRuntime( 2909):     at com.as.anagramsolver.DictionaryDBCcreator.getMatchingAnagrams(DictionaryDBCcreator.java:172)
E/AndroidRuntime( 2909):     at com.as.anagramsolver.StartPage$DBSearchTask.searchAllMatchingAnagrams(StartPage.java:208)
E/AndroidRuntime( 2909):     at com.as.anagramsolver.StartPage$DBSearchTask.doInBackground(StartPage.java:142)
E/AndroidRuntime( 2909):     at com.as.anagramsolver.StartPage$DBSearchTask.doInBackground(StartPage.java:1)
E/AndroidRuntime( 2909):     at android.os.AsyncTask$2.call(AsyncTask.java:288)
E/AndroidRuntime( 2909):     at java.util.concurrent.FutureTask.run(FutureTask.java:237)
E/AndroidRuntime( 2909):     ... 4 more
```




IN-FIELD FAILURE REPRODUCTION

- ❖ Requires potentially expensive program instrumentation, not suitable for a mobile environment.
- ❖ Requires oracles in order to capture and reproduce failures in the field.
- ❖ May not be easily adaptable to the event-driven and fragmented nature of mobile apps.



THE LEXICAL GAP IN BUG REPORTING

Reporters:

-Functional Knowledge of a Software Bug.



Developers:

-Intimate Code Level Knowledge of Application





THE LEXICAL GAP IN BUG REPORTING

Reporters:

-Functional Knowledge of a Software Bug.



Inherent Lexical Gap

Developers:

-Intimate Code Level Knowledge of Application





WHAT MAKES A GOOD BUG REPORT ?

- ❖ **Insufficient information** in bug reports is one of the leading causes of non-reproducible reports¹
- ❖ Developers consider (i) **steps to reproduce**, (ii) **stack traces**, and (iii) **test cases/scenarios** as the most helpful sources of information in bug reports²
- ❖ Information needs are **greatest** earliest in a bug's lifecycle³

¹M. Erfani Joorabchi, M. Mirzaaghaei, and A. Mesbah. Works for me! characterizing non-reproducible bug reports. MSR 2014,

²N. Bettenburg, S. Just, A. Schröter, C. Weiss, R. Premraj, and T. Zimmermann. What makes a good bug report? (SIGSOFT '08/FSE-16),

³S. Breu, R. Premraj, J. Sillito, and T. Zimmermann. Information needs in bug reports: Improving cooperation between developers and users. (CSCW)



FUSION: THE KEY IDEA

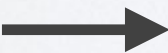


Static Code Analysis

```
private void createNote() {
    Intent i = new Intent(this, QuoteEdit.class);
    startActivityForResult(i, ACTIVITY_CREATE);
}

@Override
protected void onItemClick(ListView l, View v, int position, long id) {
    super.onItemClick(l, v, position, id);
    Cursor c = mNotesCursor;
    c.moveToPosition(position);
    Intent i = new Intent(this, QuoteEdit.class);
    i.putExtra(QuotesDBAdapter.KEY_ROWID, id);
    i.putExtra(QuotesDBAdapter.KEY_QUOTES, c.getString(
        c.getColumnIndexOrThrow(QuotesDBAdapter.KEY_QUOTES)));
    startActivityForResult(i, ACTIVITY_EDIT);
}

@Override
protected void onActivityResult(int requestCode, int resultCode, Intent intent) {
    super.onActivityResult(requestCode, resultCode, intent);
    Bundle extras = intent.getExtras();
    switch(requestCode) {
        case ACTIVITY_CREATE:
            String title = extras.getString(QuotesDBAdapter.KEY_QUOTES);
            mDbHelper.createQuote(title);
            fillData();
            break;
        case ACTIVITY_EDIT:
            Long rowId = extras.getLong(QuotesDBAdapter.KEY_ROWID);
            if (rowId != null) {
                String editTitle = extras.getString(QuotesDBAdapter.KEY_QUOTES);
                mDbHelper.updateQuote(rowId, editTitle);
            }
            fillData();
            break;
    }
}
```



System A - Bug report
(The easy way to write and submit bug reports for Android apps)

Buy 14180094009 for Document viewer, version 2.2

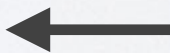
Sometimes Go to doesn't work (By Participant 4) [Nesha 7](#) [portrait](#)

What should happen: -- It should go to the page - What happens instead: -- It doesn't. The steps for reproducing the bug are the following:

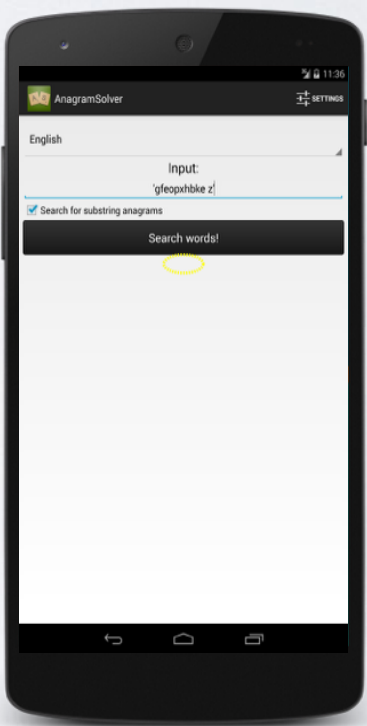
1. CLICK Invol RelativeLayout located at: Top left. The component is in the activity "ig.abookandroid.ui.library.RecentActivity".
Component image: Screen image: (Also see thumbnail in corresponding step below)
2. CLICK Invol TextView located at: Top. The component is in the activity "ig.abookandroid.ui.viewer.ViewerActivity".
Component image: Screen image: (Also see thumbnail in corresponding step below)
3. CLICK Invol LinearLayout located at: Center. The component is in the activity "ig.abookandroid.ui.viewer.ViewerActivity".
Component image: Screen image: (Also see thumbnail in corresponding step below)
4. TYPE "2" Invol EditText located at: Top. The component is in the activity "ig.abookandroid.ui.viewer.ViewerActivity".
Component image: Screen image: (Also see thumbnail in corresponding step below)
5. CLICK Invol TextView located at: Top. The component is in the activity "ig.abookandroid.ui.viewer.ViewerActivity". Additional info: Prior to clicking again, swipe back up to page one.
Component image: Screen image: (Also see thumbnail in corresponding step below)
6. CLICK Invol LinearLayout located at: Center. The component is in the activity "ig.abookandroid.ui.viewer.ViewerActivity".
Component image: Screen image: (Also see thumbnail in corresponding step below)
7. TYPE "2" Invol EditText located at: Top. The component is in the activity "ig.abookandroid.ui.viewer.ViewerActivity". Additional info: After clicking this, it doesn't go to page 2 anymore.
Component image: Screen image: (Also see thumbnail in corresponding step below)

If there are any steps with it means System A was not able to find information for those steps

[Step 1](#) [Step 2](#) [Step 3](#) [Step 4](#) [Step 5](#) [Step 6](#) [Step 7](#)

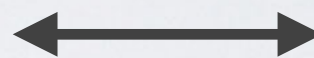
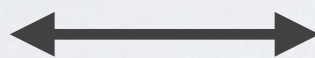


Dynamic Analysis





FUSION: THE KEY IDEA

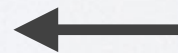
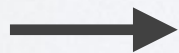


Static Code Analysis

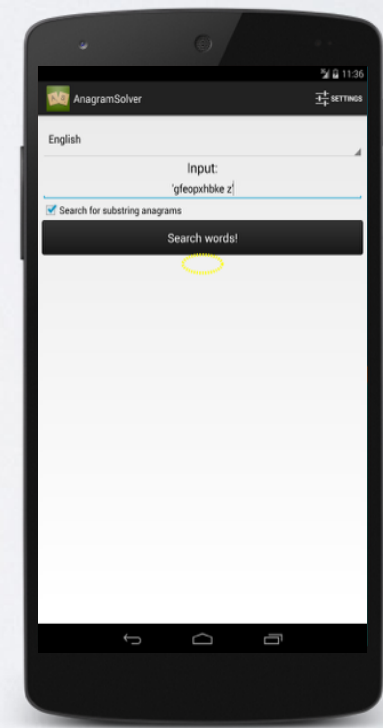
```
private void createNote() {
    Intent i = new Intent(this, QuoteEdit.class);
    startActivityForResult(i, ACTIVITY_CREATE);
}

@Override
protected void onItemClick(ListView l, View v, int position, long id) {
    super.onItemClick(l, v, position, id);
    Cursor c = mNotesCursor;
    c.moveToPosition(position);
    Intent i = new Intent(this, QuoteEdit.class);
    i.putExtra(QuotesDBAdapter.KEY_ROWID, id);
    i.putExtra(QuotesDBAdapter.KEY_QUOTES, c.getString(
        c.getColumnIndexOrThrow(QuotesDBAdapter.KEY_QUOTES)));
    startActivityForResult(i, ACTIVITY_EDIT);
}

@Override
protected void onActivityResult(int requestCode, int resultCode, Intent intent) {
    super.onActivityResult(requestCode, resultCode, intent);
    Bundle extras = intent.getExtras();
    switch(requestCode) {
        case ACTIVITY_CREATE:
            String title = extras.getString(QuotesDBAdapter.KEY_QUOTES);
            mDbHelper.createQuote(title);
            fillData();
            break;
        case ACTIVITY_EDIT:
            Long rowId = extras.getLong(QuotesDBAdapter.KEY_ROWID);
            if (rowId != null) {
                String editTitle = extras.getString(QuotesDBAdapter.KEY_QUOTES);
                mDbHelper.updateQuote(rowId, editTitle);
            }
            fillData();
            break;
    }
}
```



Dynamic Analysis

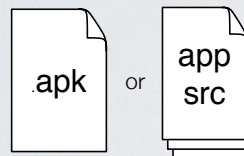




FUSION: OVERVIEW

Analysis Phase

① - Static App Analyzer (*Primer*)



Physical Device or Emulator



② - Dynamic Program Analyzer (*Engine*)

③ - FUSION Database

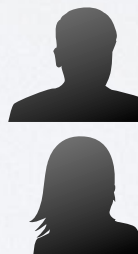
Report Generation Phase

Testers

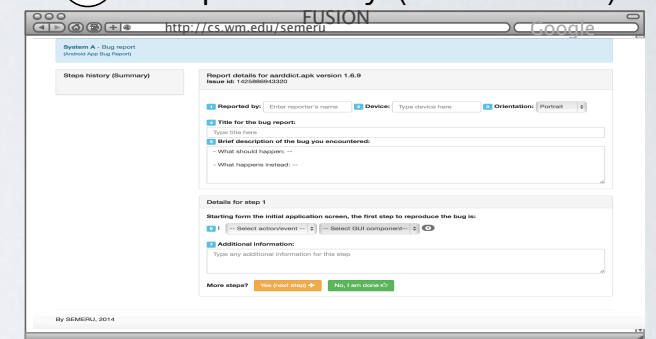


④ - Auto-Completion Engine

Application Developers



⑤ - Report Entry (FUSION UI)

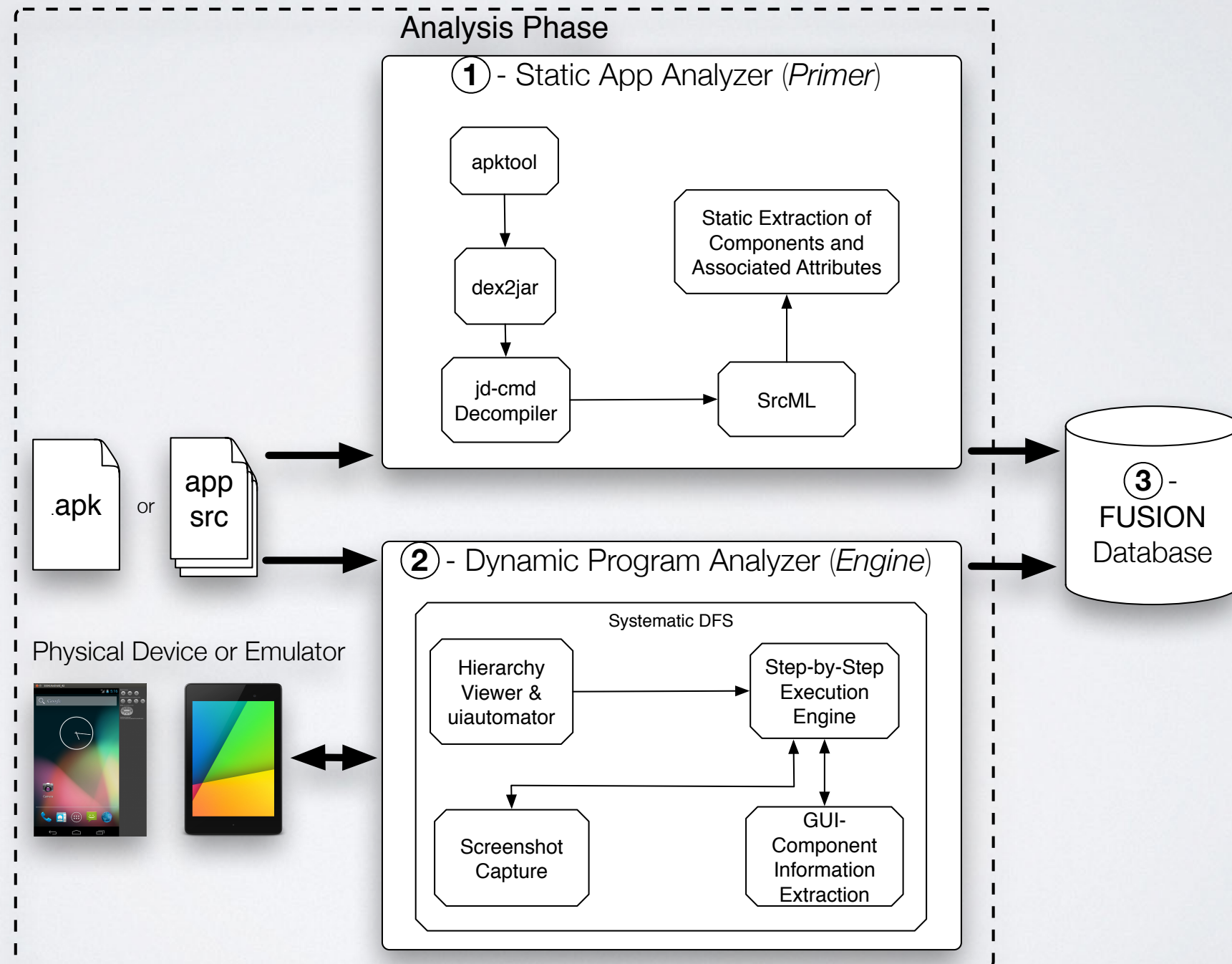


⑥ - Generated Reports (FUSION UI)



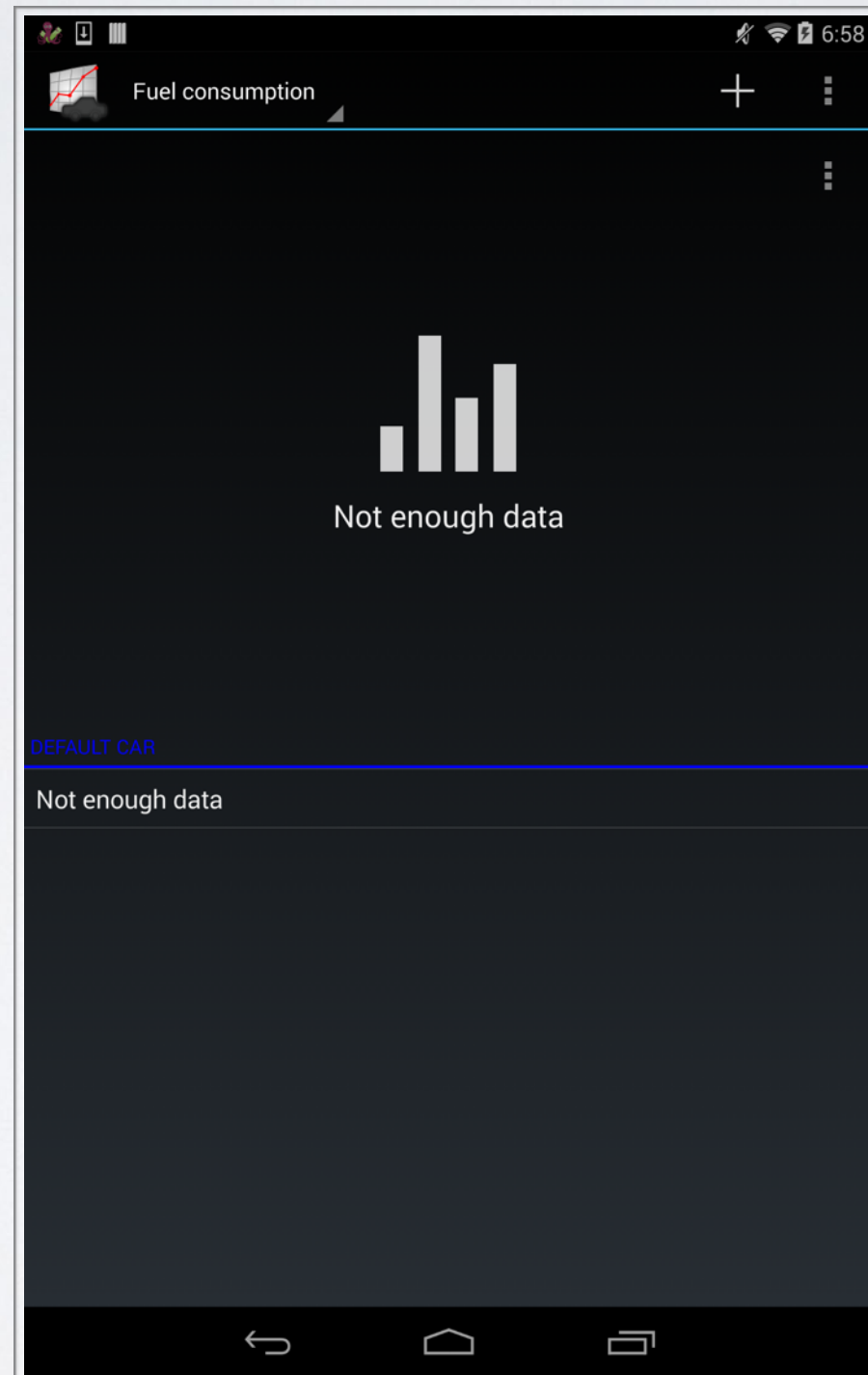


FUSION: ANALYSIS PHASE





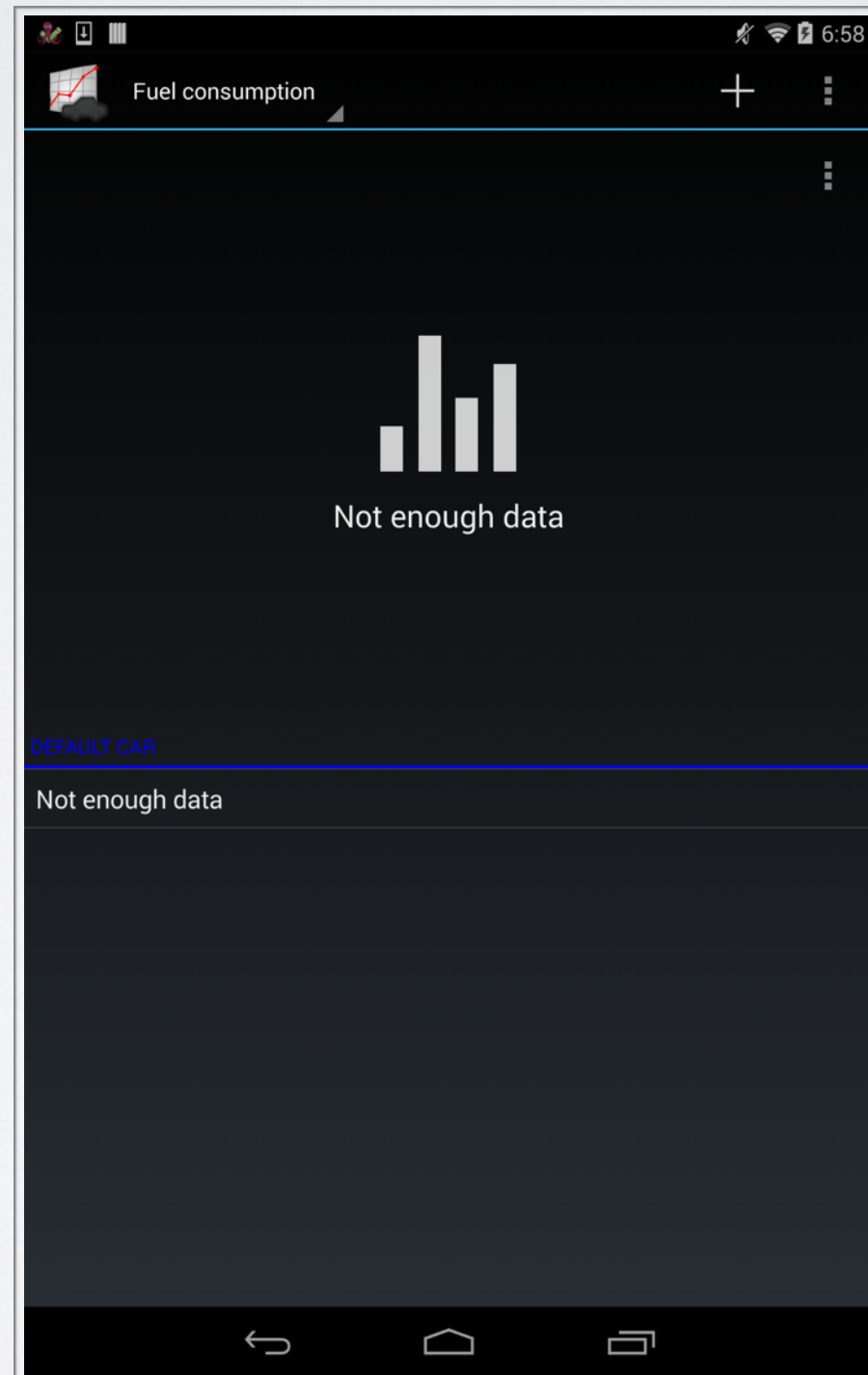
FUSION: OVERVIEW





FUSION: OVERVIEW

uiautomator



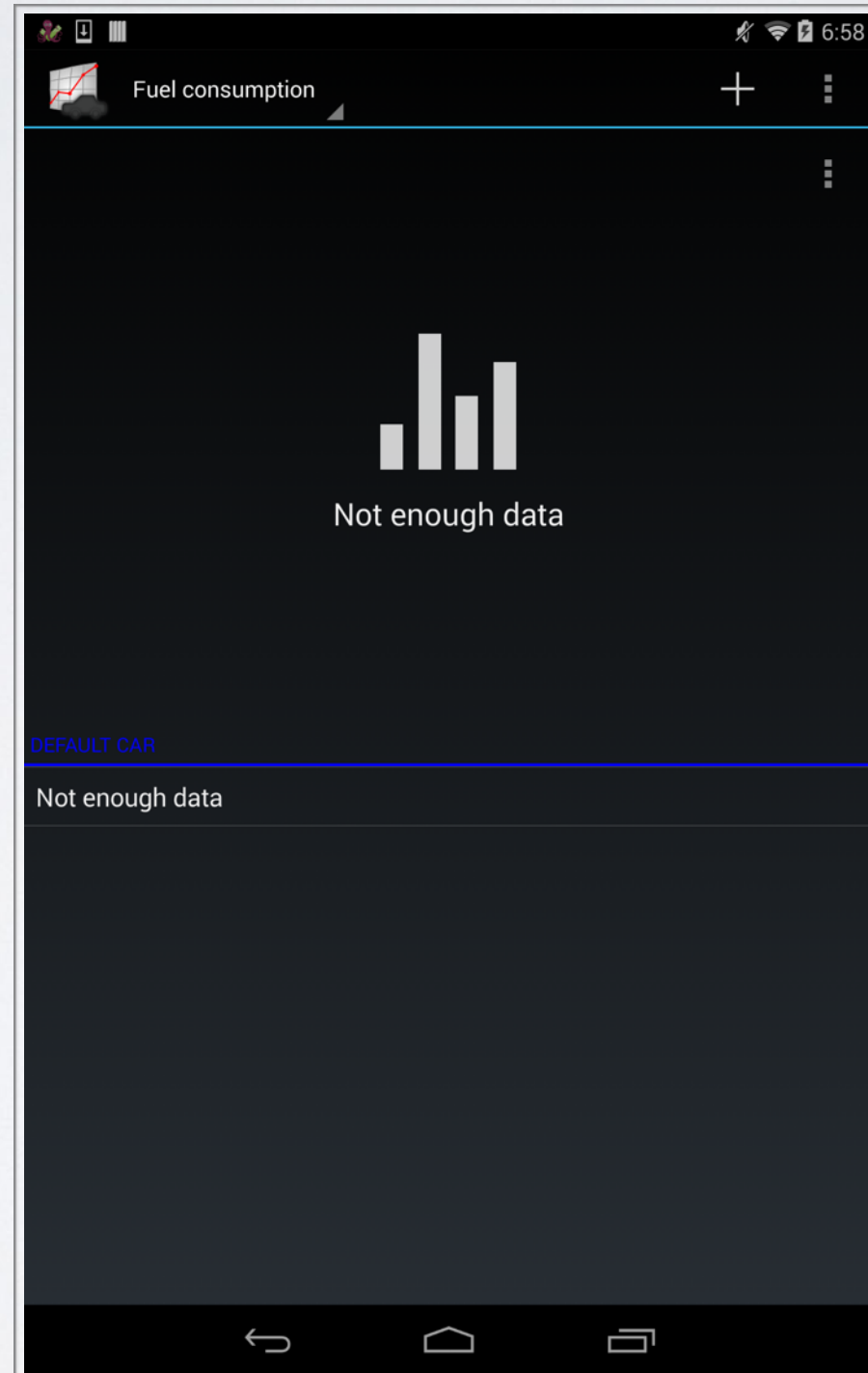
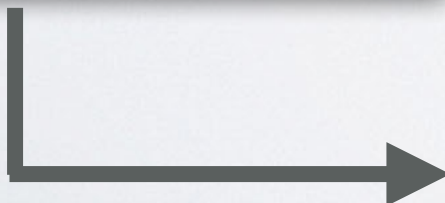


FUSION: OVERVIEW

uiautomator

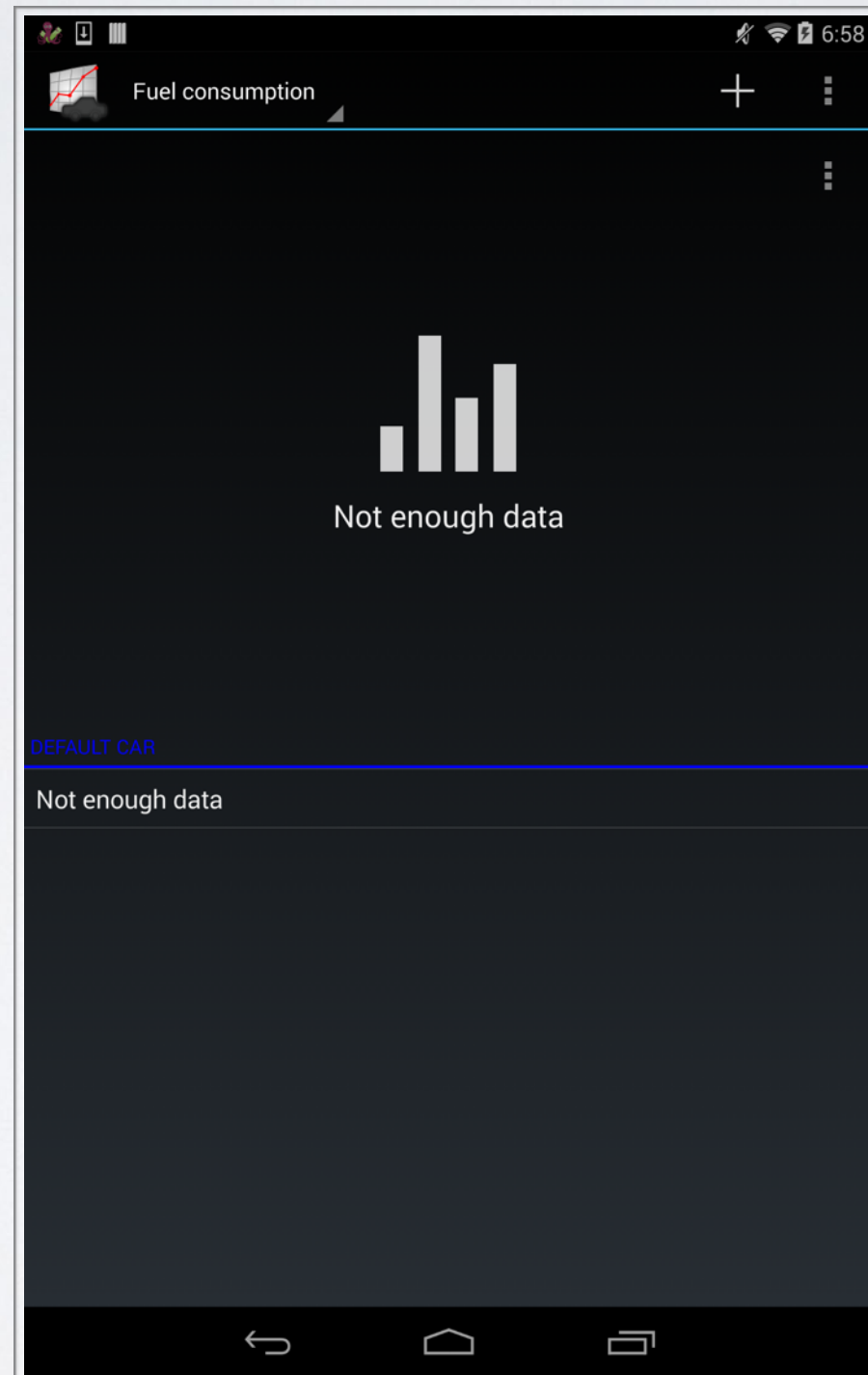


```
<?xml version='1.0' encoding='UTF-8' standalone='yes' ?><hierarchy rotation="0"><node index="0"
text="" resource-id="" class="android.widget.FrameLayout" package="com.evancharlton.mileage"
content-desc="" checkable="false" checked="false" clickable="false" enabled="true"
focusable="false" focused="false" scrollable="false" long-clickable="false" password="false"
selected="false" bounds="[0,0][1200,1824]"><node index="0" text="" resource-id=""
class="android.widget.LinearLayout" package="com.evancharlton.mileage" content-desc=""
checkable="false" checked="false" clickable="false" enabled="true" focusable="false"
focused="false" scrollable="false" long-clickable="false" password="false" selected="false"
bounds="[0,0][1200,1824]"><node index="0" text="" resource-id=""
class="android.widget.FrameLayout" package="com.evancharlton.mileage" content-desc=""
checkable="false" checked="false" clickable="false" enabled="true" focusable="false"
focused="false" scrollable="false" long-clickable="false" password="false" selected="false"
bounds="[0,50][1200,100]"><node index="0" text="Average fuel price" resource-id="android:id/title"/>
```



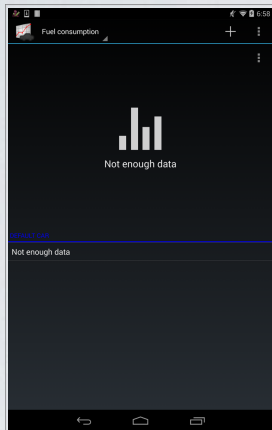


FUSION: OVERVIEW



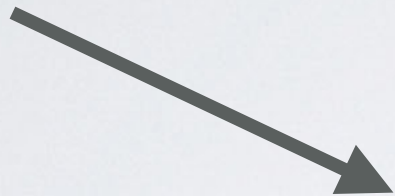
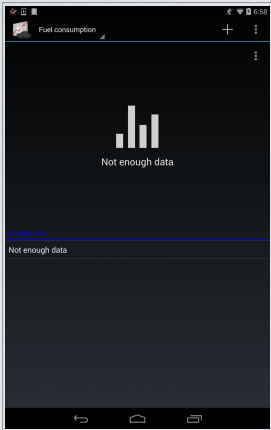


FUSION: OVERVIEW





FUSION: OVERVIEW

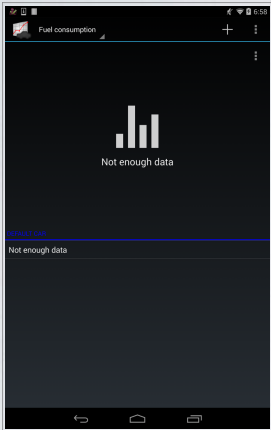


- Activity
- Checkable, Checked, Clickable, Long Clickable?
- Component Index
- Current Window
- Enabled?
- XML_ID
- Component Type
- Position (Absolute and Relative)
- Text
- Screenshot →





FUSION: OVERVIEW

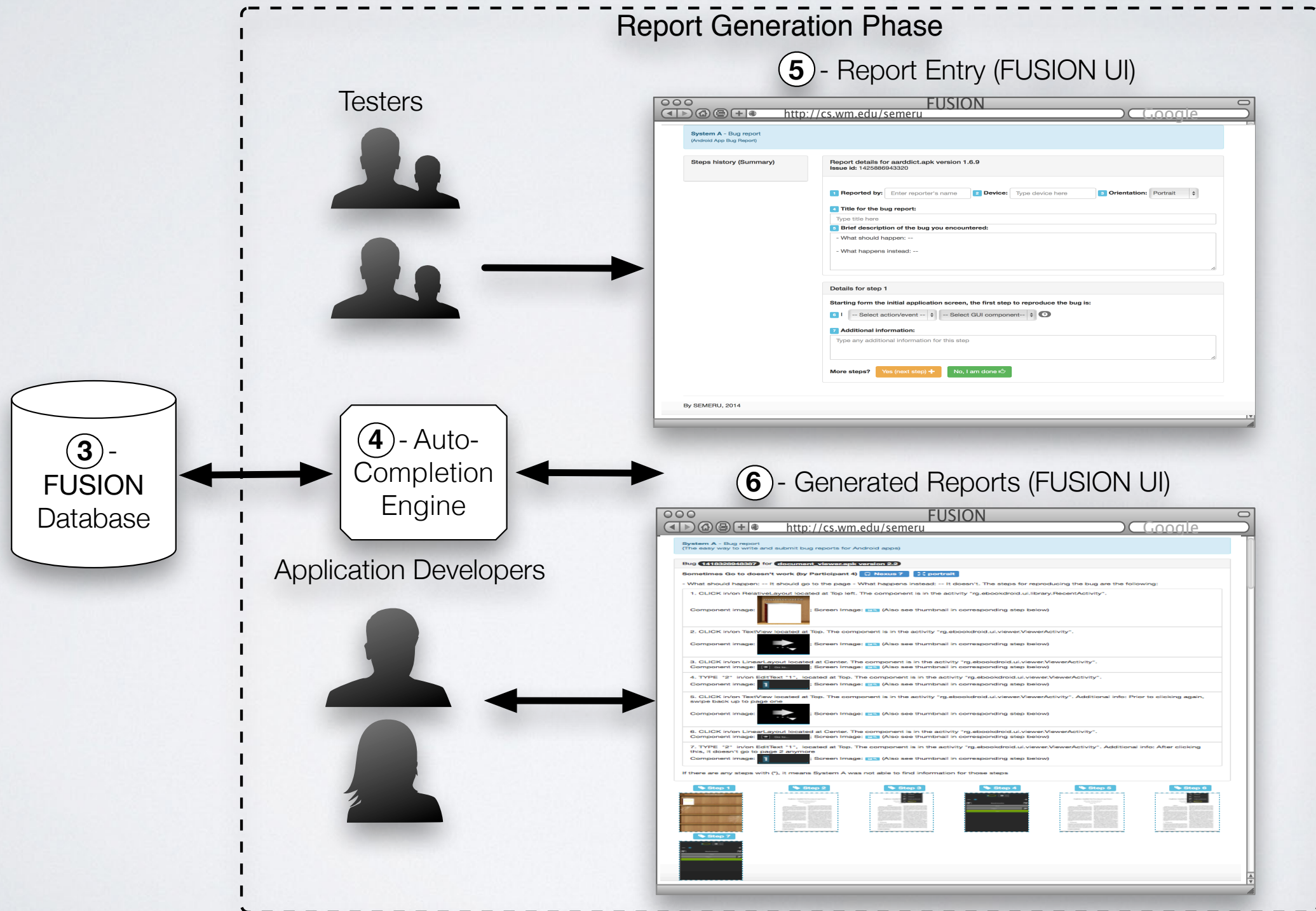


```
'73', 'me.kuehle.carreport/.gui.ReportActivity', '0', '0', '1', '1',  
'me.kuehle.carreport/.gui.ReportActivity#null.FrameLayout.FrameLayout.LinearLayout.FrameLayout  
.Spinner.CheckedTextView.TextView.ImageButton.FrameLayout.FrameLayout.ImageButton.ListView.Lin  
earLayout', '1', '1', '0', '64', 'me.kuehle.carreport:id/btnMenu', '0',  
'android.widget.ImageButton', '0', '1104', '194', 'TopRight', '0', '0', '', '64',  
'me.kuehle.carreport__1_gui.png'
```



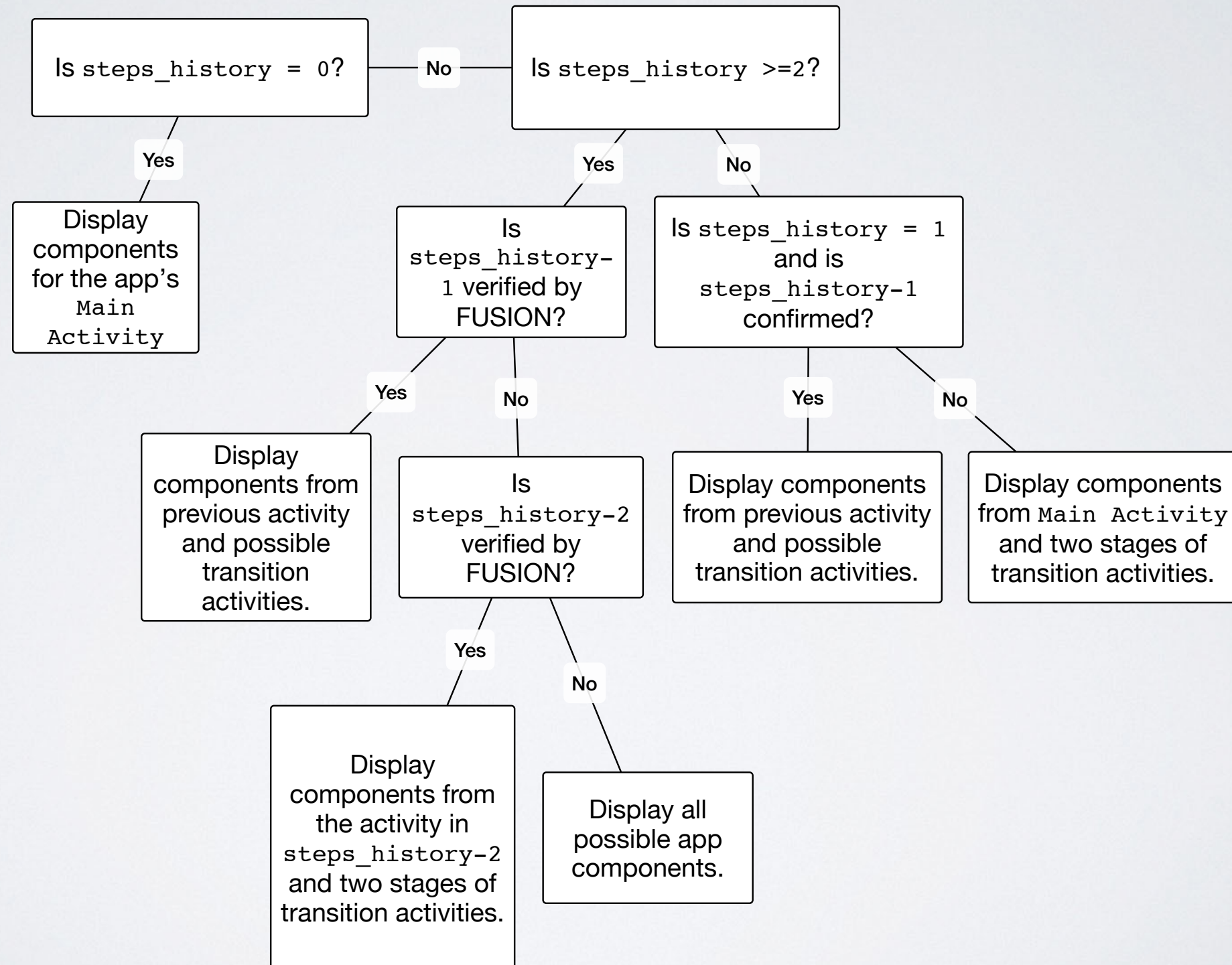


FUSION: REPORT GENERATION PHASE





FUSION: AUTO-COMPLETION ENGINE





FUSION: AUTO-COMPLETION ENGINE

- FUSION tracks the users location in the app's event-flow.
- Suggests only components from the current screen, and possible transition screens, based on the last action.
- If steps cannot be autocompleted, FUSION expands the number of components it displays.

transition activities.

Report details for aarddict.apk version 1.6.9

Issue id: 1441125984977

1 Reported by: Kevin Moran

2 Device: Type device here

3 Orientation: Portrait

4 Title for the bug report:

Type title here

5 Brief description of the bug you encountered:

- What should happen: --
- What happens instead: --

Report details for aarddict.apk version 1.6.9

Issue id: 1441125984977

1 Reported by: Kevin Moran

2 Device: Type device here

3 Orientation: Portrait

4 Title for the bug report:

Type title here

5 Brief description of the bug you encountered:

- What should happen: --
- What happens instead: --

FUSION - Bug report

(The easy way to write and submit bug reports for Android apps)


Bug **1418328948387** for **document_viewer.apk version 2.2**

The "Go To Page" Function does not work properly (by Kevin Moran)  Nexus 7  portrait

- What should happen: -- When the "Go To Page" button is pressed, the document should seek to the corresponding page.- What happens instead: --When the button is pressed, the document stays on the current page.

Details for step 1

Starting from the initial application screen, the first step to reproduce the bug is:

6 I 

7 Additional information:

Type any additional information for this step


More steps?

Yes (next step) +

No, I am done 👍

Details for step 1

Starting from the initial application screen, the first step to reproduce the bug is:

6 I 

7 Additional information:

Type any additional information for this step

More steps?

Yes (next step) +

No, I am done 👍

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1. CLICK in/on RelativeLayout located at Top left. The component is in the activity "rg.ebookdroid.ui.library.RecentActivity".



Component image: ; Screen Image:  (Also see thumbnail in corresponding step below)

FUSION - Bug report

(The easy way to write and submit bug reports for Android apps)

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FUSION - Bug report

(The easy way to write and submit bug reports for Android apps)

Bug **1418328948387** for **document_viewer.apk version 2.2**

The "Go To Page" Function does not work properly (by Kevin Moran)  **Nexus 7**  **portrait**

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Details for step 4

6

I

-- Select action/event --



-- Select GUI component--



7

Additional information:

Type any additional information for this step

More steps?

Yes (next step) +

No, I am done !

Details for step 4

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-- Select action/event --



-- Select GUI component--



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If there are any steps with (*), it means System A was not able to find information for those steps

Step 1



Step 2



Step 3



Step 4



Step 5



Step 6



Step 7



Back to Fusion 

Print report 

Go to viewer 

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Step 4



Step 5




Step 6



Step 7

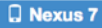



Back to Fusion 

Print report 



Go to viewer 

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[Back to Fusion](#) 

[Print report](#) 

[Go to viewer](#) 



EMPIRICAL EVALUATION

- Empirical study involving two software maintenance tasks and 28 users:
- Creating a bug report for a real app issue.
- Reproducing the bug on a device from a report.
- We used 15 real-world Android application bugs and compare FUSION to the Google Code Issue Tracker (GCIT) as well as the Original Bug Reports.



CONTEXT: BUG REPORTS USED IN THE STUDY

Summary of the bug reports used for the empirical studies: GDE = GUI Display Error, C = Crash, DIC = Data Input/Calculation Error, NE = Navigation Error

App (Bug Index)	Bug ID	Min # of Steps	Bug Type	DFS Activity Coverage
1) A Time Tracker	24	3	GDE	1/5
2) Aarddict	106	4-5	GDE	3/6
3) ACV	11	5	C	3/11
4) Car report	43	10	DIC	5/6
5) Document	48	4	NE	4/8
6) DroidWeight	38	7	GDE	3/8
7) Eshotroid	2	10	GDE/NE	6/6
8) GnuCash	256	10	DIC	3/4
9) GnuCash	247	10	DIC	3/4
10) Mileage	31	5	GDE/DIC	2/27
11) NetMBuddy	3	4	GDE/NE	5/13
12) Notepad	23	6	C	4/7
13) OI Notepad	187	10	GDE/DIC	3/9
14) Olam	2	3	C	1/1
15) QuickDic	85	25	GDE	3/6



TASK 1: BUG REPORT CREATION

- Goal: To assess whether FUSION's features are useful when reporting bugs for Android apps.
- Eight students from W&M, 4 CS graduate students, 4 undergraduate students.
- Users were exposed to the bugs through titled videos.
- All participants reproduced bugs on Google Nexus 7 Tablets with Android v4.4.3 KitKat installed.



TASK 2: BUG REPRODUCTION

- Goal: Evaluate the ability of FUSION to improve the reproducibility of bug reports
- 20 participants, all CS graduate students
- 135 bug reports were evaluated (120 from Study 1, plus the 15 original bug reports), each by two participants
- All participants reproduced bugs on Google Nexus 7 Tablets with Android v4.4.3 KitKat installed



RESEARCH QUESTIONS

- **RQ_1** : Ease of Use?
- **RQ_2** : Information Preferences?
- **RQ_3** : Reproducibility of Reports?
- **RQ_4** : Speed of Reproduction?



RESEARCH QUESTIONS

- RQ_1 : FUSION is about as *easy for developers to use* as traditional bug-tracking systems
- RQ_2 : Extra Information *increased quality* of reports
- RQ_3 : FUSION reports are *more reproducible* than traditional bug reports
- RQ_4 : Developers take *slightly longer* to reproduce FUSION Reports than traditional reports



FUSION: Improving Mobile Bug Reporting

Team Members: Kevin Moran, Mario Linares-Vásquez, Carlos Bernal-Cárdenas, & Denys Poshyvanyk

College of William & Mary --- SEMERU

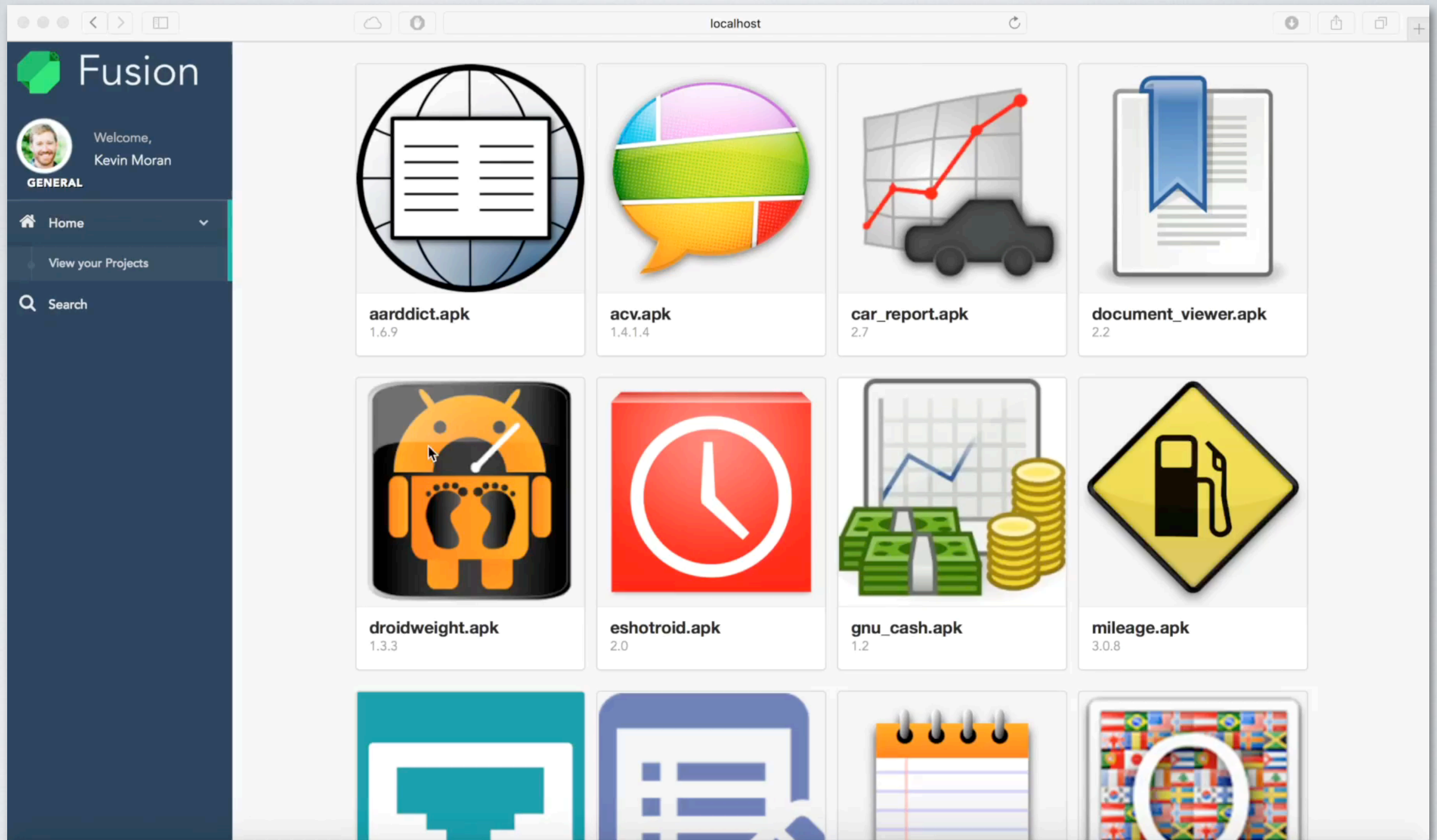


&



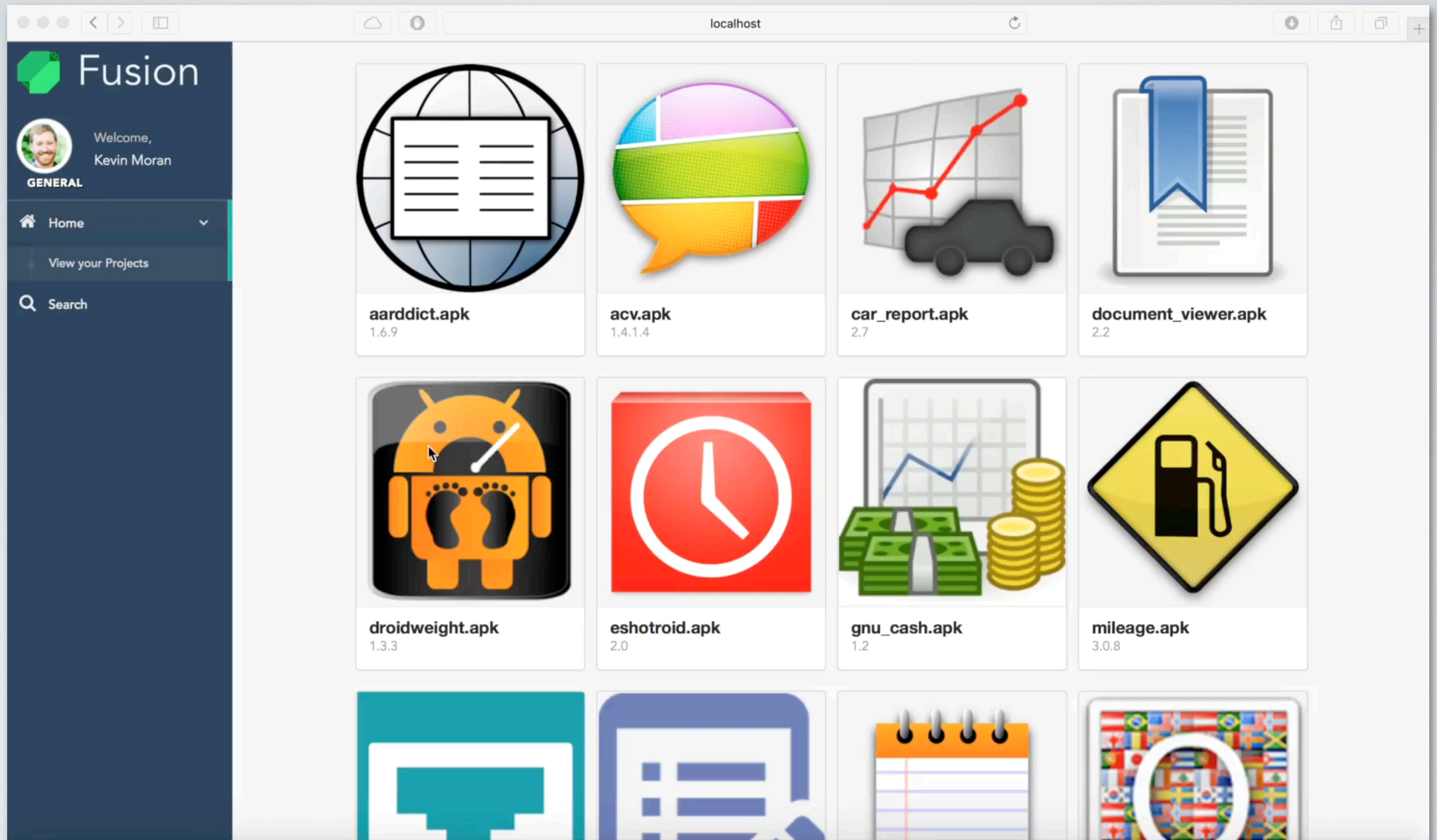
Purpose

This project was created by the Software Engineering Maintenance and Evolution Research Unit (SEMERU) at the College of William & Mary, under the supervision of Dr. Denys Poshyvanyk. The major goal of the FUSION project is provide a more effective means of off-device bug reporting for Android applications that facilitates reporting through auto-completion, and provides detailed information to developers to aid in bug reproduction. In the future we hope to build out the tool to provide fault location capabilities and bug fixing suggestions.



Credits: Jacob Lisi, Ulises Giacomani, Sarah Melvin, Jiangnan Fu





Credits: Jacob Lisi, Ulises Giacomani, Sarah Melvin, Jiangnan Fu



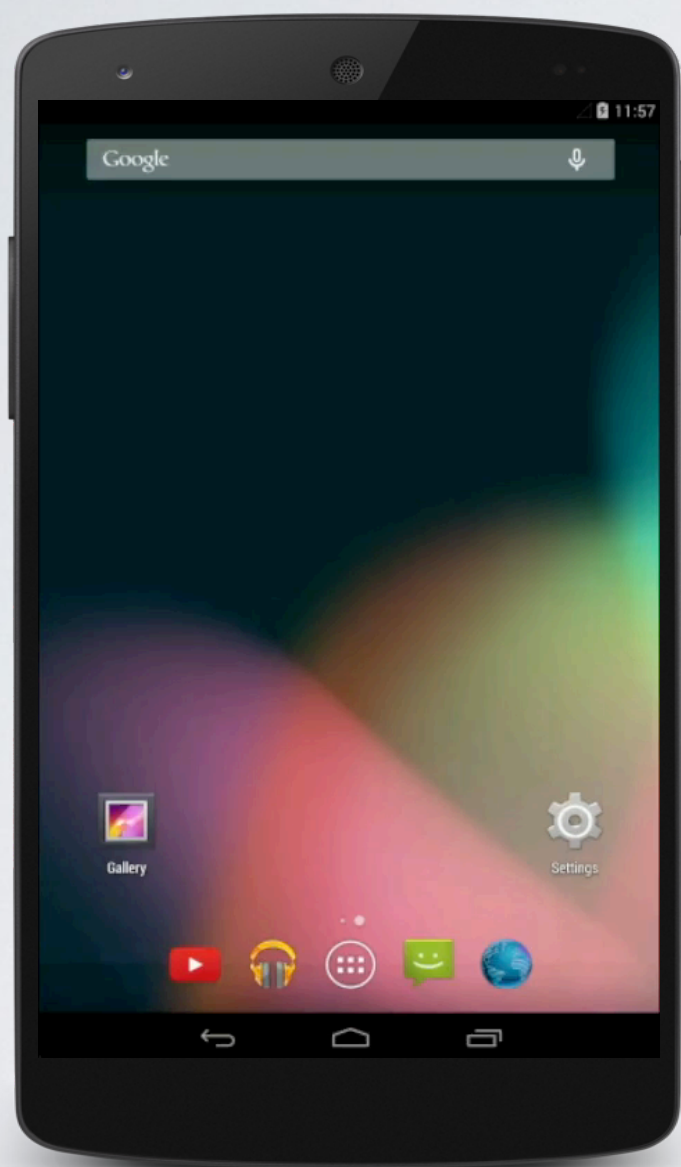
Thank you!

Questions?



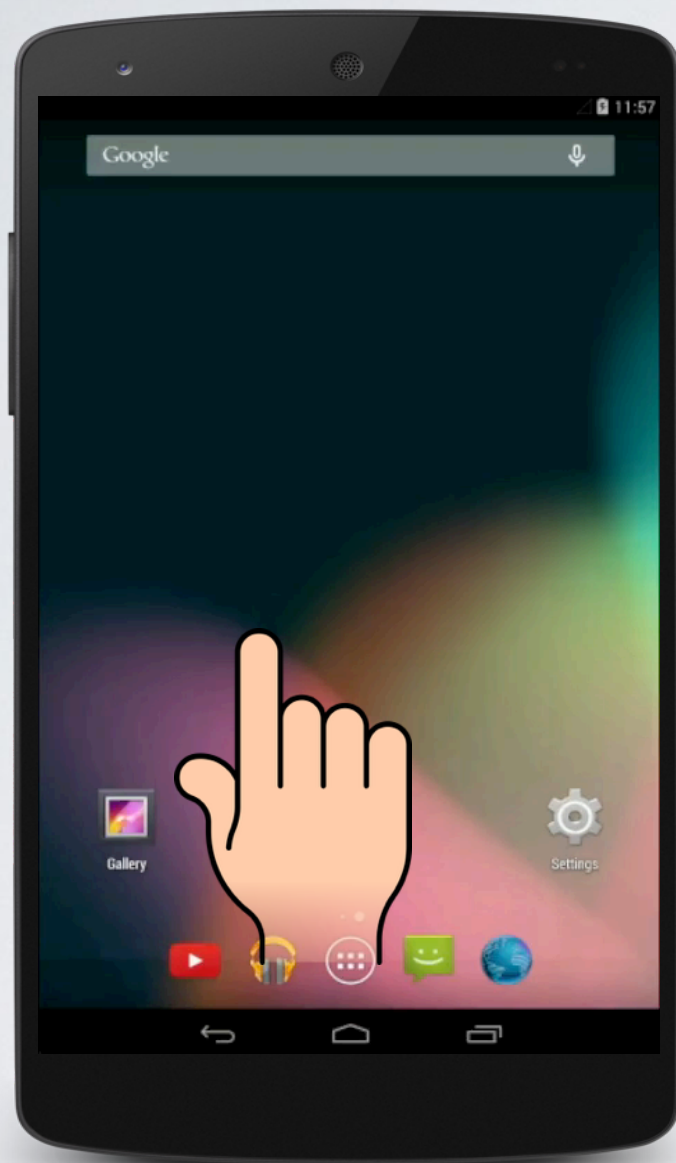
www.fusion-android.com

ADDITIONAL SLIDES



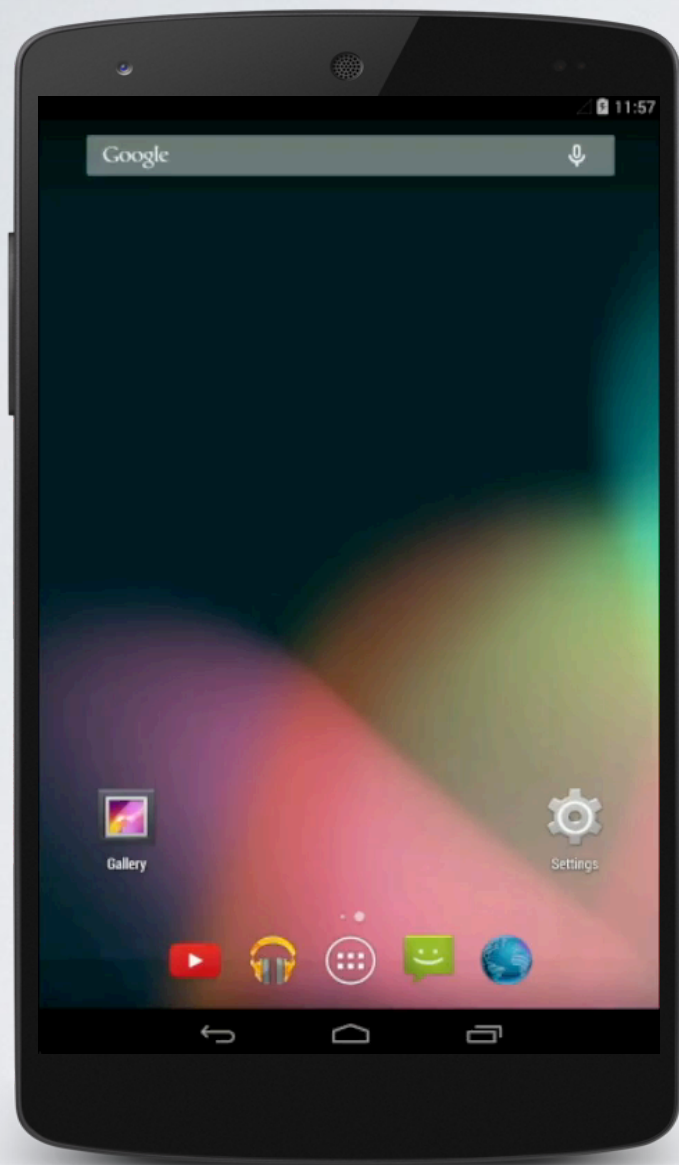


MANUAL TESTING



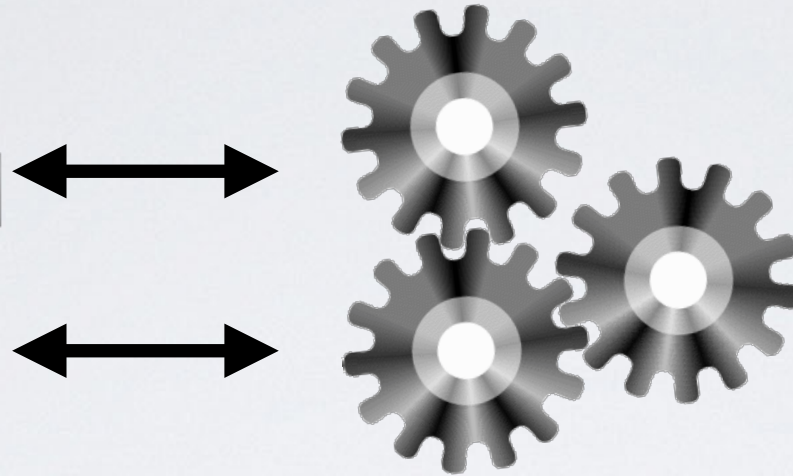
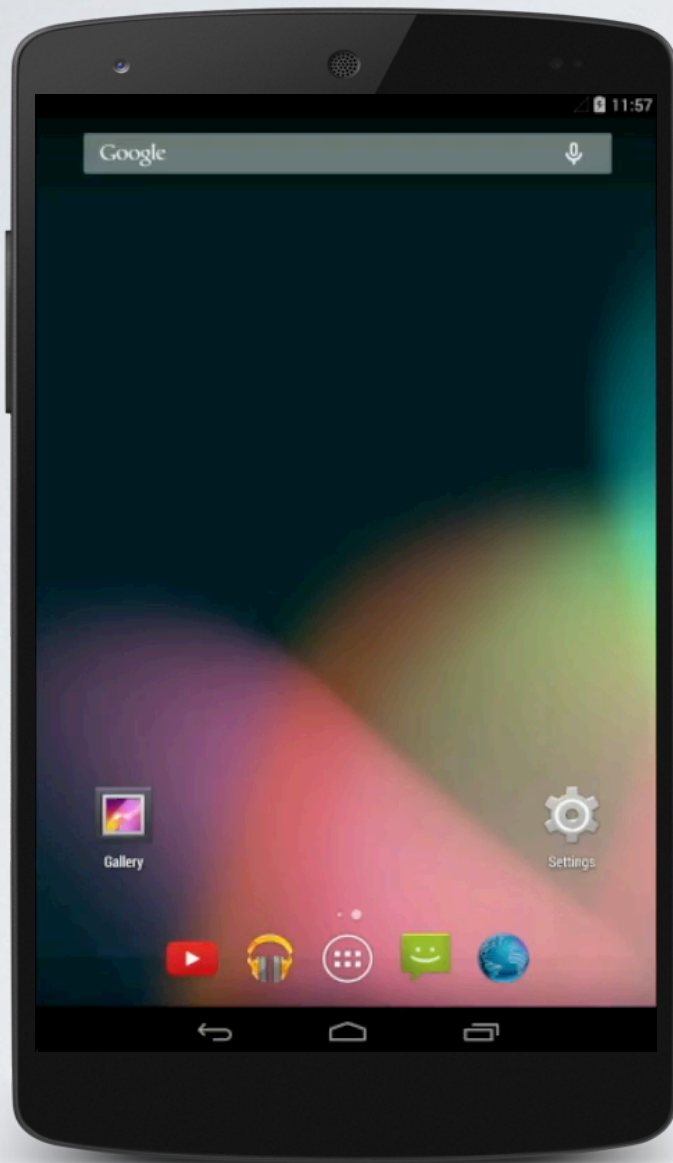


MANUAL TESTING





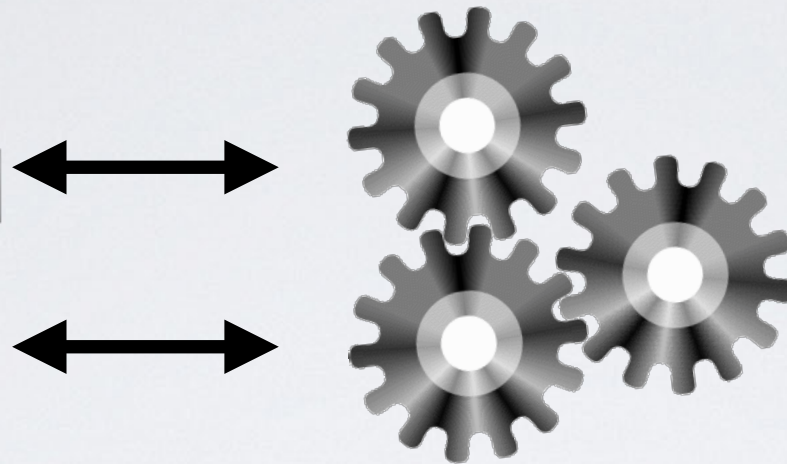
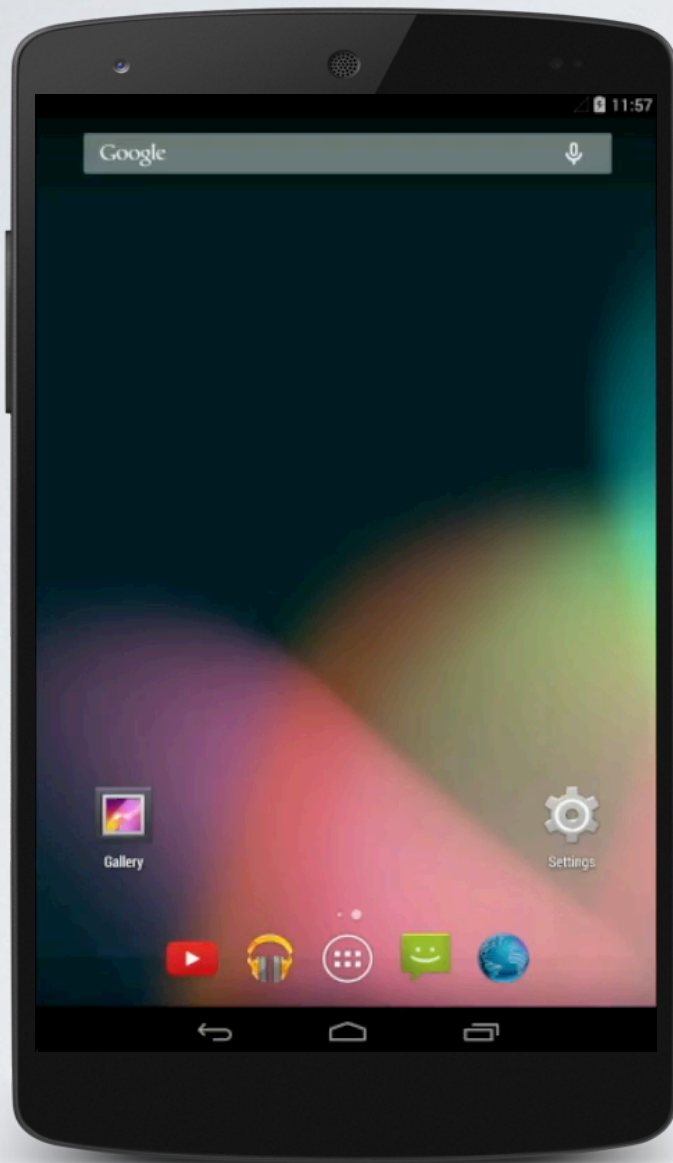
AUTOMATED TESTING



```
KevinMoran — adb shell logcat — 120x40
D/dalvikvm( 505): GC_CONCURRENT freed 761K, 13% free 5867K/6744K, paused 0ms+0ms, total 5ms
D/dalvikvm( 505): WAIT_FOR_CONCURRENT_GC blocked 3ms
D/dalvikvm( 505): GC_CONCURRENT freed 761K, 14% free 5867K/6744K, paused 1ms+0ms, total 7ms
D/dalvikvm( 505): WAIT_FOR_CONCURRENT_GC blocked 5ms
D/dalvikvm( 505): GC_CONCURRENT freed 759K, 13% free 5867K/6744K, paused 3ms+1ms, total 8ms
D/dalvikvm( 505): WAIT_FOR_CONCURRENT_GC blocked 4ms
D/dalvikvm( 505): GC_CONCURRENT freed 711K, 13% free 5875K/6744K, paused 1ms+1ms, total 8ms
D/dalvikvm( 505): GC_CONCURRENT freed 770K, 14% free 5867K/6744K, paused 0ms+1ms, total 5ms
D/dalvikvm( 505): WAIT_FOR_CONCURRENT_GC blocked 3ms
D/ConnectivityService( 505): [CheckMp] isMobileOk: X result=2
D/ConnectivityService( 505): [CheckMp] onPostExecute: result=2
D/ConnectivityService( 505): CheckMp.onComplete: result=2
D/ConnectivityService( 505): CheckMp.onComplete: ignore, connected or no connection
D/CaptivePortalTracker( 505): Checking http://70.186.30.21/generate_204
W/ActivityThread( 505): ClassLoader.loadClass: The class loader returned by Thread.getContextClassLoader() may fail for processes that host multiple applications. You should explicitly specify a context class loader. For example: Thread.setContextClassLoader(getClass().getClassLoader());
D/CaptivePortalTracker( 505): Don't send network conditions - lacking user consent.
D/CaptivePortalTracker( 505): isCaptivePortal: ret=false rspCode=204
D/CaptivePortalTracker( 505): Not captive network NetworkInfo: type: WIFI, state: CONNECTED/CONNECTED, reason: (unspecified), extra: "WiredSSID", roaming: false, failover: false, isAvailable: true, isConnectedToProvisioningNetwork: false
D/ConnectivityService( 505): captivePortalCheckCompleted: ni=NetworkInfo: type: WIFI, state: CONNECTED/CONNECTED, reason: (unspecified), extra: "WiredSSID", roaming: false, failover: false, isAvailable: true, isConnectedToProvisioningNetwork: false captive=false
D/ConnectivityService( 505): Sampling interval elapsed, updating statistics ..
D/ConnectivityService( 505): Done.
D/ConnectivityService( 505): Setting timer for 720seconds
I/MediaFocusControl( 505): AudioFocus abandonAudioFocus() from android.media.AudioManager@527b6ac4com.android.music.MediaPlaybackService$3@527b61c4
I/ActivityManager( 505): Start proc com.android.musicfx for broadcast com.android.musicfx/.ControlPanelReceiver: pid=1370 uid=10010 gids={50010, 3003, 3002}
V/MusicFXControlPanelReceiver( 1370): onReceive
V/MusicFXControlPanelReceiver( 1370): Action: android.media.action.CLOSE_AUDIO_EFFECT_CONTROL_SESSION
V/MusicFXControlPanelReceiver( 1370): Package name: com.android.music
V/MusicFXControlPanelReceiver( 1370): Audio session: 4
V/MusicFXControlPanelEffect( 1370): closeSession(android.app.ReceiverRestrictedContext@527b1204, com.android.music, 4)
```



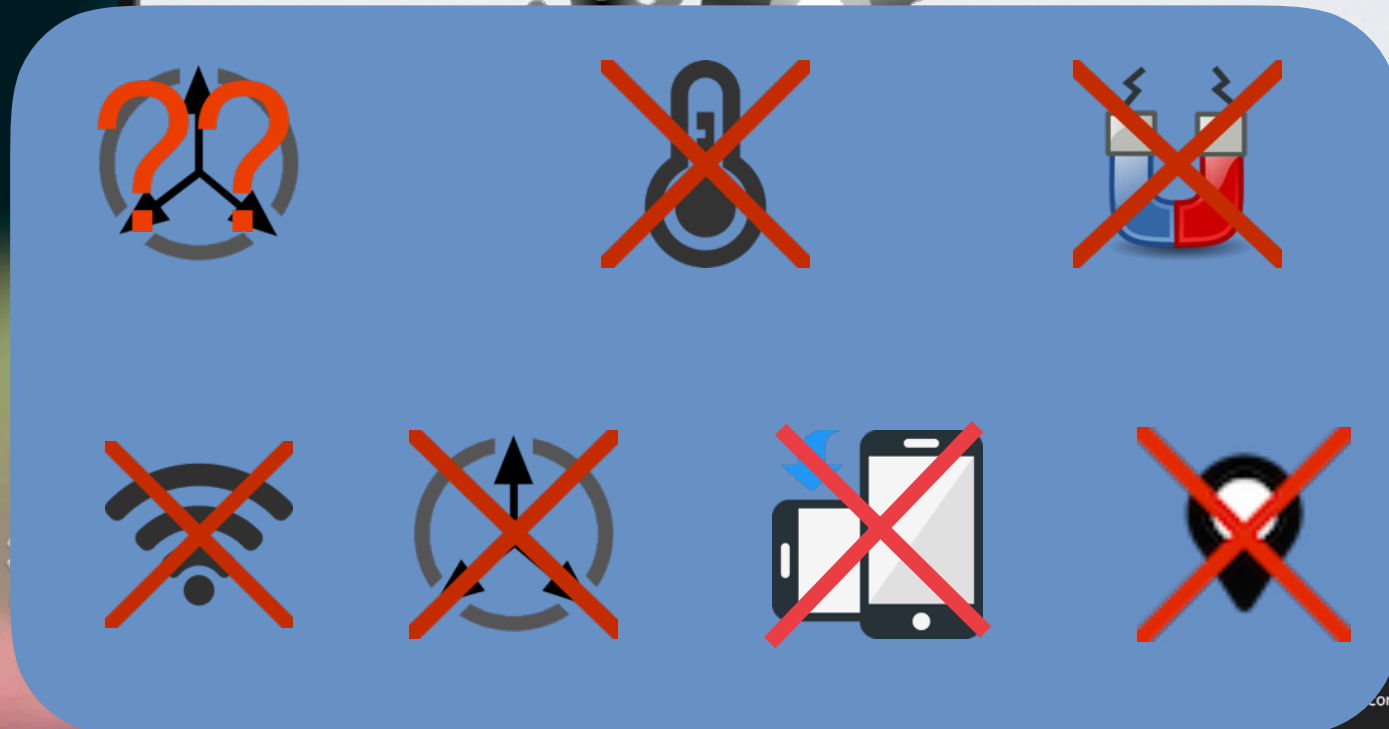
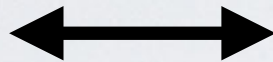

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AUTOMATED TESTING



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```



THE CURRENT STATE OF AUTOMATED MOBILE APPLICATION TESTING

Tool Name	Instr.	GUI Exploration	Types of Events	Crash Resilient	Replayable Test Cases	NL Crash Reports	Emulators, Devices
Dynodroid	Yes	Guided/Random	System, GUI, Text	Yes	No	No	No
EvoDroid	No	System/Evo	GUI	No	No	No	N/A
AndroidRipper	Yes	Systematic	GUI, Text	No	No	No	N/A
MobiGUITar	Yes	Model-Based	GUI, Text	No	Yes	No	N/A
A3E DFS	Yes	Systematic	GUI	No	No	No	Yes
A3E Targeted	Yes	Model-Based	GUI	No	No	No	Yes
Swifthand	Yes	Model-Based	GUI, Text	N/A	No	No	Yes
PUMA	Yes	Programmable	System, GUI, Text	N/A	No	No	Yes
ACTEve	Yes	Systematic	GUI	N/A	No	No	Yes
VANARSena	Yes	Random	System, GUI, Text	Yes	Yes	No	N/A
Thor	Yes	Test Cases	Test Case Events	N/A	N/A	No	No
QUANTUM	Yes	Model-Based	System, GUI	N/A	Yes	No	N/A
AppDoctor	Yes	Multiple	System, GUI, Text	Yes	Yes	No	N/A
ORBIT	No	Model-Based	GUI	N/A	No	No	N/A
SPAG-C	No	Record/Replay	GUI	N/A	N/A	No	No
JPF-Android	No	Scripting	GUI	N/A	Yes	No	N/A
MonkeyLab	No	Model-based	GUI, Text	No	Yes	No	Yes
CrashDroid	No	Manual Rec/Replay	GUI, Text	Manual	Yes	Yes	Yes
SIG-Droid	No	Symbolic	GUI, Text	N/A	Yes	No	N/A
CrashScope	No	Systematic	GUI, Text, System	Yes	Yes	Yes	Yes



LIMITATIONS OF AUTOMATED MOBILE TESTING AND DEBUGGING

- Lack of detailed, easy to understand testing results for faults/crashes¹
- No easy way to reproduce test scenarios¹
- Not practical from a developers viewpoint
- Few approaches enable different strategies capable of generating text and testing contextual features

¹S. R. Choudhary, A. Gorla, and A. Orso. Automated Test Input Generation for Android: Are we there yet? In 30th IEEE/ACM International Conference on Automated Software Engineering (ASE 2015), 2015



PAST STUDIES OF MOBILE CRASHES AND BUGS

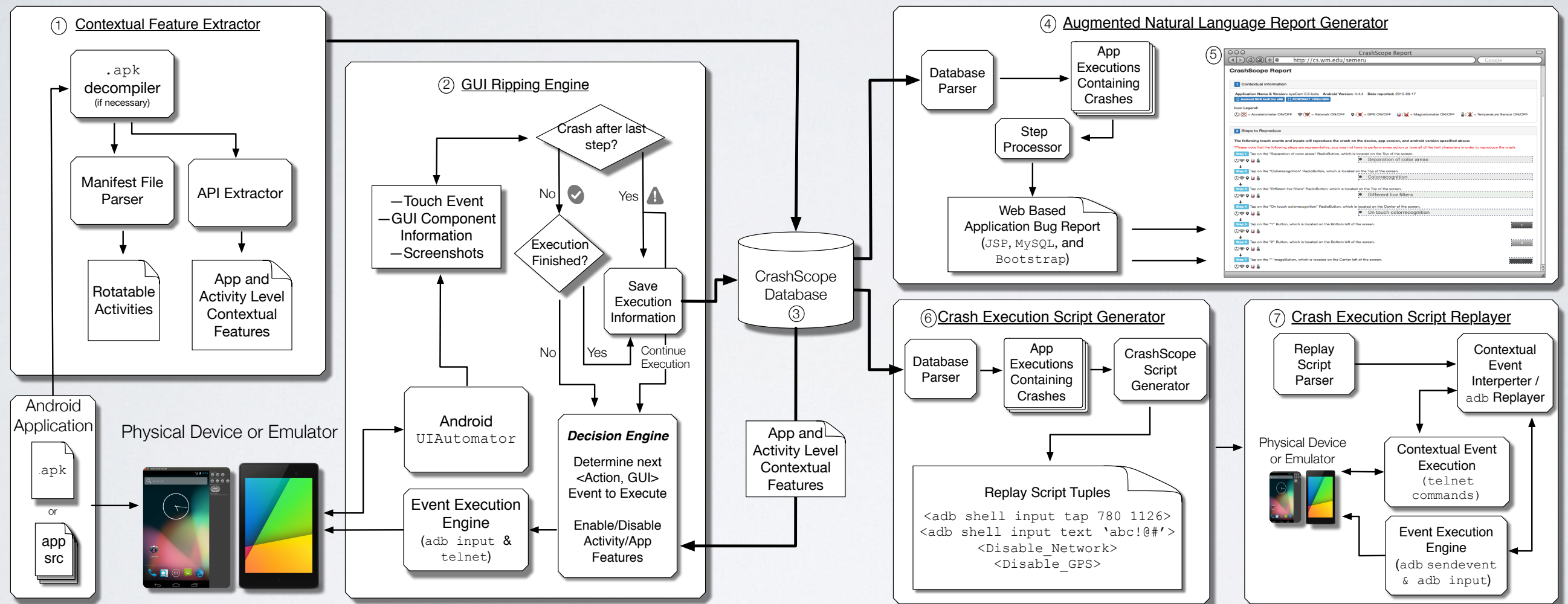
- Many crashes can be mapped to ***well-defined, externally inducible*** faults¹
- ***Contextual features***, such as network connectivity and screen rotation, account for many of these externally inducible faults¹²
- These dominant root causes can affect ***many different*** user execution paths¹

¹L. Ravindranath, S. Nath, J. Padhye, and H. Balakrishnan. Automatic and scalable fault detection for mobile applications. MobiSys '14

²R. N. Zaeem, M. R. Prasad, and S. Khurshid. Automated generation of oracles for testing user-interaction features of mobile apps, ICST '14

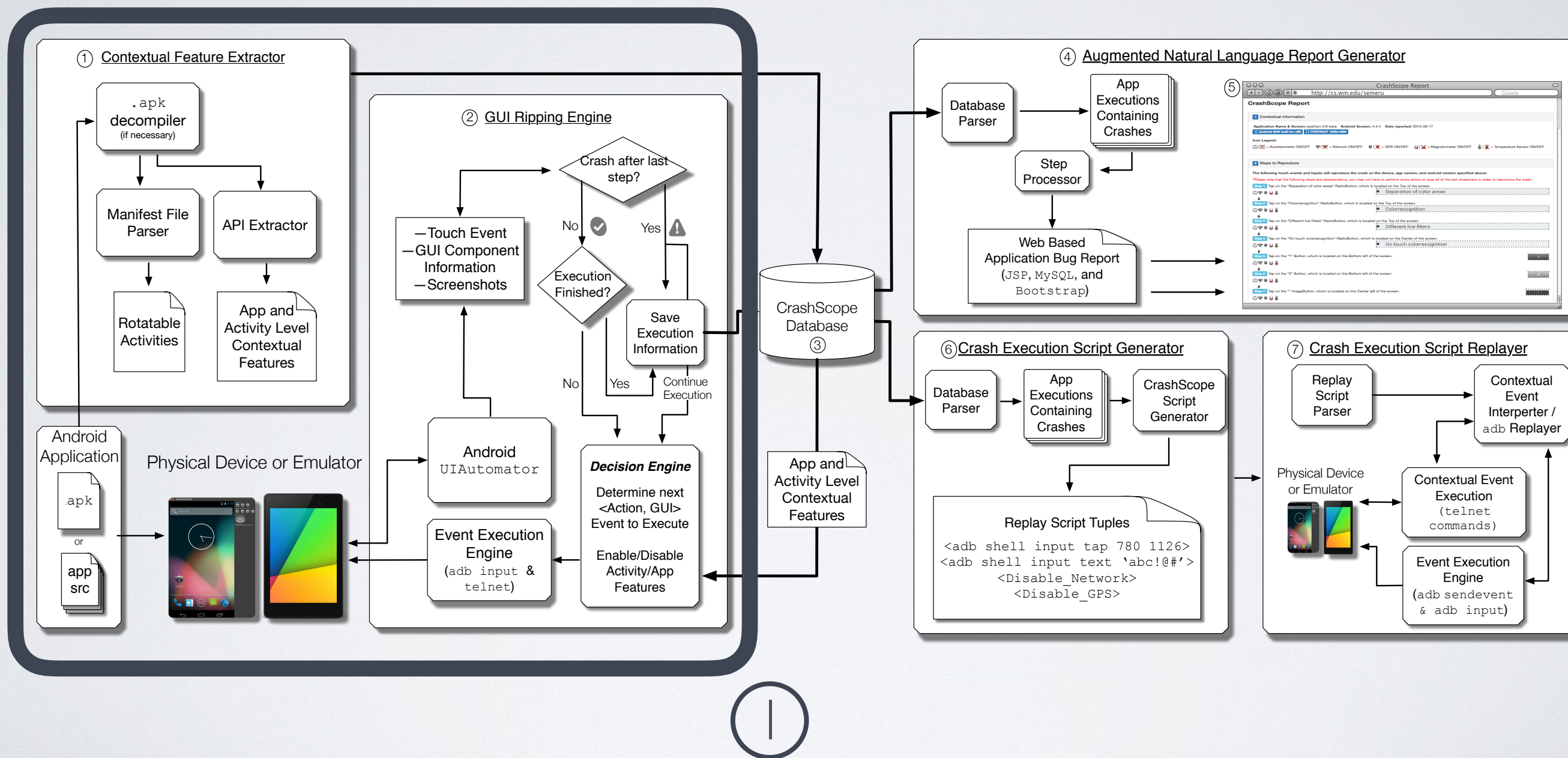


CRASHSCOPE DESIGN



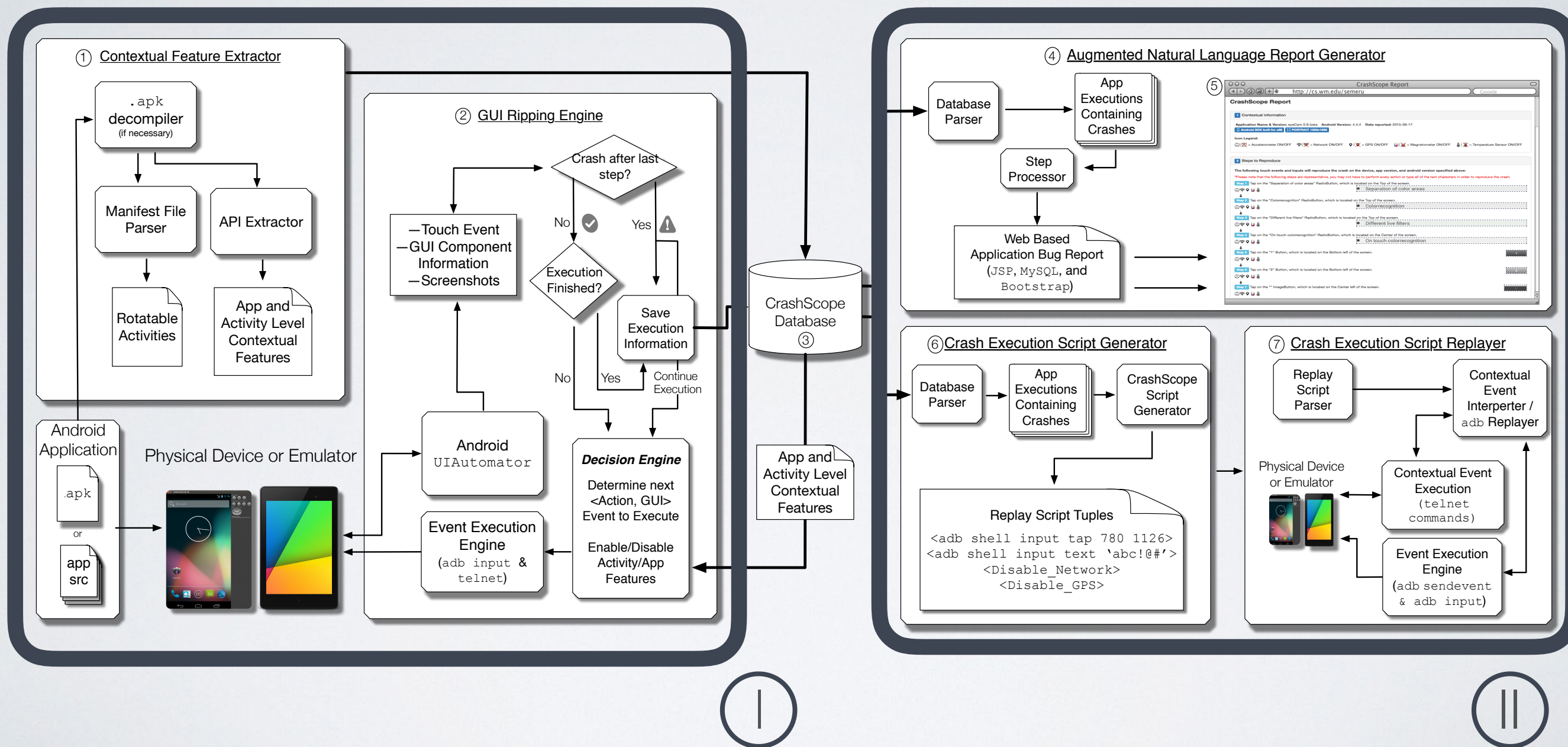


CRASHSCOPE DESIGN



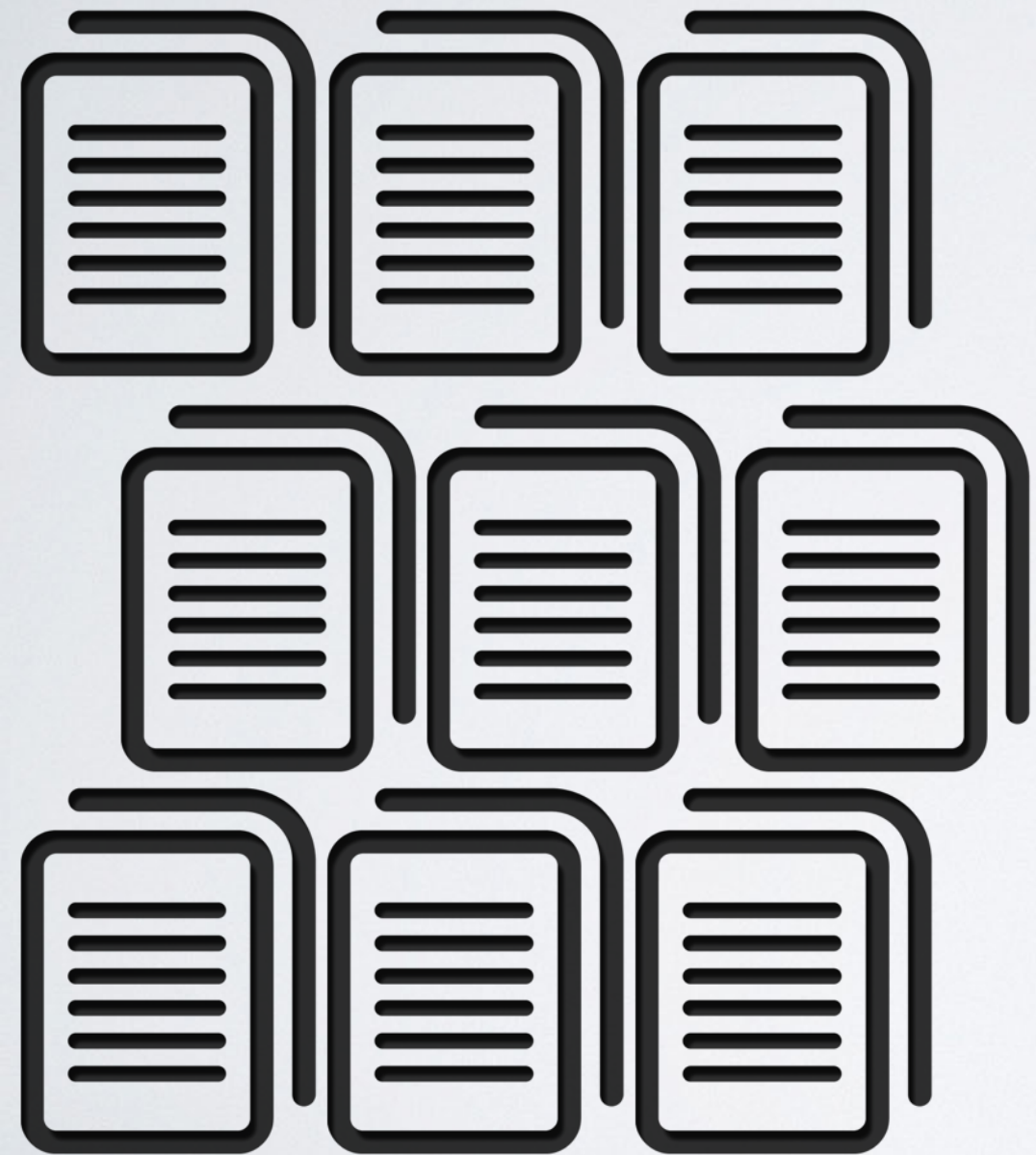


CRASHSCOPE DESIGN



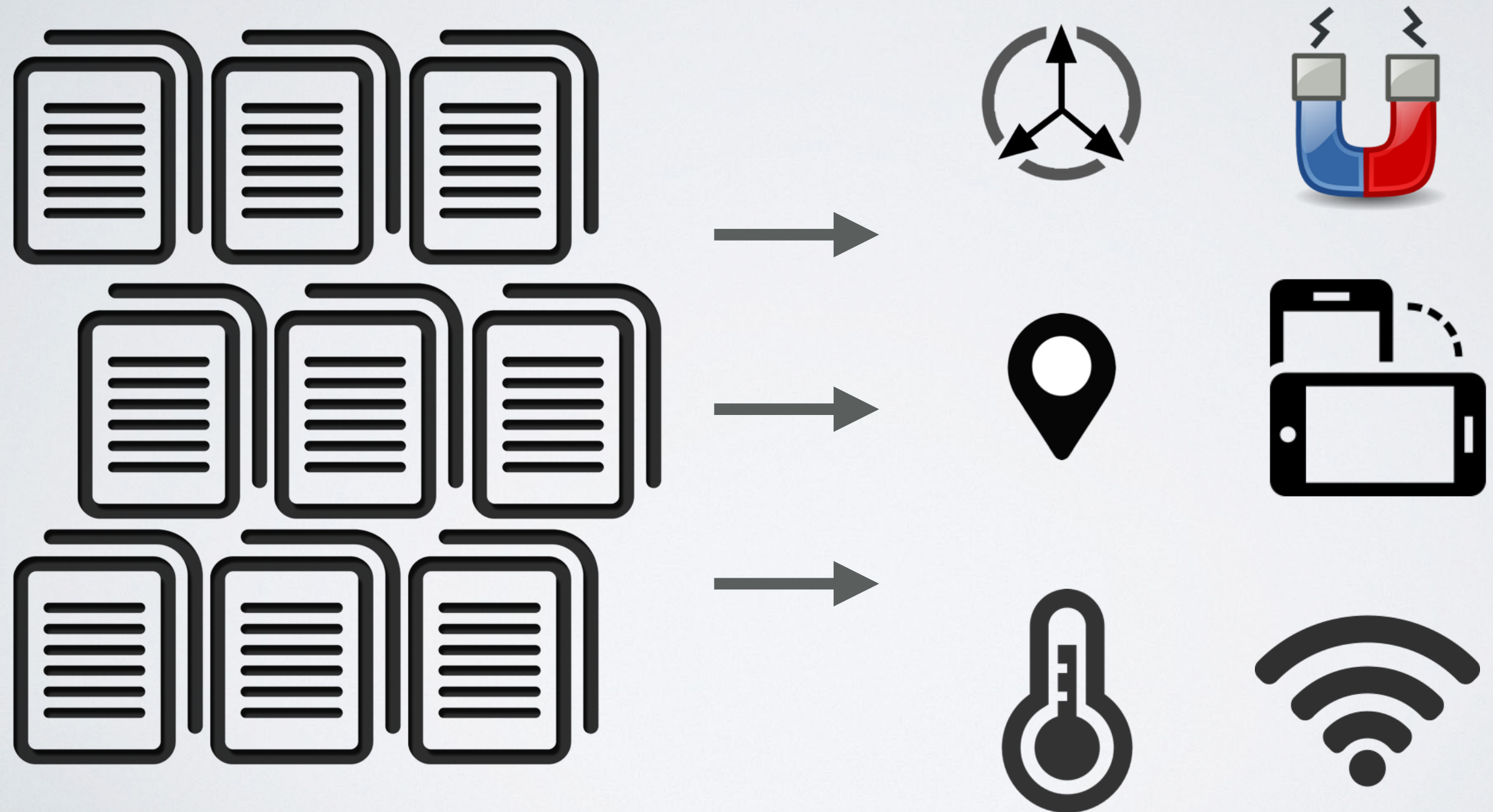


CRASHSCOPE: EXPLORATION





CRASHSCOPE: EXPLORATION



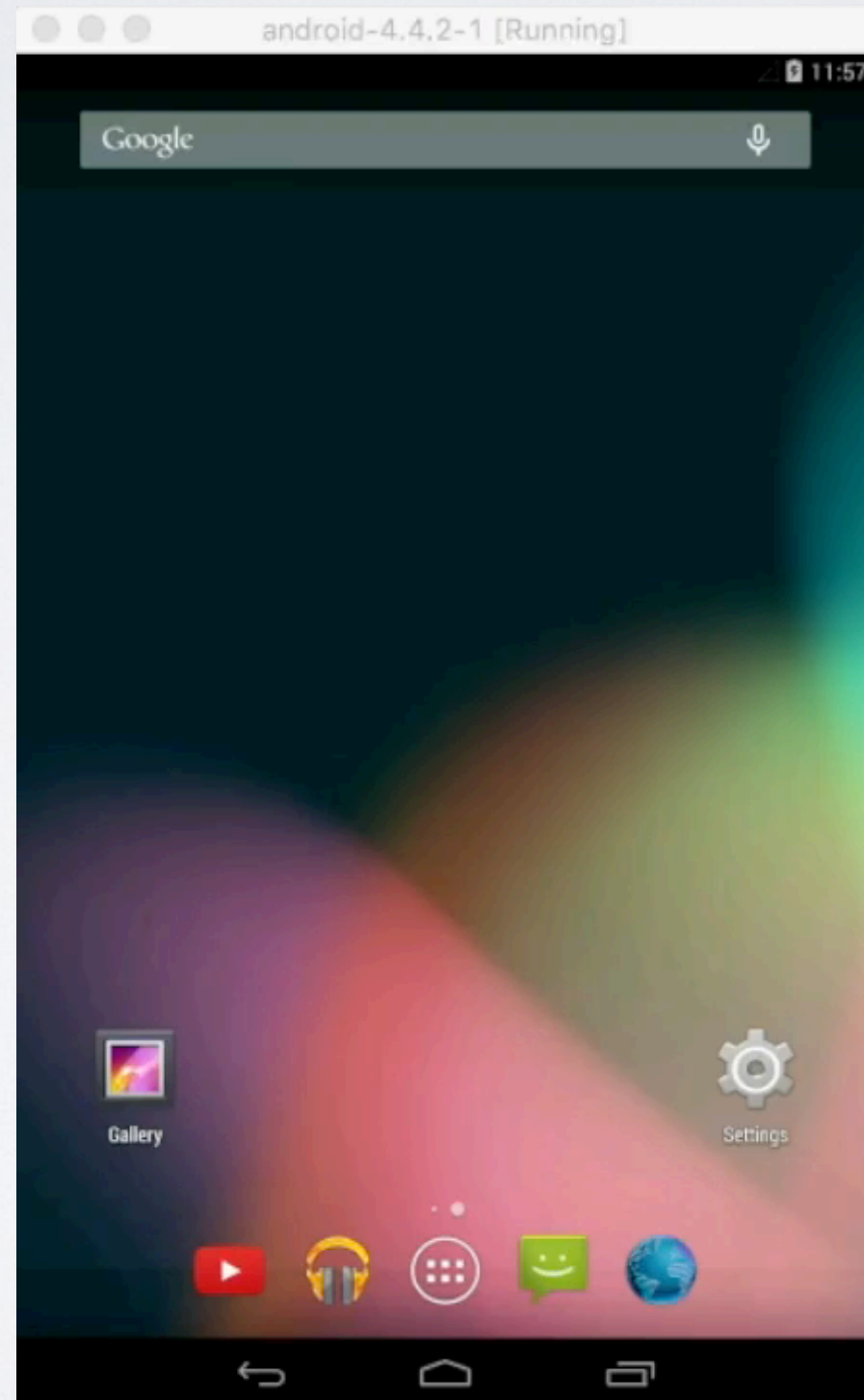


CRASHSCOPE STRATEGIES

- ***GUI-Traversal:*** Top-Down & Bottom Up
- ***Text Entry:*** Expected, Unexpected, No Text
- ***Contextual Features:*** Enabled or Disabled

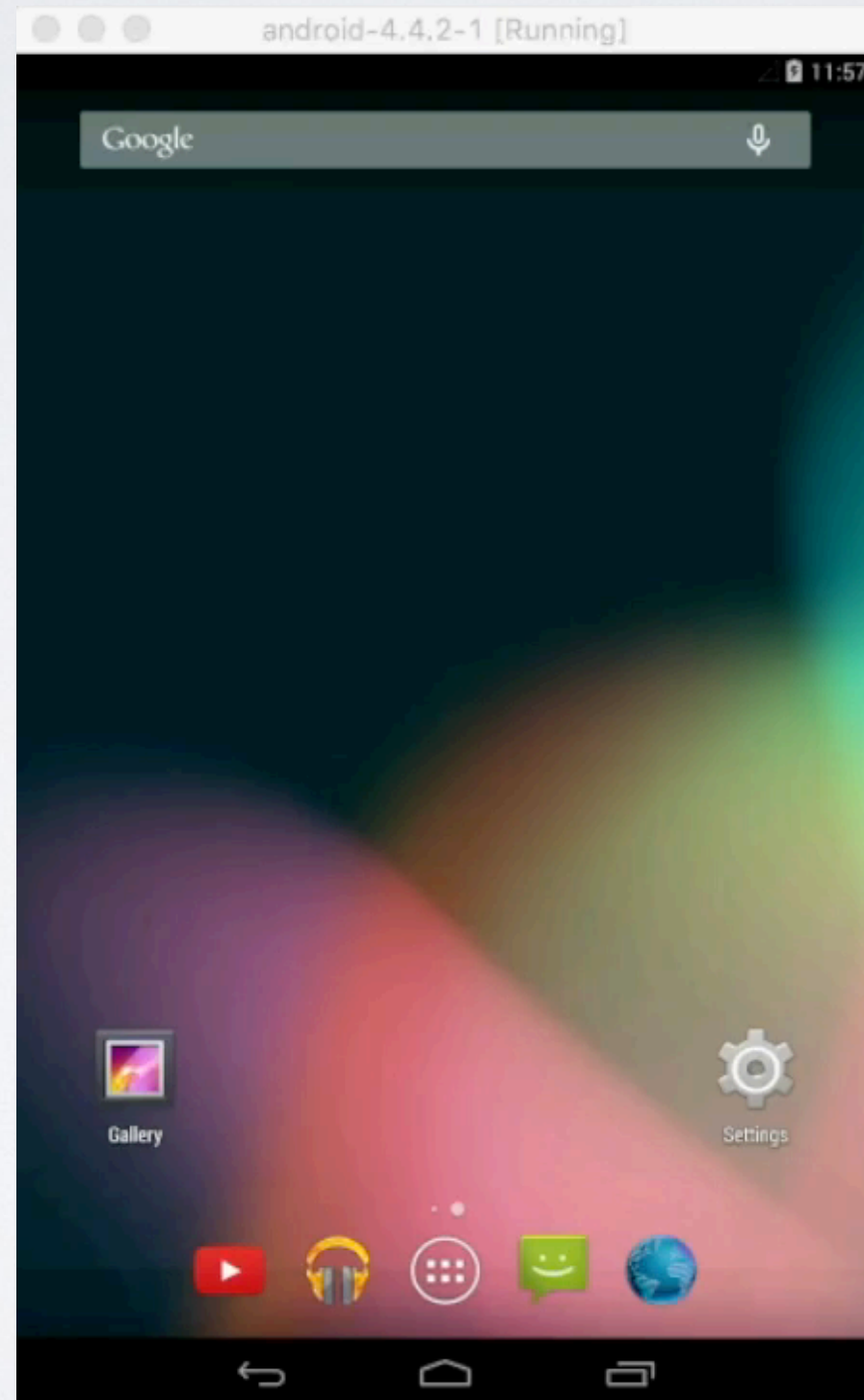


CRASHSCOPE DEMO





CRASHSCOPE DEMO





CRASHSCOPE: REPORTS

CrashScope Report

1 Contextual information

Application Name & Version: GnuCash 1.0.3 Android Version: 4.4.4 Date reported: 2015-08-17

Android SDK built for x86 PORTRAIT 1200x1920

Icon Legend:

= Accelerometer ON/OFF = Network ON/OFF = GPS ON/OFF = Magnetometer ON/OFF = Temperature Sensor ON/OFF

2 Steps to Reproduce

The following touch events and inputs will reproduce the crash on the device, app version, and android version specified above:

*Please note that the following steps are representative, you may not have to perform every action or type all of the text characters in order to reproduce the crash.

Step 1 Tap on the "Expenses" CheckedTextView, which is located on the Center of the screen.



Step 2 Tap on the "Income" CheckedTextView, which is located on the Center of the screen.



Step 3 Tap on the "Assets" CheckedTextView, which is located on the Center of the screen.



Step 4 Tap on the "Entertainment" CheckedTextView, which is located on the Center of the screen.



Step 5 Tap on the "Insurance" CheckedTextView, which is located on the Center of the screen.



Step 6 Tap on the "Expenses" CheckedTextView, which is located on the Center of the screen.



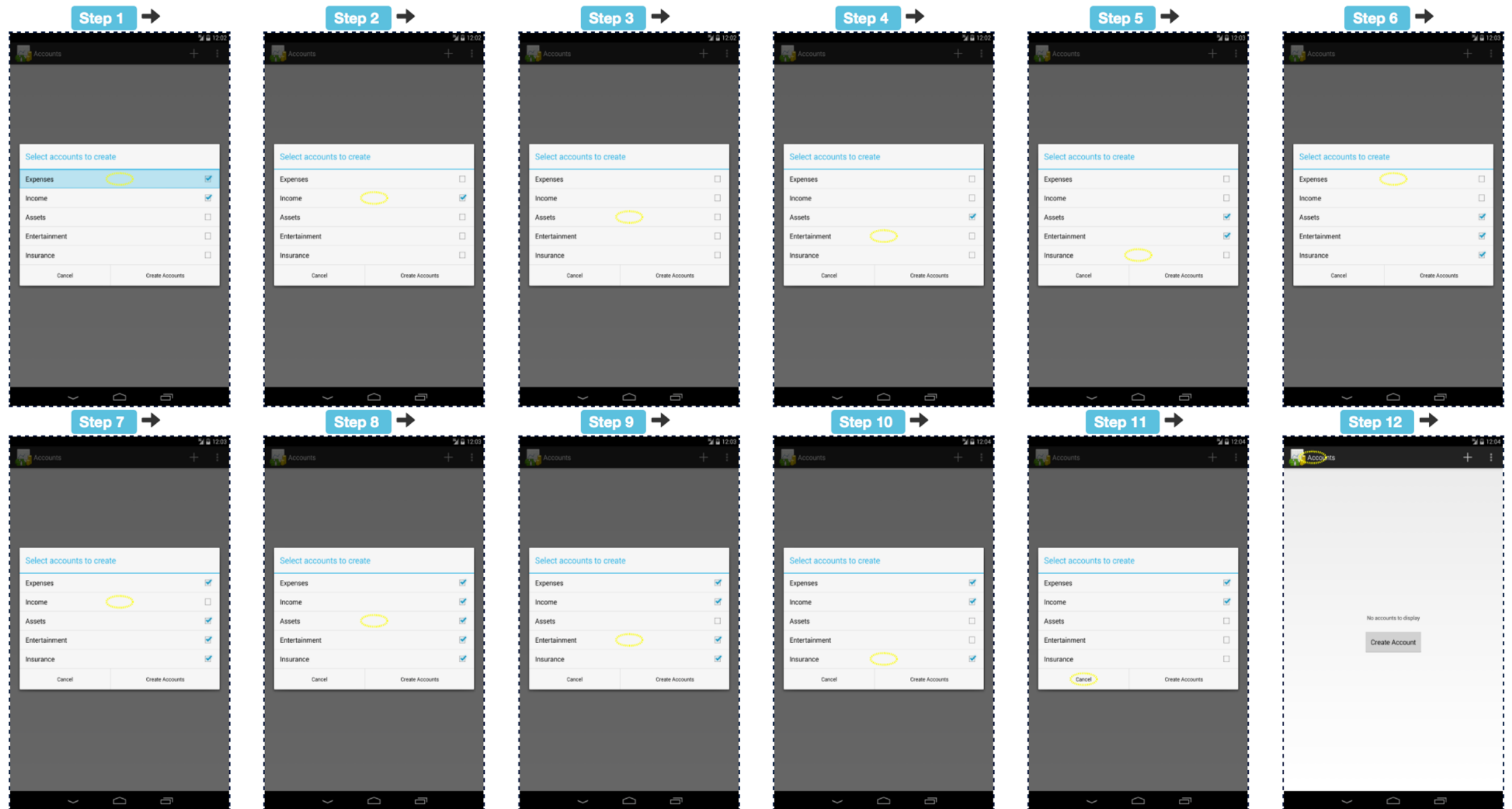
Expenses	<input checked="" type="checkbox"/>
Income	<input checked="" type="checkbox"/>
Assets	<input type="checkbox"/>
Entertainment	<input type="checkbox"/>
Insurance	<input type="checkbox"/>
Expenses	<input type="checkbox"/>



CRASHSCOPE: REPORTS

3 Crash Application Screen-Flow

[\(Go top\)](#)





CRASHSCOPE: REPORTS

4 Crash Pruned Stack Trace

[\(Go top\)](#)

```
E/SQLiteLog(17653): (1) near "inhphsjgf": syntax error
E/AndroidRuntime(17653): FATAL EXCEPTION: main
E/AndroidRuntime(17653): Process: org.gnucash.android, PID: 17653
E/AndroidRuntime(17653): android.database.sqlite.SQLiteException: near "inhphsjgf": syntax error (code 1): , while compiling: SELECT _id, uid FROM accounts WHERE uid = 'inhphsjgf-d724114f522e'
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteConnection.nativePrepareStatement(Native Method)
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteConnection.acquirePreparedStatement(SQLiteConnection.java:889)
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteConnection.prepare(SQLiteConnection.java:500)
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteSession.prepare(SQLiteSession.java:588)
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteProgram.(SQLiteProgram.java:58)
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteQuery.(SQLiteQuery.java:37)
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteDirectCursorDriver.query(SQLiteDirectCursorDriver.java:44)
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteDatabase.rawQueryWithFactory(SQLiteDatabase.java:1314)
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteDatabase.queryWithFactory(SQLiteDatabase.java:1161)
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteDatabase.query(SQLiteDatabase.java:1032)
E/AndroidRuntime(17653):     at android.database.sqlite.SQLiteDatabase.query(SQLiteDatabase.java:1200)
E/AndroidRuntime(17653):     at org.gnucash.android.db.AccountsDbAdapter.getAccountID(AccountsDbAdapter.java:166)
E/AndroidRuntime(17653):     at org.gnucash.android.db.AccountsDbAdapter.addAccount(AccountsDbAdapter.java:76)
E/AndroidRuntime(17653):     at org.gnucash.android.ui.accounts.NewAccountDialogFragment$1.onClick(NewAccountDialogFragment.java:156)
E/AndroidRuntime(17653): )
E/AndroidRuntime(17653):     at android.view.View.performClick(View.java:4438)
E/AndroidRuntime(17653):     at android.view.View$PerformClick.run(View.java:18422)
E/AndroidRuntime(17653):     at android.os.Handler.handleCallback(Handler.java:733)
E/AndroidRuntime(17653):     at android.os.Handler.dispatchMessage(Handler.java:95)
E/AndroidRuntime(17653):     at android.os.Looper.loop(Looper.java:136)
E/AndroidRuntime(17653):     at android.app.ActivityThread.main(ActivityThread.java:5001)
E/AndroidRuntime(17653):     at java.lang.reflect.Method.invokeNative(Native Method)
E/AndroidRuntime(17653):     at java.lang.reflect.Method.invoke(Method.java:515)
E/AndroidRuntime(17653):     at com.android.internal.os.ZygoteInit$MethodAndArgsCaller.run(ZygoteInit.java:785)
E/AndroidRuntime(17653):     at com.android.internal.os.ZygoteInit.main(ZygoteInit.java:601)
E/AndroidRuntime(17653):     at dalvik.system.NativeStart.main(Native Method)
```




EVALUATION

- Two Empirical Studies
- Study 1: Crash Detection Capabilities
- Study 2: Crash Report Reproducibility and Readability



STUDY I: CRASH RESULTS

Unique Crashes Discovered With Instrumented Crashes in Parentheses

App	A3E	GUI- Ripper	Dynodroid	PUMA	Monkey (All)	CrashScope
A2DP Vol	1	0	0	0	0	0
aagtl	0	0	1	0	1	0
Amazed	0	0	0	0	1	0
HNDroid	1	1	1	2	1	1
BatteryDog	0	0	1	0	1	0
Soundboard	0	1	0	0	0	0
AKA	0	0	0	0	1	0
Bites	0	0	0	0	1	0
Yahtzee	1	0	0	0	0	1
ADSDroid	1	1	1	1	1	1
PassMaker	1	0	0	0	1	1
BlinkBattery	0	0	0	0	1	0
D&C	0	0	0	0	1	0
Photostream	1	1	1	1	1	0
AlarmKlock	0	0	1	0	0	0
Sanity	1	1	0	0	0	0
MyExpenses	0	0	1	0	0	0
Zooborns	0	0	0	0	0	2
ACal	1	2	2	0	1	1
Hotdeath	0	2	0	0	0	1
Total	8 (21)	9 (5)	9 (6)	4 (0)	12 (1)	8 (0)



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AKA	0	0	0	0	1	0
Bites	0	0	0	0	1	0
Yahtzee	1	0	0	0	0	1
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BlinkBattery	0	0	0	0	1	0
D&C	0	0	0	0	1	0
Photostream	1	1	1	1	1	0
AlarmKlock	0	0	1	0	0	0
Sanity	1	1	0	0	0	0
MyExpenses	0	0	1	0	0	0
Zooborns	0	0	0	0	0	2
ACal	1	2	2	0	1	1
Hotdeath	0	2	0	0	0	1
Total	8 (21)	9 (5)	9 (6)	4 (0)	12 (1)	8 (0)



STUDY I: CRASH RESULTS

- CrashScope is about as effective as other techniques with regard to uncovering crashes.
- CrashScope is able to uncover orthogonal crashes



STUDY 2: READABILITY RESULTS

Question	CrashScope Mean	CrashScope StdDev	Original Mean	Original StdDev
UX1: I think I would like to have this type of bug report frequently.	4.00	0.89	3.06	0.77
UX2: I found this type of bug report unnecessarily complex.	2.81	1.04	2.125	0.96
UX3: I thought this type of bug report was easy to read/understand.	4.00	0.82	3.00	0.97
UX4: I found this type of bug report very cumbersome to read.	2.50	1.10	2.44	0.81
UX5: I thought the bug report was very useful for reproducing the crash.	4.13	0.62	3.44	0.89



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UX5: I thought the bug report was very useful for reproducing the crash.	4.13	0.62	3.44	0.89



STUDY 2: READABILITY RESULTS

- Reports generated by CrashScope are more readable and reproducible



CRASHSCOPE: A PRACTICAL TOOL



CrashScope | Dashboard

localhost:8080/CrashScope/app/report_results.xhtml

Kevin

Requests/Tasks New CrashScope Task Kevin

Detected Crashes

Link to Bug Report	Crash ID	# Steps	Strategies
View Report	1	29	📄📄📄
View Report	2	12	📄📄📄
View Report	3	9	📄📄📄

Strategy Icon Legend
Top-Down Exploration: 📄
Bottom-Up Exploration: 📄
Unexpected Text Input: 📄
Expected Text input: 📄
No Text Input: 📄
Contextual Features Enabled/Disabled: ☑/☒

Report Viewer

1 Contextual information
Application Name & Version: GnuCash 1.0.3 **Android Version:** 4.4.4 **Date reported:** Mon Aug 17 00:00:00 EDT 2015
Android SDK built for x86 **PORTRAIT 1200x1920**
Icon Legend:
📶☒ = Accelerometer ON/OFF 📶☒ = Network ON/OFF 📶☒ = GPS ON/OFF 📶☒ = Magnetometer ON/OFF 📶☒ = Temperature Sensor ON/OFF

2 Steps to Reproduce
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Step 1 Tap on the "android.widget.CheckedTextView" Expenses, which is located on the Center of the screen.
📶📶📶📶📶
↓
Step 2 Tap on the "android.widget.CheckedTextView" Income, which is located on the Center of the screen.
📶📶📶📶📶
↓
Step 3 Tap on the "android.widget.CheckedTextView" Assets, which is located on the Center of the screen.
📶📶📶📶📶
↓
Step 4 Tap on the "android.widget.CheckedTextView" Entertainment, which is located on the Center of the screen.



CRASHSCOPE: A PRACTICAL TOOL



CrashScope | Dashboard

localhost:8080/CrashScope/app/report_results.xhtml

Kevin

Requests/Tasks New CrashScope Task Kevin

Detected Crashes

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View Report	2	12	📄📄📄
View Report	3	9	📄📄📄

Strategy Icon Legend
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↓
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📶📶📶📶📶
↓
Step 3 Tap on the "android.widget.CheckedTextView" Assets, which is located on the Center of the screen.
📶📶📶📶📶
↓
Step 4 Tap on the "android.widget.CheckedTextView" Entertainment, which is located on the Center of the screen.

LOOKING FORWARD: POTENTIAL RESEARCH MAP

The Starting Point



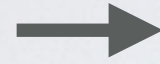
&



The Starting Point



&



On-Device
Bug Reporting





FUSION: ON-DEVICE BUG REPORTING

Advisees:
Richard Bonnet,
Brendan Otten,
Daniel Park





FUSION: ON-DEVICE BUG REPORTING

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The Starting Point



&



On-Device
Bug Reporting



The Starting Point



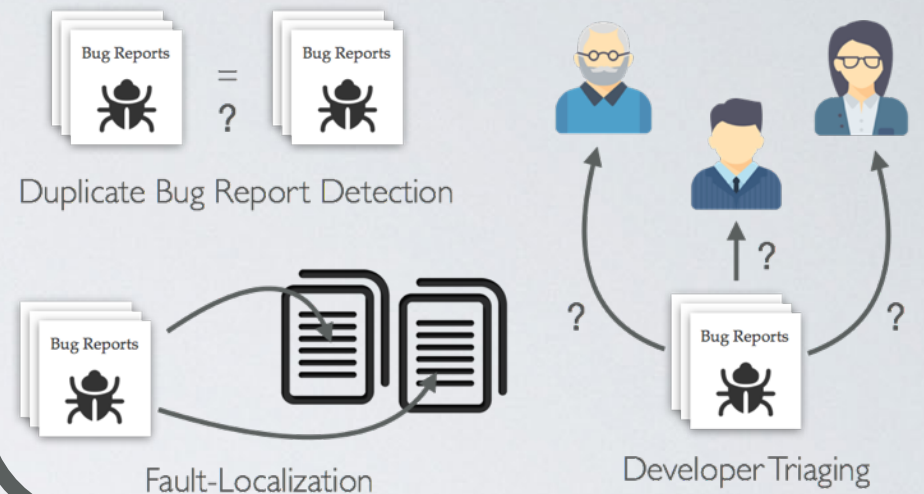
&



On-Device Bug Reporting



Improving Related Maintenance Tasks



The Starting Point



&



On-Device Bug Reporting



Improving Related Maintenance Tasks



Large-Scale Dynamic Analysis



The Starting Point



&



On-Device
Bug Reporting



Improving Related
Maintenance Tasks



Large-Scale Dynamic
Analysis



FUSION for
Web-Apps



The Starting Point



&



On-Device Bug Reporting



Improving Related Maintenance Tasks



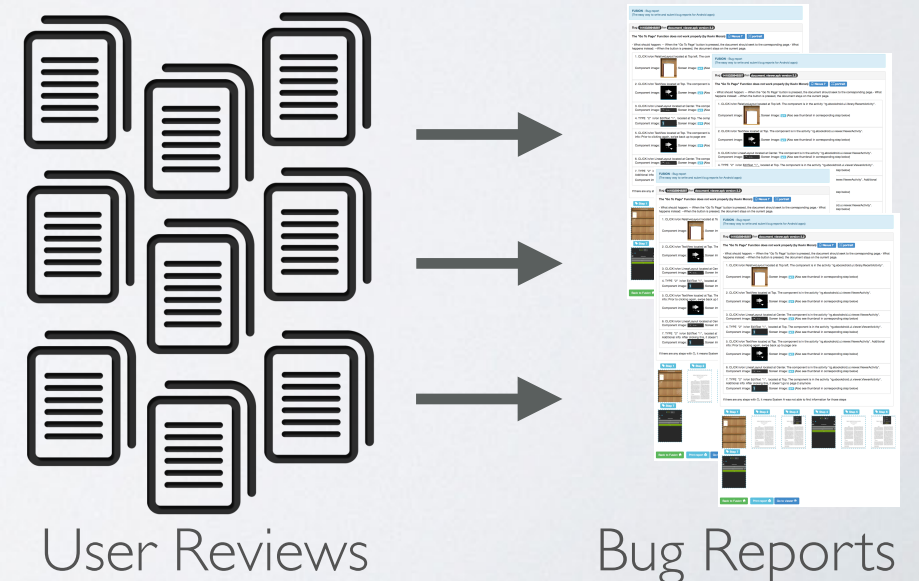
Large-Scale Dynamic Analysis



FUSION for Web-Apps



Inferring Bug Reports from User Reviews





THE LEXICAL GAP IN BUG REPORTING

Reporters:

-Functional Knowledge of a
Software Bug.



Developers:

-Intimate Code Level Knowledge
of Application



Inherent Lexical
Gap

Images Courtesy of Google

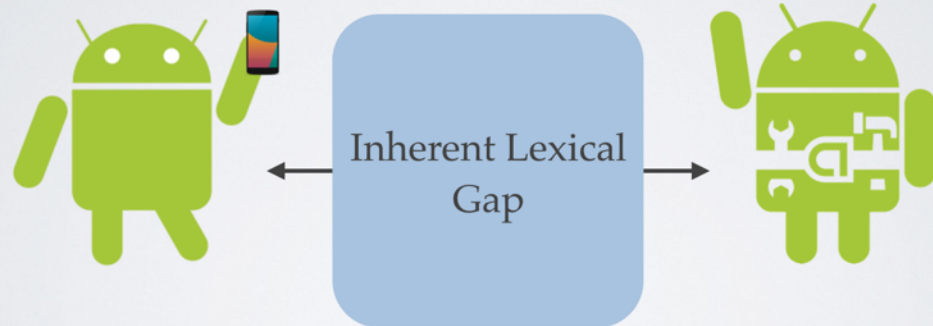
THE LEXICAL GAP IN BUG REPORTING

Reporters:

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Images Courtesy of Google

fusion-android.com

OVERVIEW FUSION  FUSION REPLICATION PACKAGE

FUSION: Improving Mobile Bug Reporting

Team Members: Kevin Moran, Mario Linares-Vásquez, Carlos Bernal-Cárdenas, & Denys Poshyvanyk

College of William & Mary --- SEMERU

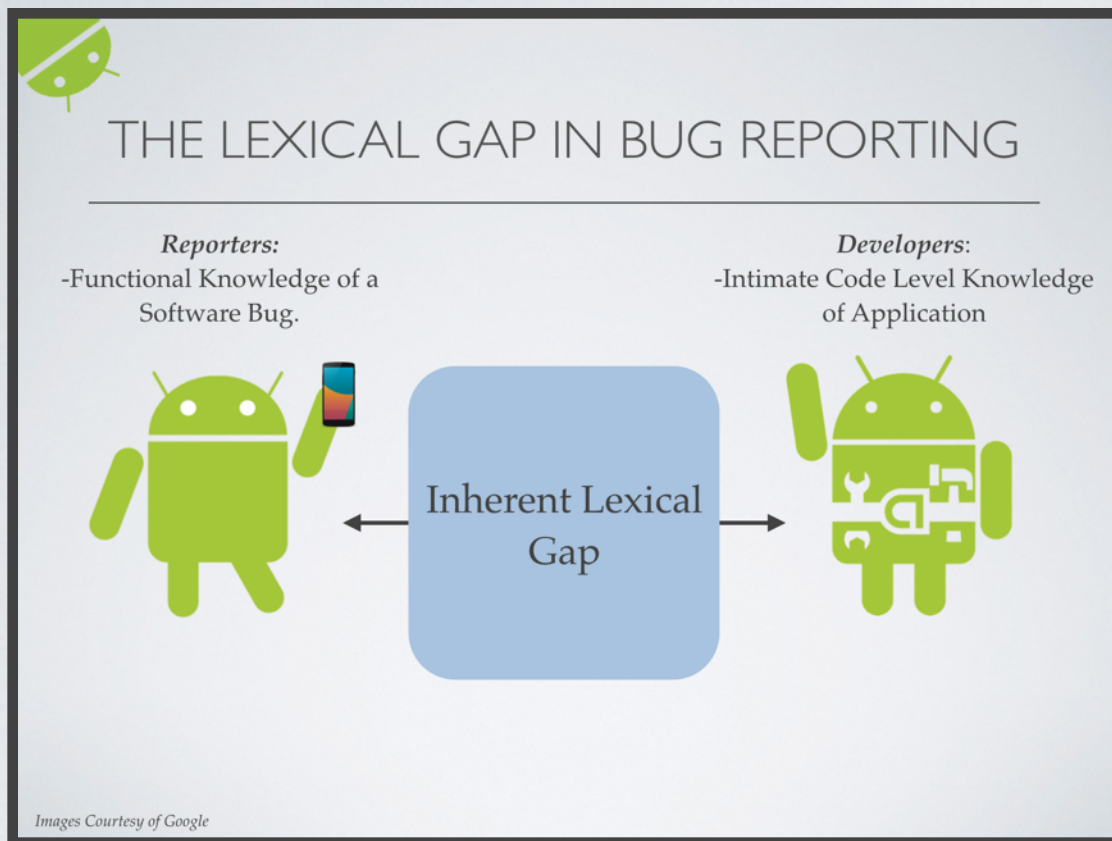


&



Purpose

This project was created by the Software Engineering Maintenance and Evolution Research Unit (SEMERU) at the College of William & Mary, under the supervision of Dr. Denys Poshyvanyk. The major goal of the FUSION project is provide a more effective means of off-device bug reporting for Android applications that facilitates reporting through auto-completion, and provides detailed information to developers to aid in bug reproduction. In the future we hope to build out the tool to provide fault location capabilities and bug fixing suggestions.

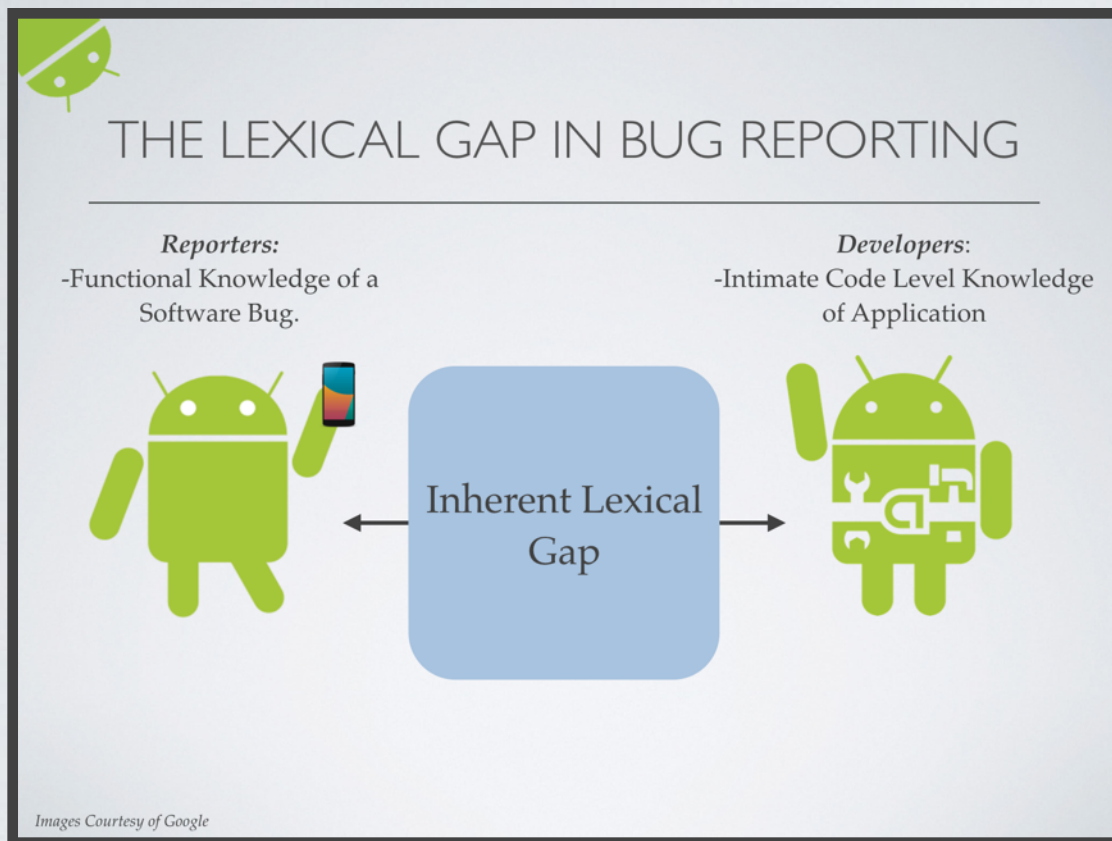


The screenshot shows the homepage of the FUSION project website. The header is red with the text 'OVERVIEW', 'FUSION', and 'REPLICATION PACKAGE'. The main content area is white and features the title 'FUSION: Improving Mobile Bug Reporting'. Below the title, it lists the team members: Kevin Moran, Mario Linares-Vázquez, Carlos Bernal-Cárdenas, and Denys Poshyvanyk. The website also mentions the College of William & Mary and SEMERU. The purpose of the project is described as providing a more effective means of off-device bug reporting for Android applications.

The screenshot shows the interface of the CRASHSCOPE tool, a practical tool for analyzing Android crashes. The interface is divided into several sections:

- Detected Crashes:** A table listing detected crashes with columns for Link to Bug Report, Crash ID, # Steps, and Strategies.
- Report Viewer:** A section for viewing the details of a selected crash, including contextual information and steps to reproduce the crash.
- Strategy Icon Legend:** A legend explaining the icons used in the strategies column of the Detected Crashes table.

The interface is branded with the HUAWEI logo in the top right corner.



OVERVIEW FUSION  FUSION REPLICATION PACKAGE

FUSION: Improving Mobile Bug Reporting


Team Members: Kevin Moran, Mario Linares-Vásquez, Carlos Bernal-Cárdenas, & Denys Poshyvanyk

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CRASHSCOPE: A PRACTICAL TOOL



Requests/Tasks ▾ New CrashScope Task ➕

Link to Bug Report	Crash ID	# Steps	Strategies
View Report	1	29	17 2 1
View Report	2	12	17 2 1
View Report	3	9	17 2 1

Strategy Icon Legend
Top-Down Exploration: 17
Bottom-Up Exploration: 2
Unexpected Text Input: 1
Expected Text Input: 2
No Text Input: 1
Contextual Features Enabled/Disabled: 2/1

Report Viewer

1 Contextual information

Application Name & Version: GnuCash 1.0.3 Android Version: 4.4.4 Date reported: Mon Aug 17 00:00:00 EDT 2015

Android SDK built for x86 PORTRAIT 1080x1920

Icon Legend:
Accelerometer ON/OFF Network ON/OFF GPS ON/OFF Magnetometer ON/OFF Temperature Sensor ON/OFF

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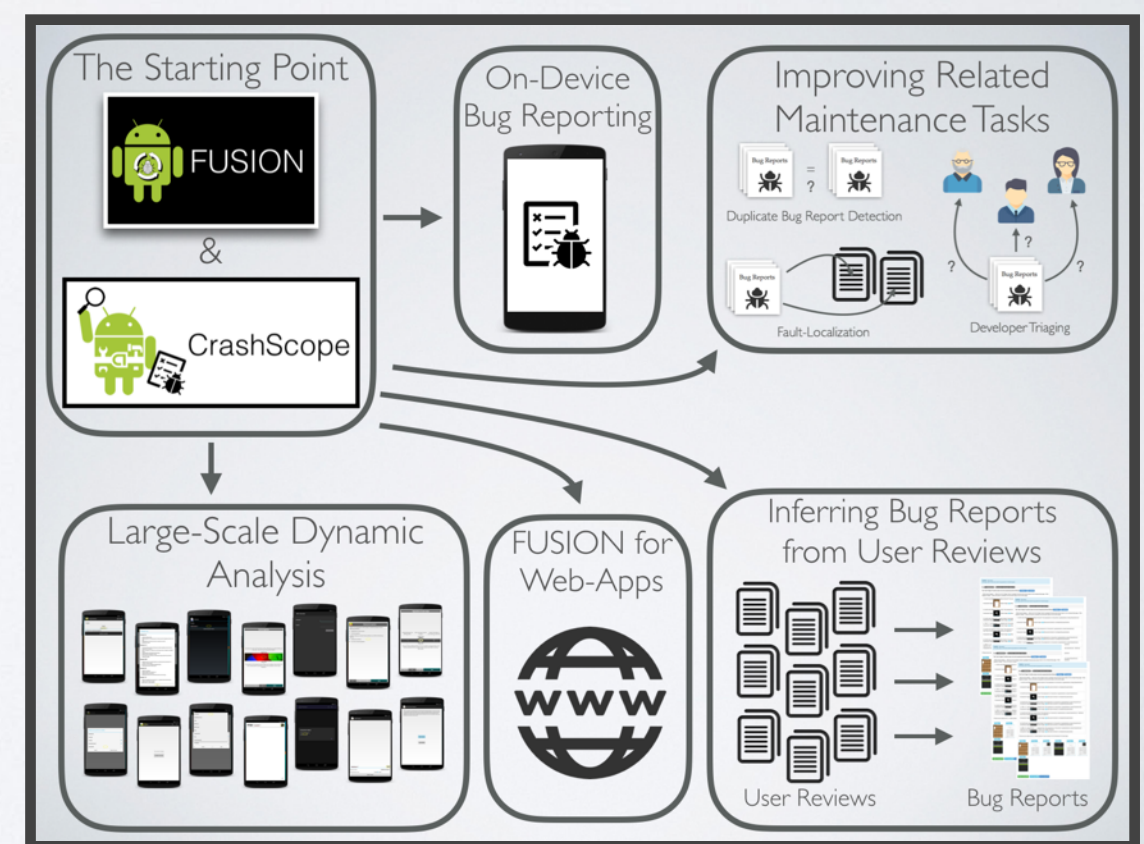
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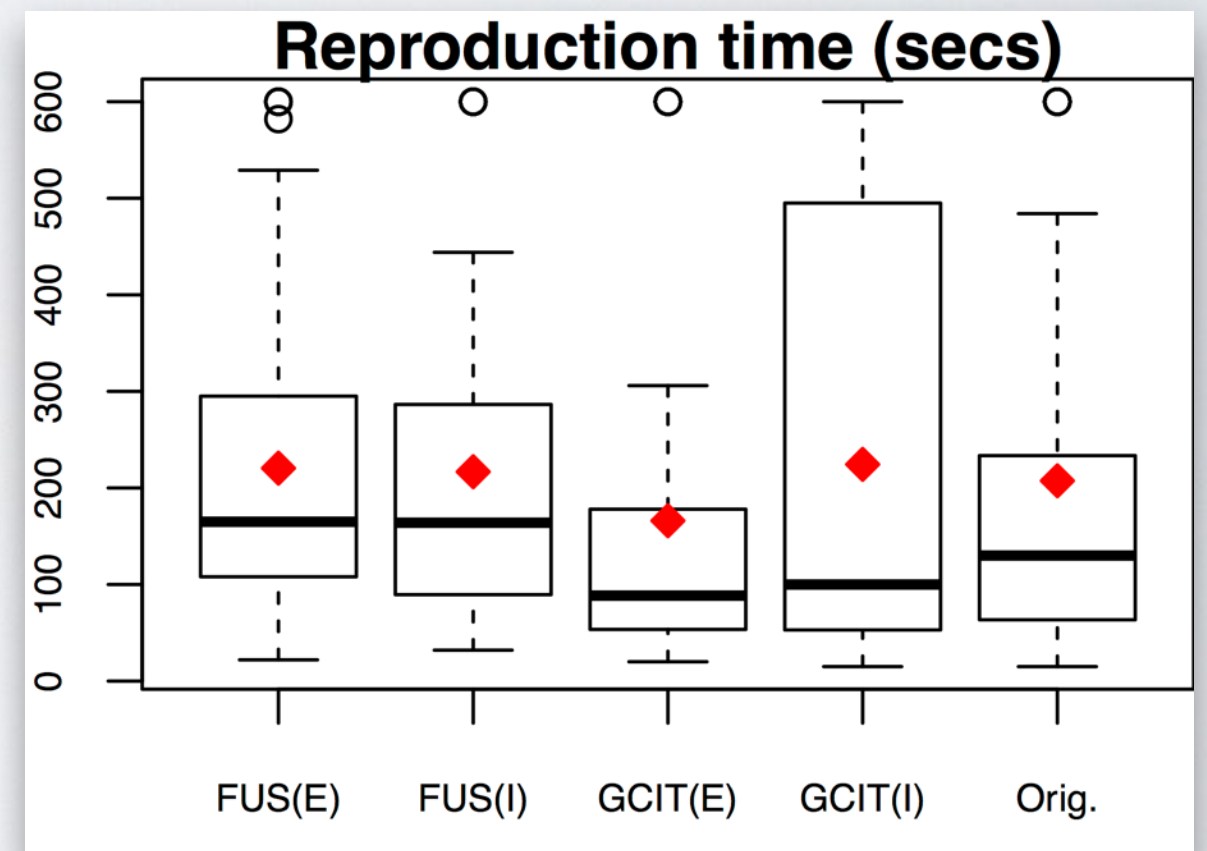
Step 4 Tap on the "android.widget.CheckedTextView" Entertainment, which is located on the Center of the screen.





RESULTS: REPRODUCTION TIME

Bug Report Type	Avg Time to Reproduce
FUSION (E)	3:15
FUSION(I)	2:35
Google Code (E)	1:46
Google Code (I)	1:46
Original	1:59
FUSION Average	2:55
Google Code Average	1:46

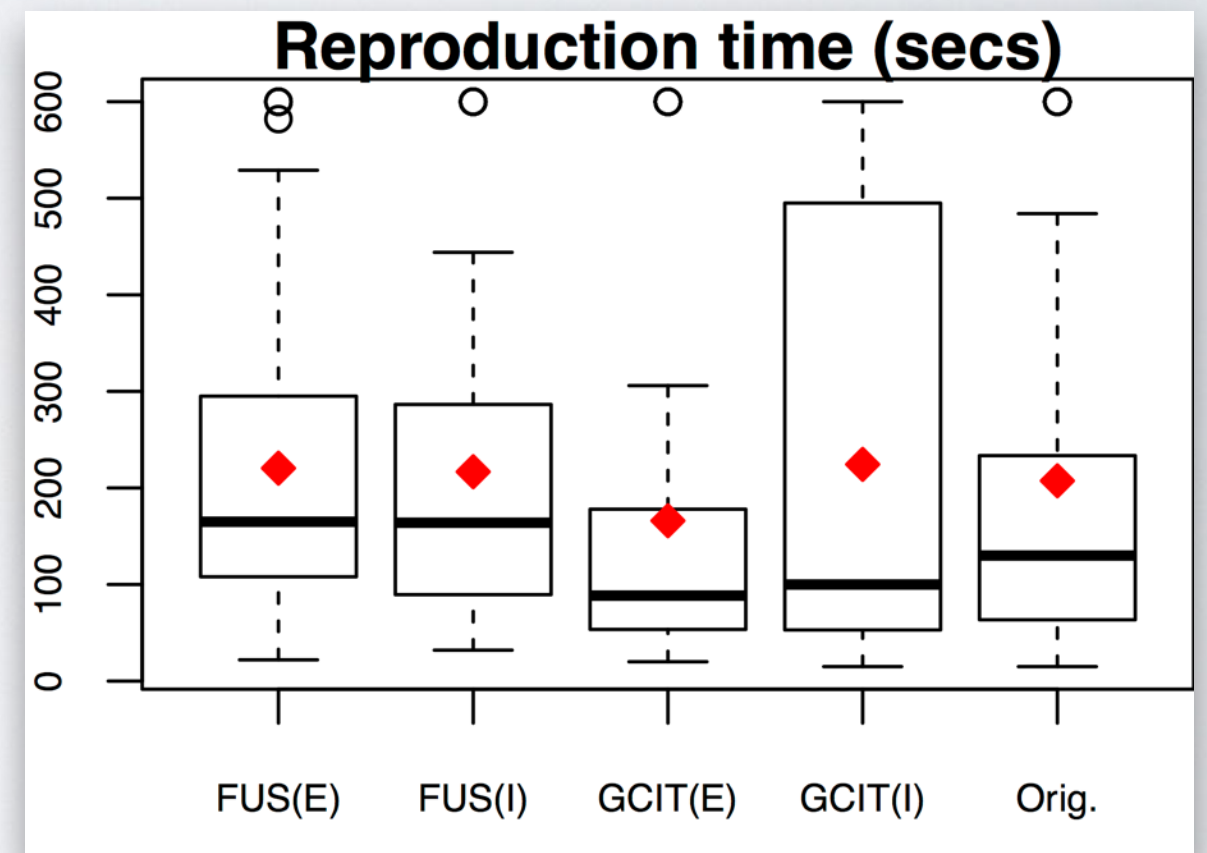


Average Time to Reproduce Bug
by Bug Report Type



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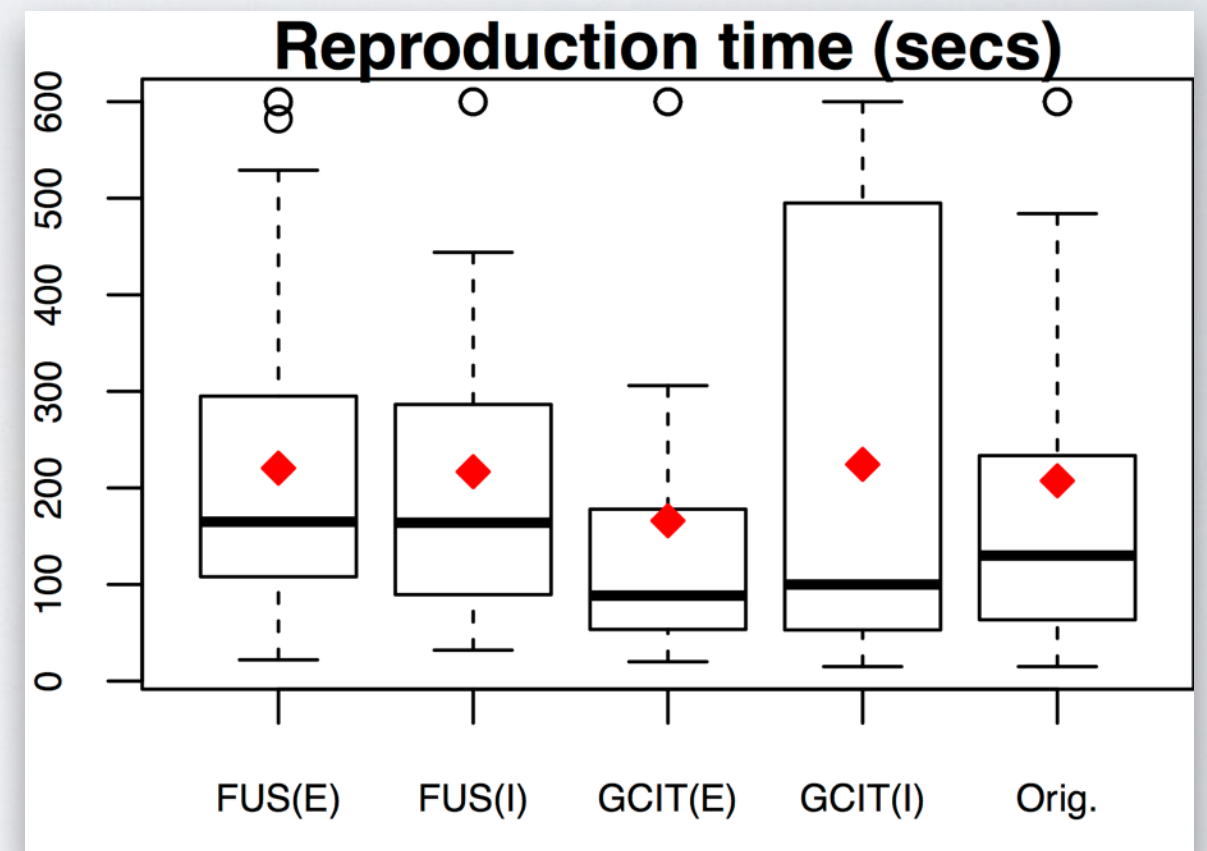


Average Time to Reproduce Bug
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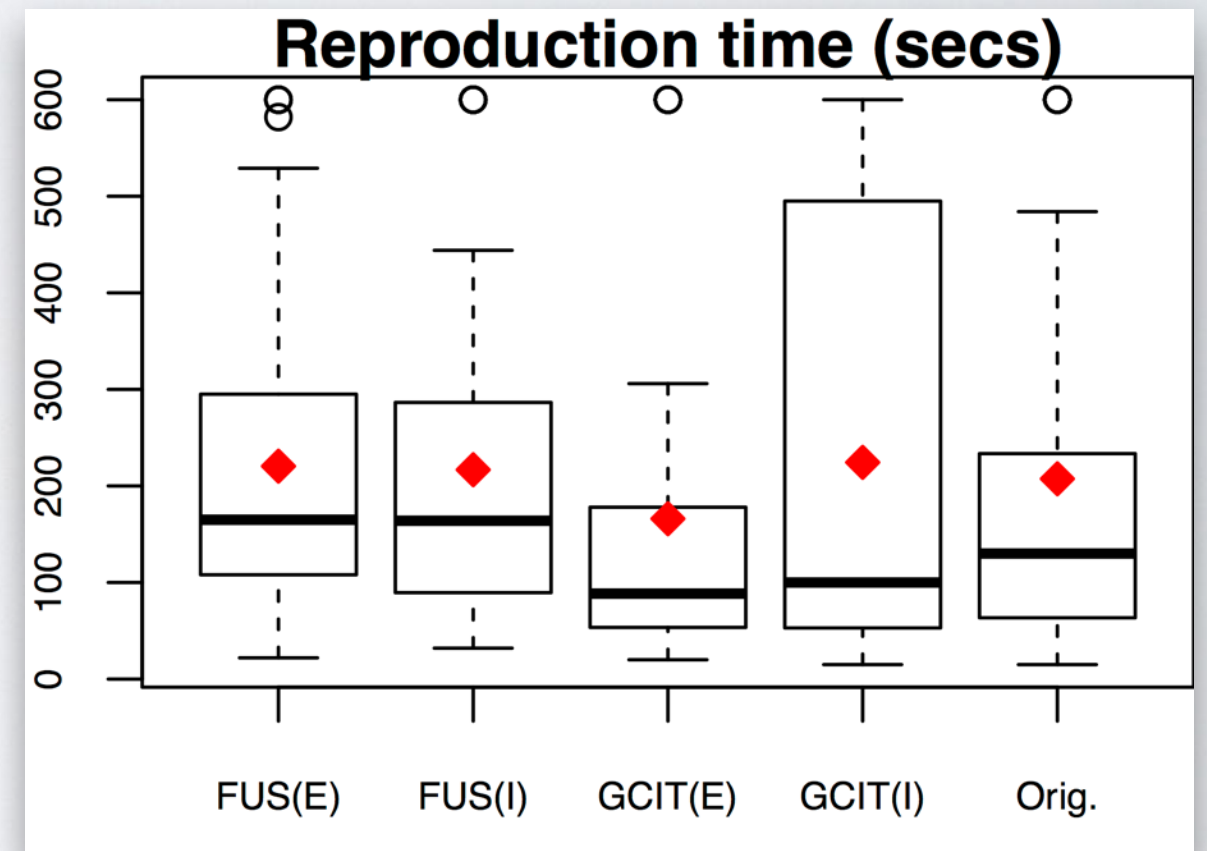


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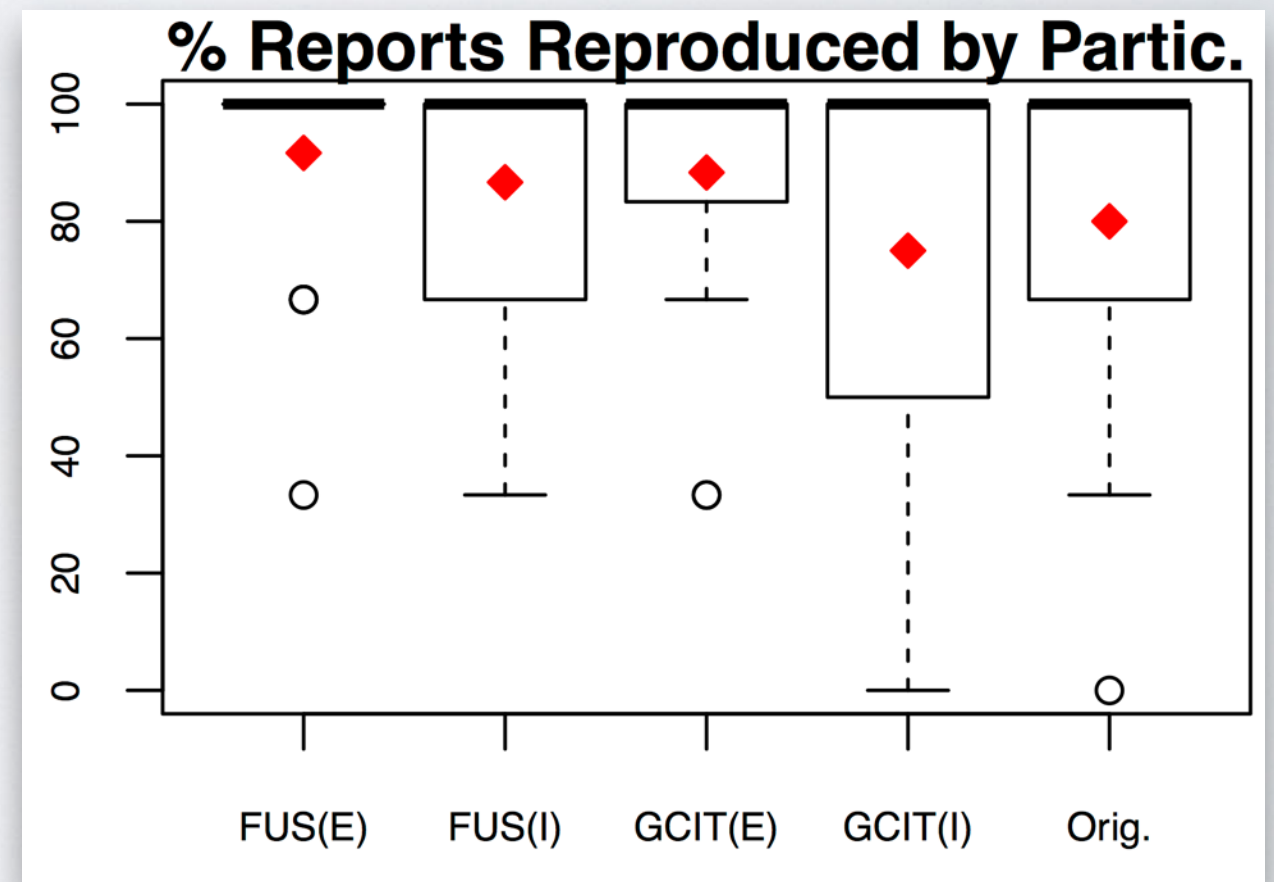


Average Time to Reproduce Bug
by Bug Report Type



RESULTS: REPRODUCTION

Bug Report Type	# of Bugs that were not reproduced
FUSION (E)	5
FUSION(I)	8
Google Code (E)	8
Google Code (I)	15
Original	11
FUSION Total	13
Google Code Total	23

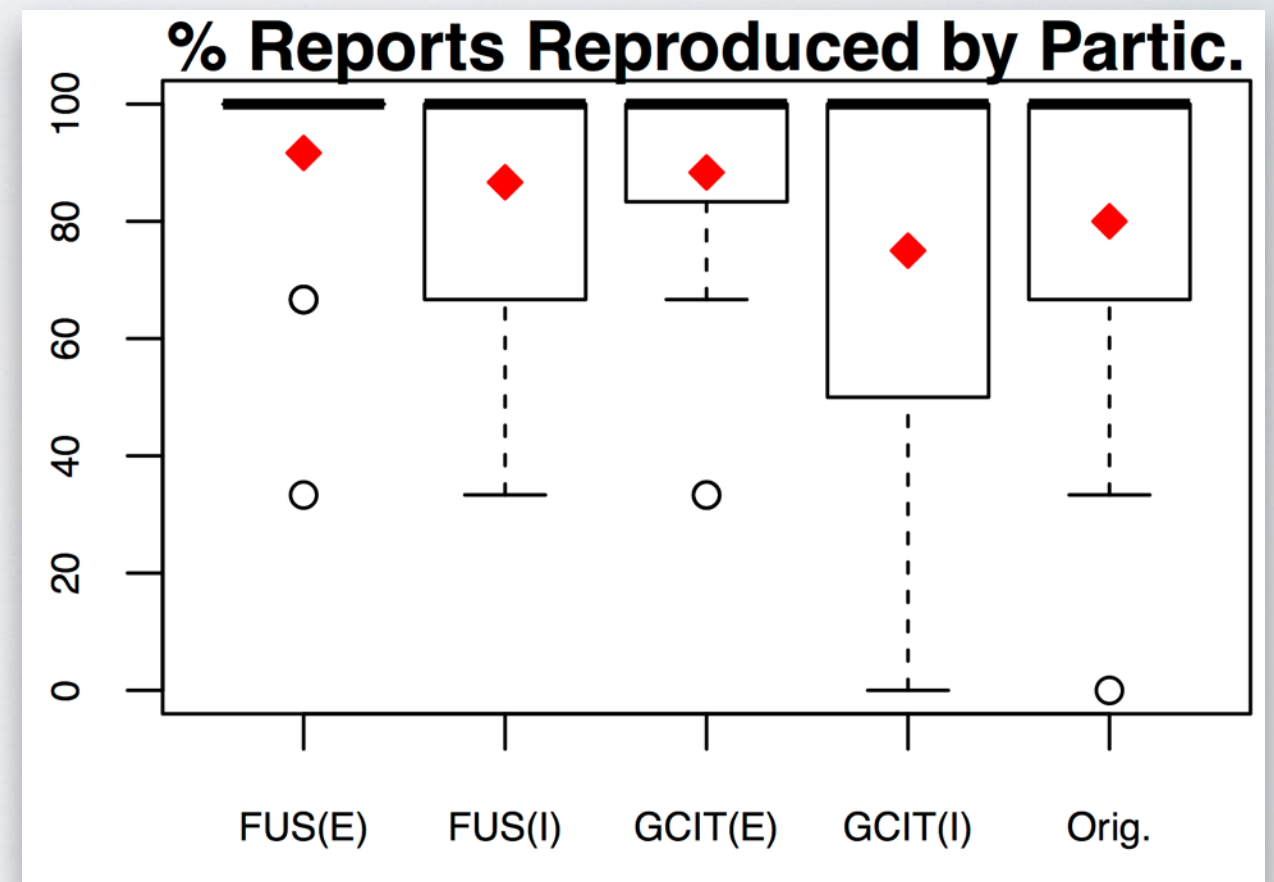


% of Bugs reproduced by Bug Report Type



RESULTS: REPRODUCTION

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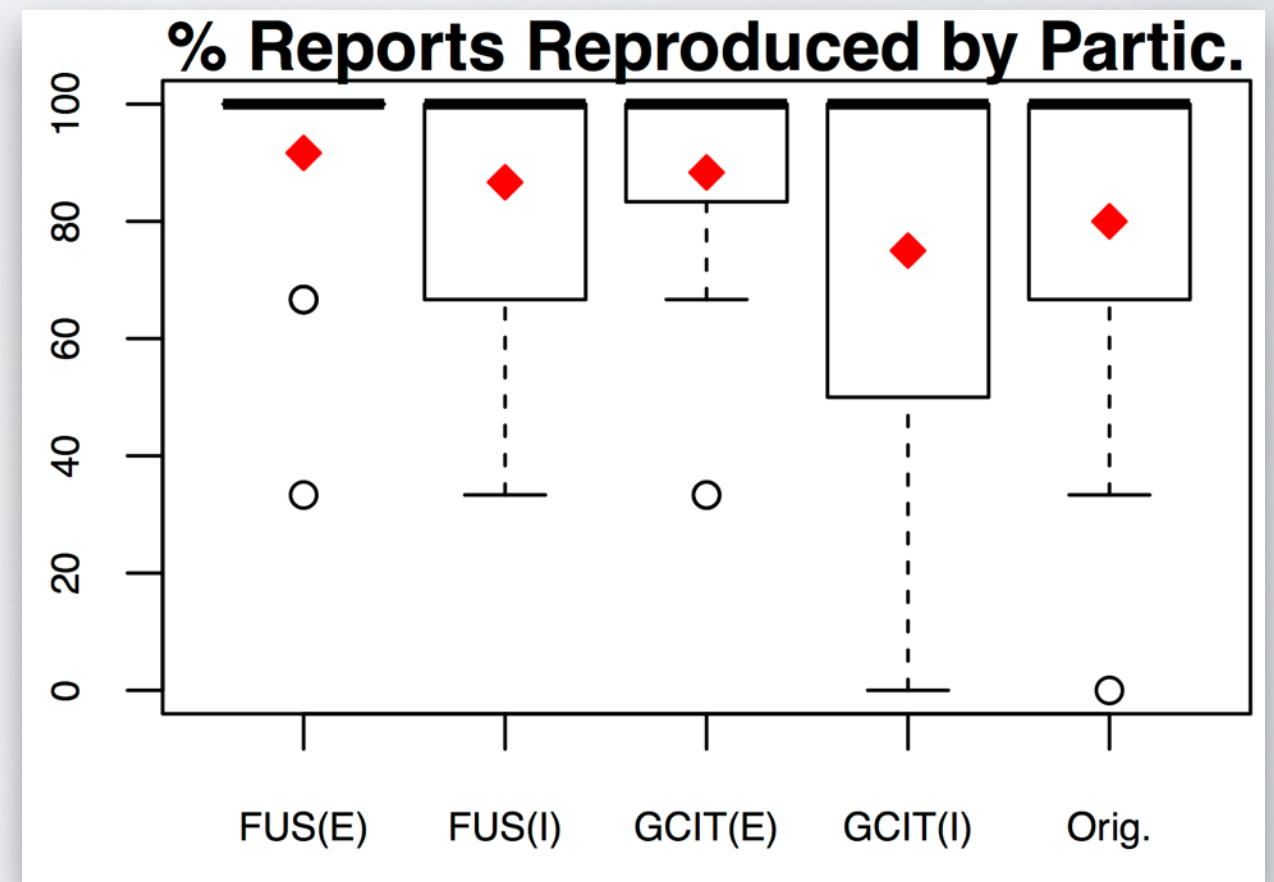


% of Bugs reproduced by Bug Report Type



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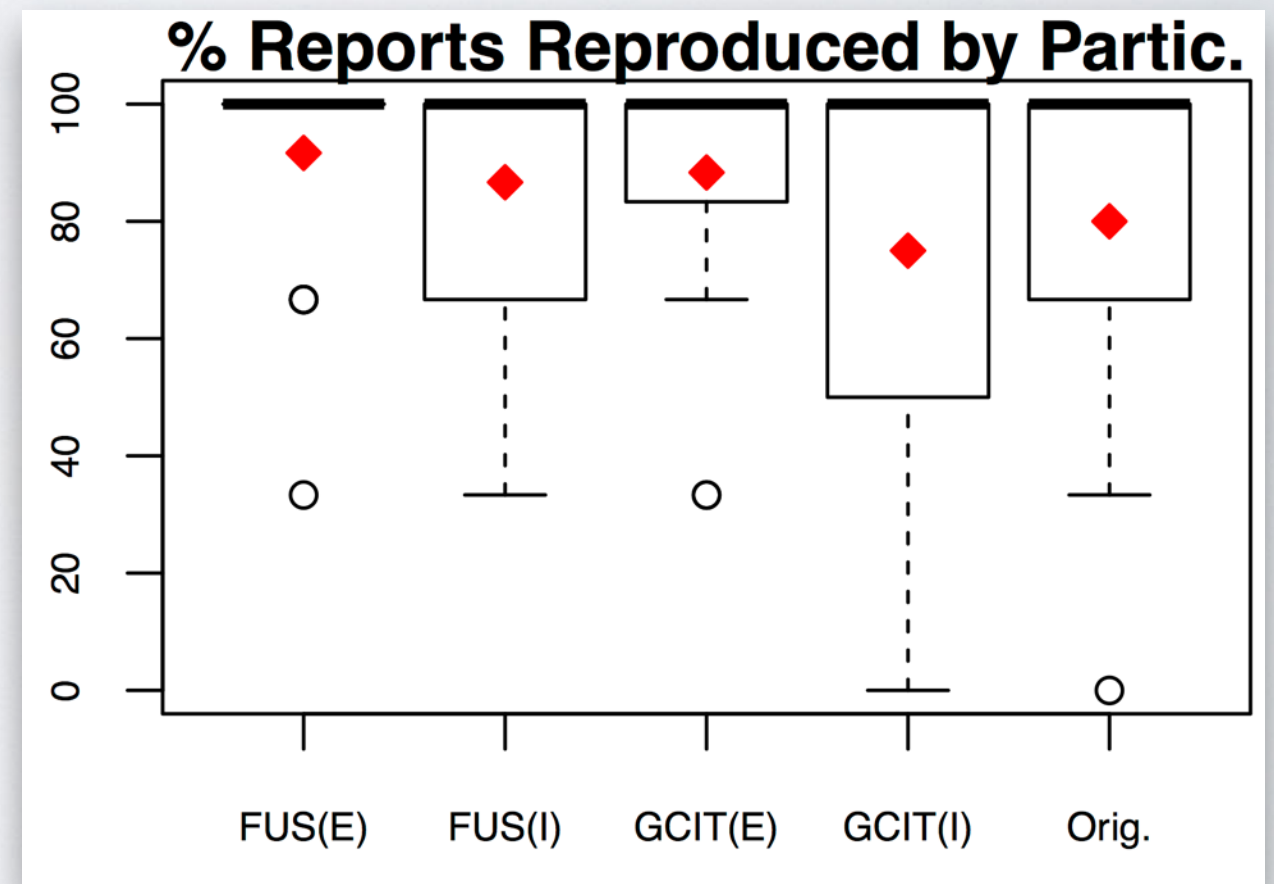


% of Bugs reproduced by Bug Report Type



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FUSION(I)	8
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Original	11
FUSION Total	13
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% of Bugs reproduced by Bug Report Type



DYNAMIC PROGRAM ANALYZER (ENGINE)

- Extracts run-time information of components exercised.
- Extracts the XML GUI Hierarchy using UIAutomator subroutines.
- Able to detect when execution leaves the subject app, and re-launch the app.

Details for step 4

6

I

-- Select action/event --



-- Select GUI component--



7

Additional information:

Type any additional information for this step

More steps?

Yes (next step) +

No, I am done !

Details for step 4

6

I

-- Select action/event --



-- Select GUI component--



7

Additional information:

Type any additional information for this step

More steps?

Yes (next step) +

No, I am done !




CONTEXT: BUG REPORTS USED IN THE STUDY



CONTEXT: BUG REPORTS USED IN THE STUDY

SurveyMonkey, Inc



Bug Report System A Feedback

Usability

Please answer the questions below to rank the usability of the tool you used

* 5. I think that I would like to use System A frequently.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 6. I found System A very cumbersome to use.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 7. I found the various functions in System A were well integrated.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. I thought System A was easy to use.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 9. I found System A unnecessarily complex

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 10. I thought System A was really useful for reporting a bug

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Prev Next



USER EXPERIENCE (UX) QUESTIONS

Question Identifier	Question
UX1	I think that I would like to have this type of bug report/system frequently.
UX2	I found this type of bug report/system unnecessarily complex.
UX3	I thought this type of bug report/system was easy to read/use.
UX4	I found this type of bug report/system very cumbersome to read/use.
UX5	I thought the bug report/system was really useful for reporting/reproducing the bug



USER PREFERENCE (UP) QUESTIONS

Question Identifier	Question
UP1	What information from this <system> did you find useful for reporting / reproducing the bug?
UP2	What other information (if any) would you like to see in this <system>?
UP3	What elements do you like the most from this <system>?
UP4	What elements do you like the least from this <system>?



BUG REPORTING TIME RESULTS: FUSION

Bug Index	App	Participant #1 (Experienced)	Participant #2 (Experienced)	Participant #3 (Inexperienced)	Participant #4 (Inexperienced)
1	A Time Tracker	7:48	11:30	24:30	2:01
2	Aarddict	4:12	4:10	3:30	4:51
3	ACV	2:27	5:30	8:18	05:14
4	Car Report	12:21	4:50*	15:45	8:00*
5	Document	4:03*	5:10	16:32*	6:38*
6	Droid Weight	3:10*	2:10*	7:43*	6:09
7	Eshotroid	7:30	6:30	10:29	6:21
8	GnuCash	9:45	7:10*	18:45	08:23
9	GnuCash	9:23	7:30	20:03	9:27
10	Mileage	2:22*	5:10	7:07	3:04*
11	NetMBuddy	2:02	3:15	4:00	1:27
12	Notepad	3:53	3:20	4:45	3:14
13	OI Notepad	5:15	9:20	13:30	6:17
14	Olam	1:23	2:20	2:30	1:40
15	QuickDic	2:58	2:10	2:40	2:01
	Average	5:14	5:20	10:40	4:59



BUG REPORTING TIME RESULTS: FUSION

Bug Index	App	Participant #1 (Experienced)	Participant #2 (Experienced)	Participant #3 (Inexperienced)	Participant #4 (Inexperienced)
1	A Time Tracker	7:48	11:30	24:30	2:01
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6	Droid Weight	3:10*	2:10*	7:43*	6:09
7	Eshotroid	7:30	6:30	10:29	6:21
8	GnuCash	9:45	7:10*	18:45	08:23
9	GnuCash	9:23	7:30	20:03	9:27
10	Mileage	2:22*	5:10	7:07	3:04*
11	NetMBuddy	2:02	3:15	4:00	1:27
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	Average	5:14	5:20	10:40	4:59



BUG REPORTING TIME RESULTS: GCIT

Bug Index	App	Participant #1 (Experienced)	Participant #2 (Experienced)	Participant #3 (Inexperienced)	Participant #4 (Inexperienced)
1	A Time Tracker	4:16	7:30	1:51	1:56
2	Aarddict	3:33	8:25	2:13	2:22
3	ACV	2:37	11:10	0:51	1:42
4	Car Report	2:52	12:23	0:40	2:39
5	Document	3:15	9:31	0:45	1:46
6	Droid Weight	2:33	7:13	1:03	1:45
7	Eshotroid	2:08	5:27	1:47	1:03
8	GnuCash	2:40	6:48	1:15	2:30
9	GnuCash	6:20	5:12	1:40	2:22
10	Mileage	3:53	5:25	1:00	1:16
11	NetMBuddy	3:52	3:13	1:20	1:48
12	Notepad	2:02	4:32	1:01	1:23
13	OI Notepad	3:16	6:25	0:58	1:12
14	Olam	4:26	3:13	1:16	1:49
15	QuickDic	1:37	03:17	0:55	0:59
	Average	3:17	6:39	1:14	1:46



BUG REPORTING TIME RESULTS: GCIT

Bug Index	App	Participant #1 (Experienced)	Participant #2 (Experienced)	Participant #3 (Inexperienced)	Participant #4 (Inexperienced)
1	A Time Tracker	4:16	7:30	1:51	1:56
2	Aarddict	3:33	8:25	2:13	2:22
3	ACV	2:37	11:10	0:51	1:42
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7	Eshotroid	2:08	5:27	1:47	1:03
8	GnuCash	2:40	6:48	1:15	2:30
9	GnuCash	6:20	5:12	1:40	2:22
10	Mileage	3:53	5:25	1:00	1:16
11	NetMBuddy	3:52	3:13	1:20	1:48
12	Notepad	2:02	4:32	1:01	1:23
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BUG REPORTING TIME RESULTS: GCIT

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10	Mileage	3:53	5:25	1:00	1:16
11	NetMBuddy	3:52	3:13	1:20	1:48
12	Notepad	2:02	4:32	1:01	1:23
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15	QuickDic	1:37	03:17	0:55	0:59
	Average	3:17	6:39	1:14	1:46



EASE OF USE: WHAT DID WE LEARN?

- **RQ₁:** Is FUSION easier to use for reporting/reproducing bugs than traditional bug tracking systems?
 - FUSION is about as easy for developers to use as a traditional bug tracking system
 - FUSION is more difficult for inexperienced users to use than traditional bug tracking systems



BUG REPORTING UX: WHAT DID WE LEARN?

- **RQ₂:** What types of information fields do developers/testers consider important when reporting and reproducing bugs in Android?
- While reporters generally felt that the opportunity to enter extra information in a bug report using FUSION increased the quality of their reports, inexperienced users would have preferred a simpler web UI.



REPRODUCTION TIME: WHAT DID WE LEARN?

- ❖ **RQ₄:** Do bug reports generated with FUSION allow for faster bug reproduction compared to reports submitted using traditional bug tracking systems?
- ❖ Bug reports generated with FUSION *do not allow for faster reproduction* of bugs compared bug reports generated using traditional bug tracking systems such as the GCIT.



REPRODUCTION UX: WHAT DID WE LEARN?

- ❖ **RQ₂:** Is FUSION easier to use for reporting/reproducing bugs than traditional bug tracking systems?
 - ❖ Participants preferred FUSION over the original bug reports and GCIT over FUSION
 - ❖ Some participants thought the FUSION steps were overly detailed.



BUG REPORTING UX: WHAT DID WE LEARN?

- ❖ ***What elements do you like most from the system?***
 - ❖ Experienced User: *“The GUI component form and the action/event. They provide an easy way to report the steps.”*
 - ❖ Inexperienced User: *“The parts where you could simply type out the issue”*

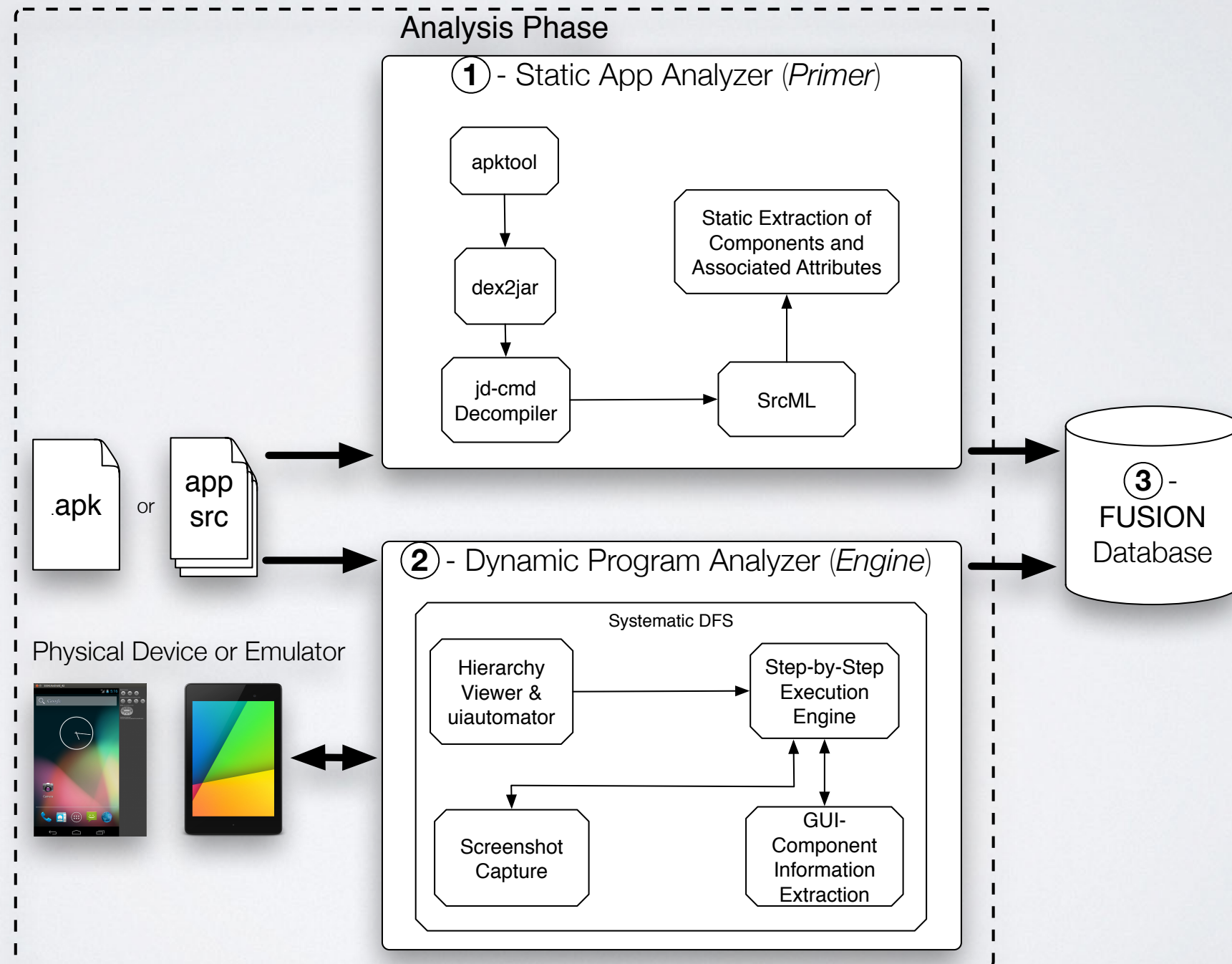


BUG REPORTING UX: WHAT DID WE LEARN?

- **RQ₃:** *Do developers/testers using FUSION reproduce more bugs compared to traditional bug tracking systems?*
- **Developers using FUSION *are able to reproduce more bugs* compared to traditional bug tracking systems such as the GCIT.**

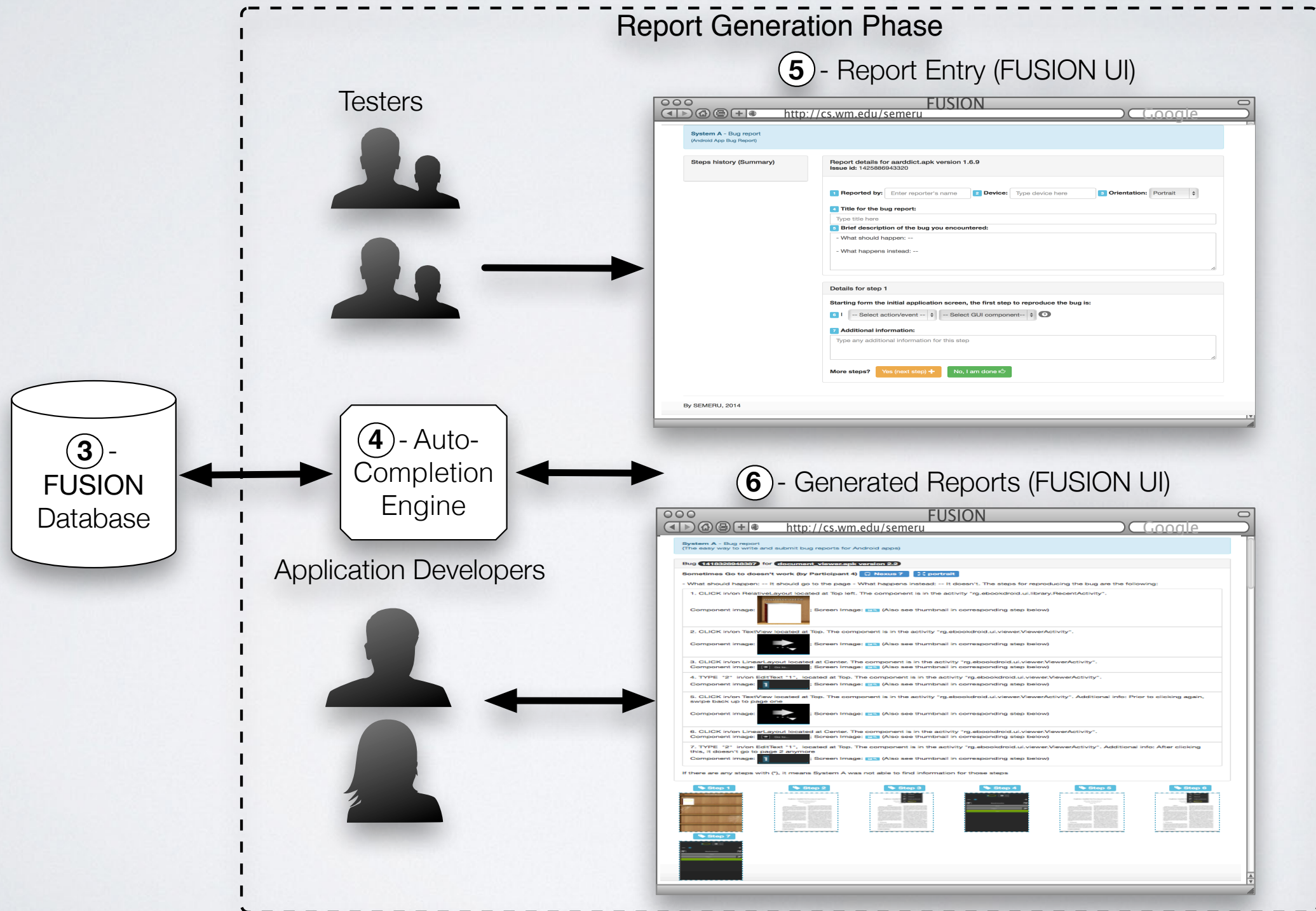


FUSION: ANALYSIS PHASE





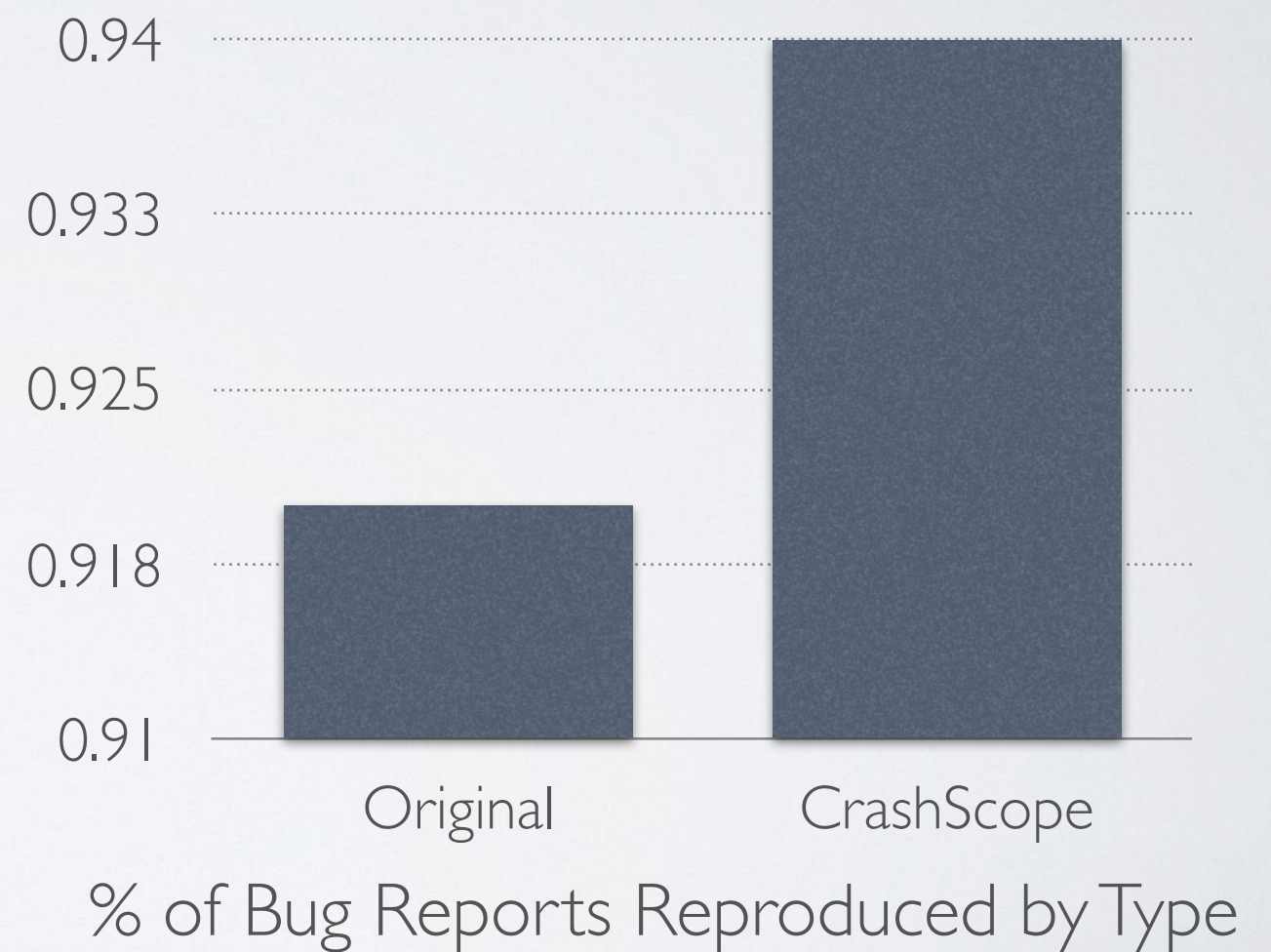
FUSION: REPORT GENERATION PHASE





STUDY 2: REPRODUCIBILITY RESULTS

Type of Crash Report	# of Total/Non-Reproducible Reports
Original Bug Reports	59/64
CrashScope Bug Reports	60/64





STUDY 2: REPRODUCIBILITY RESULTS

-CrashScope reports are about as reproducible as other reports



STUDY I: SUMMARY OF FINDINGS

- **RQ₁:** CrashScope is nearly as effective at discovering crashes as the other tools, without reporting crashes caused by instrumentation
- **RQ_{2&3}:** CrashScope's differing strategies led to the discovery of unique crashes
- **RQ₄:** Higher statement coverage does not necessarily correspond with crash detection capabilities



STUDY I: EXPERIMENTAL SETUP

TOOLS USED IN
THE
COMPARATIVE
FAULT FINDING
STUDY

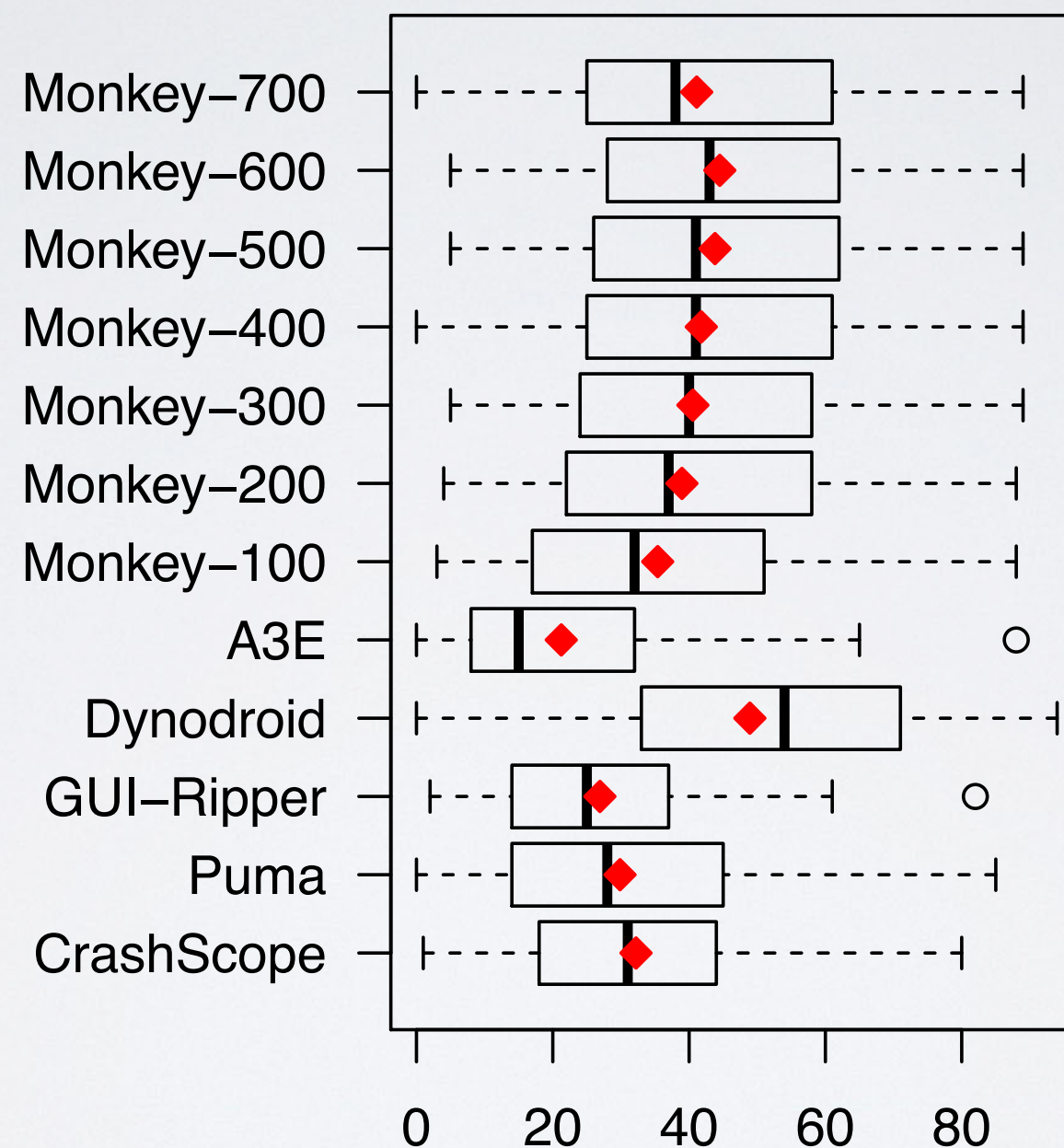
Tool Name	Android Version	Tool Type
Monkey	Any	Random
A3E Depth-First	Any	Systematic
GUI-Ripper	Any	Model-Based
Dynodroid	v2.3	Random-Based
PUMA	v4.1+	Random-Based

- 61 subject applications from the **Androtest**¹ toolset
- Each testing tool was run 5 separate times for 1 hour, whereas CrashScope ran through all strategies
- Monkey was limited by the number of events

¹S. R. Choudhary, A. Gorla, and A. Orso. Automated Test Input Generation for Android: Are we there yet? In 30th IEEE/ACM International Conference on Automated Software Engineering (ASE 2015), 2015



STUDY I: STATEMENT COVERAGE RESULTS

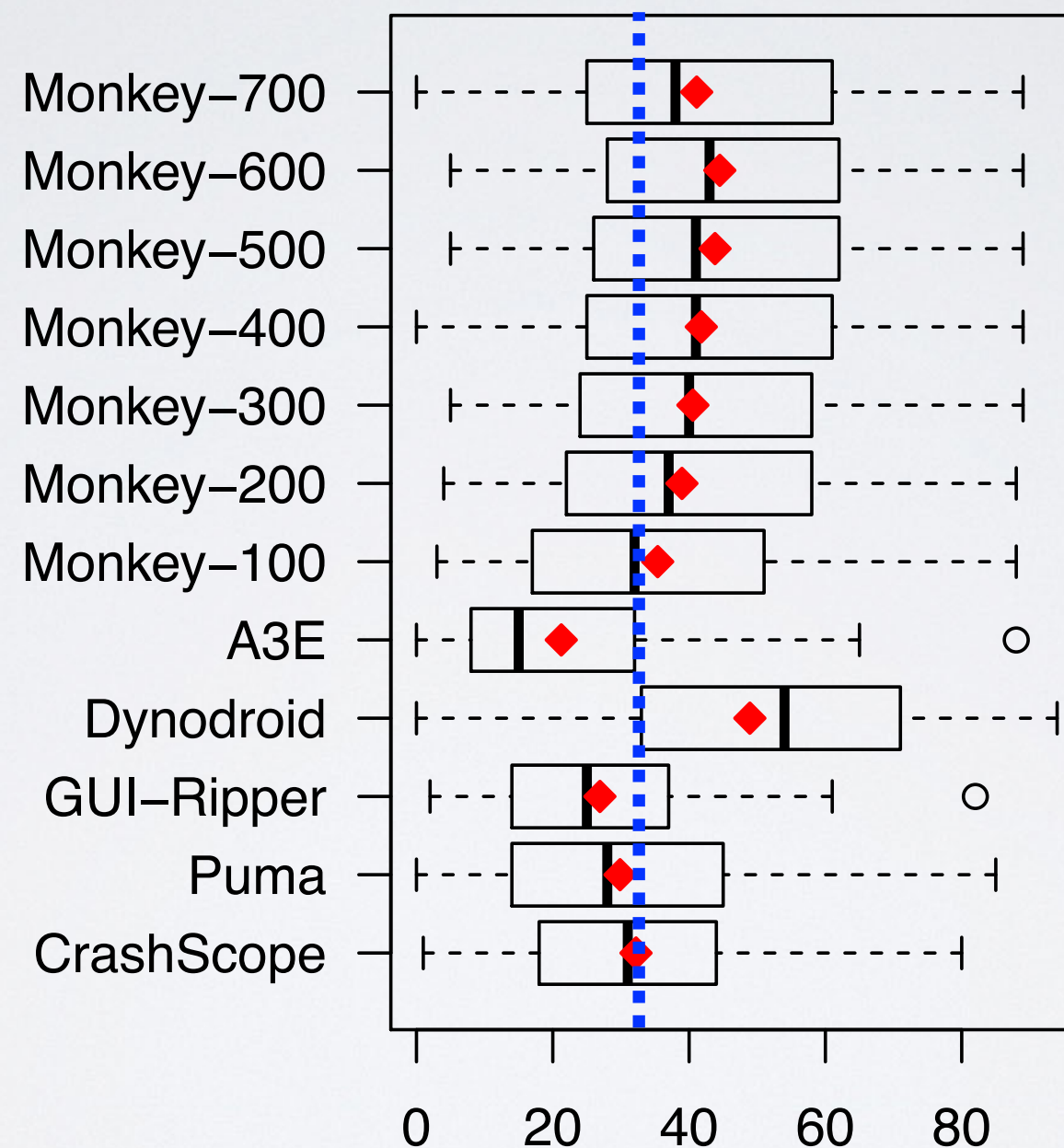


Average Statement Coverage Results for the Comparative Study

Reported in Average %



STUDY I: STATEMENT COVERAGE RESULTS



Average Statement Coverage Results for the Comparative Study

Reported in Average %



STUDY 2: EXPERIMENTAL SETUP

- 8 Real-World Crash Reports from Open Source Apps
- 16 Graduate Students from the College of William & Mary

Application Name	# of Reproduction Steps
BMI	4
Schedule	7
adsdroid	2
Anagram-solver	7
Eyecam	14
GNU Cash	29
Olam	2
CardGame Scores	23

- Each student attempted to reproduce 8 bugs: 4 from the original reports, 4 from CrashScope Reports
- Participants used a Nexus 7 tablet for reproduction



STUDY 2: SUMMARY OF FINDINGS

- **RQ₅:** Reports generated by CrashScope are about as reproducible as human written reports extracted from open-source issue trackers
- **RQ₆:** Reports generated by CrashScope are more readable and useful from a developers' perspective compared to human-written reports.



RESEARCH QUESTIONS

- **RQ_1** : Ease of Use?
- **RQ_2** : Information Preferences?
- **RQ_3** : Reproducibility of Reports?
- **RQ_4** : Speed of Reproduction?



RESEARCH QUESTIONS

- RQ_1 : FUSION is about as *easy for developers to use* as traditional bug-tracking systems
- RQ_2 : Extra Information *increased quality* of reports
- RQ_3 : FUSION reports are *more reproducible* than traditional bug reports
- RQ_4 : Developers take *slightly longer* to reproduce FUSION Reports than traditional reports