Repairing crashes in Android Apps
安卓应用的程序崩溃修复

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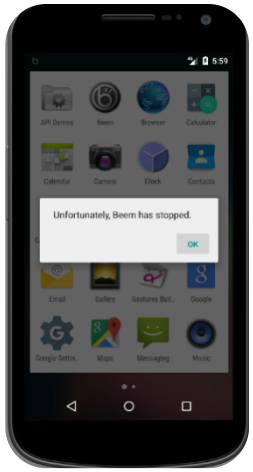

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- 程序自动修复
- 测试用例修复
- 代码注释分析
- 软件测试
- 基于搜索的软件工程

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写bug了！

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Repairing Crashes in Android Apps

Who	*Shin Hwei Tan, Zhen Dong, Xiang Gao, Abhik Roychoudhury*
Track	* ICSE 2018 * Technical Papers
When	**Wed 30 May 2018 15:00 - 15:20 at H2 room** - Apps and App Stores II Chair(s): Patrick Maeder
Link to Preprint	http://www.shinhwei.com/droixicse_camera.pdf

能工具 名为SapFix

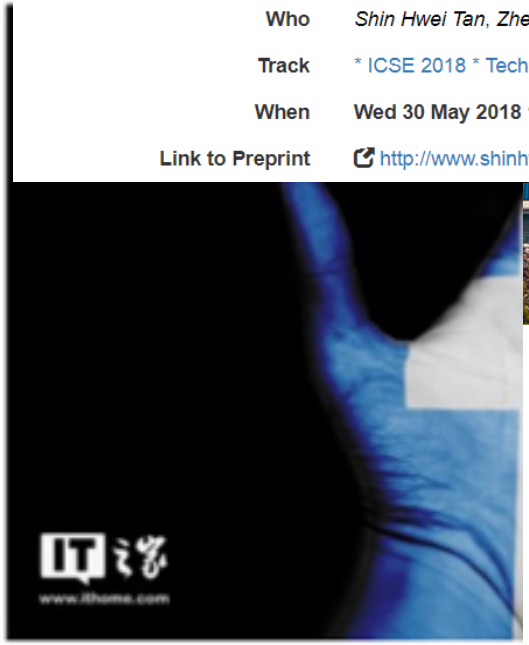
w.zdnsh.com 作者：赤壁点讯网

)工具，可以自动扫描代码，寻找漏洞，然后测试

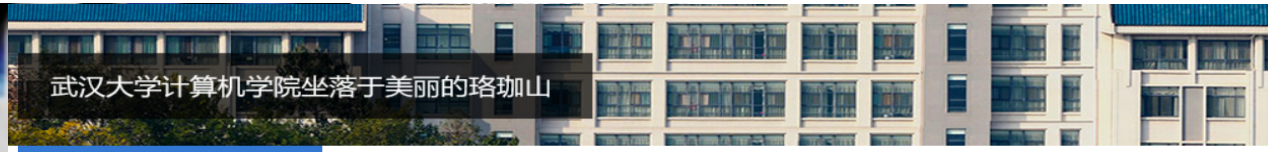
了一种名为SapFix的人工智能(AI)工具，可以自动

荐最佳修补方案。

目前已经应用于Facebook庞大的代码库。该公司还



还表示，对于高攻击错误，SapFix能创建补丁，对需求
x会从一组修复模板中进行提取，以创建补丁。当该过
ook表示，并没有视SapFix为人类程序员的替代品，而
更多的人接受编程。
青岛it培训机构，it培训，it培训价格，it培训哪家好，



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6月22日学术报告（陈馨慧 南方科技大学）

2018年06月20日09时 0人评论 64次

报告题目： 安卓应用的程序崩溃修复 Repairing crashes in Android apps
报告时间： 6月22日10:30 – 11:20
报告地点： 计算机学院E202
报告人： 陈馨慧
报告人国籍：马来西亚
报告人单位：南方科技大学

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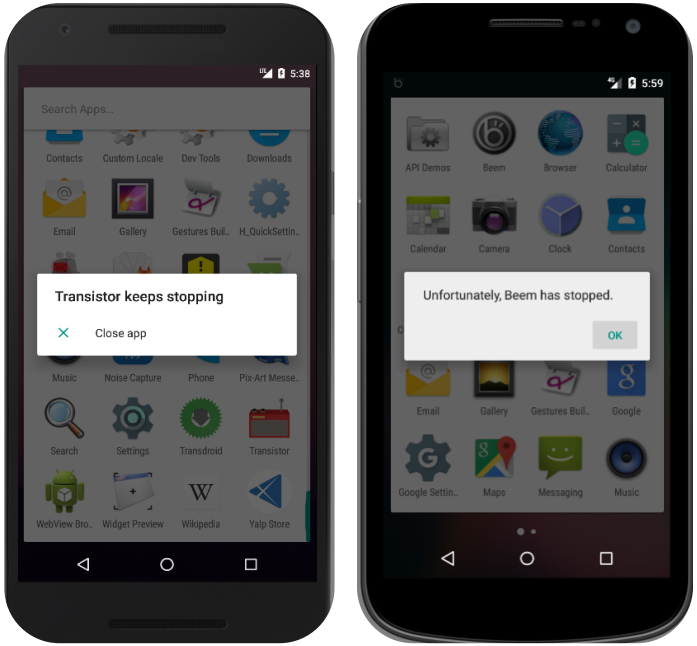
发表学术论文10余篇。曾荣获2015年Google Anita Borg Memorial Scholarship。

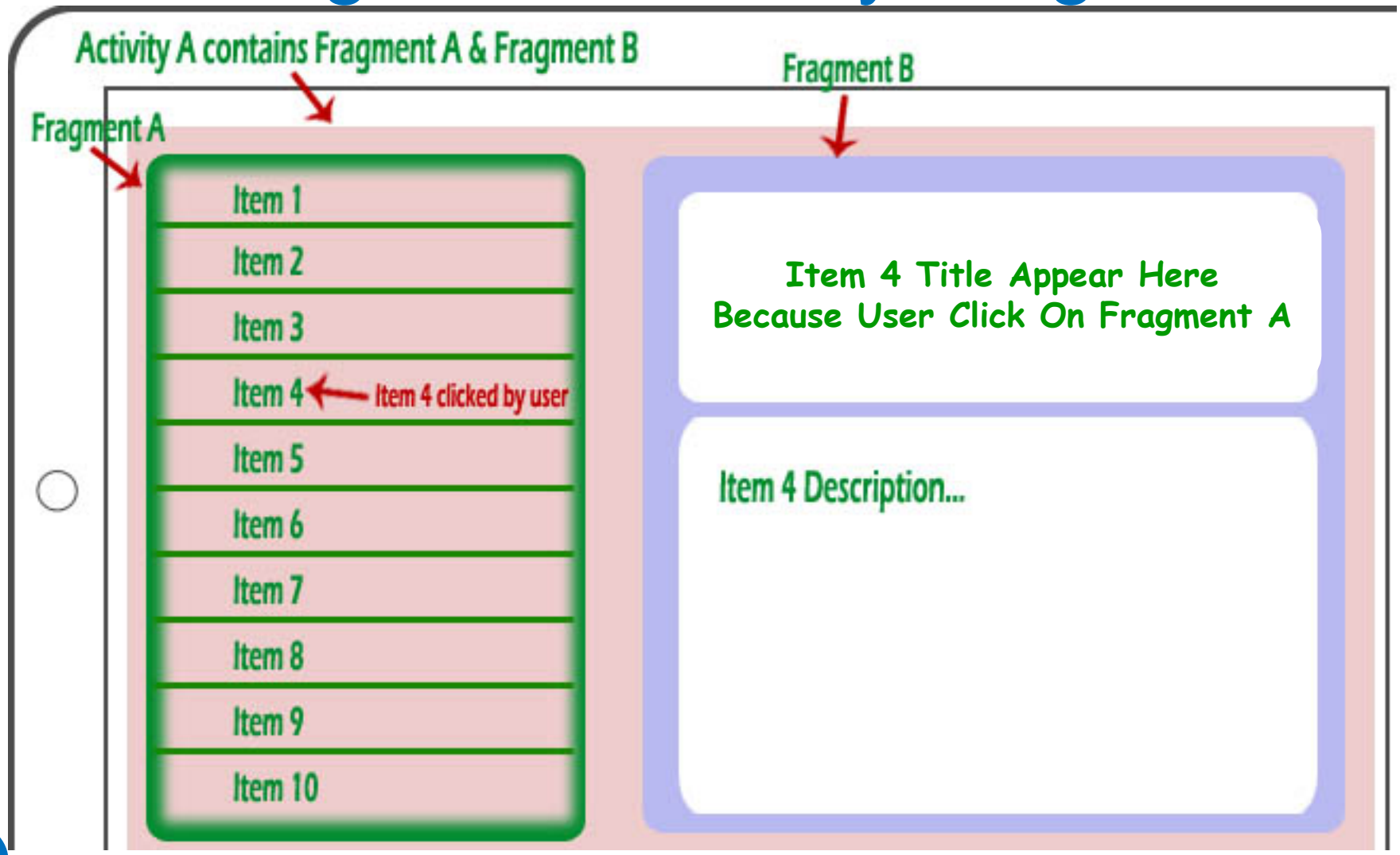
Android Repair System



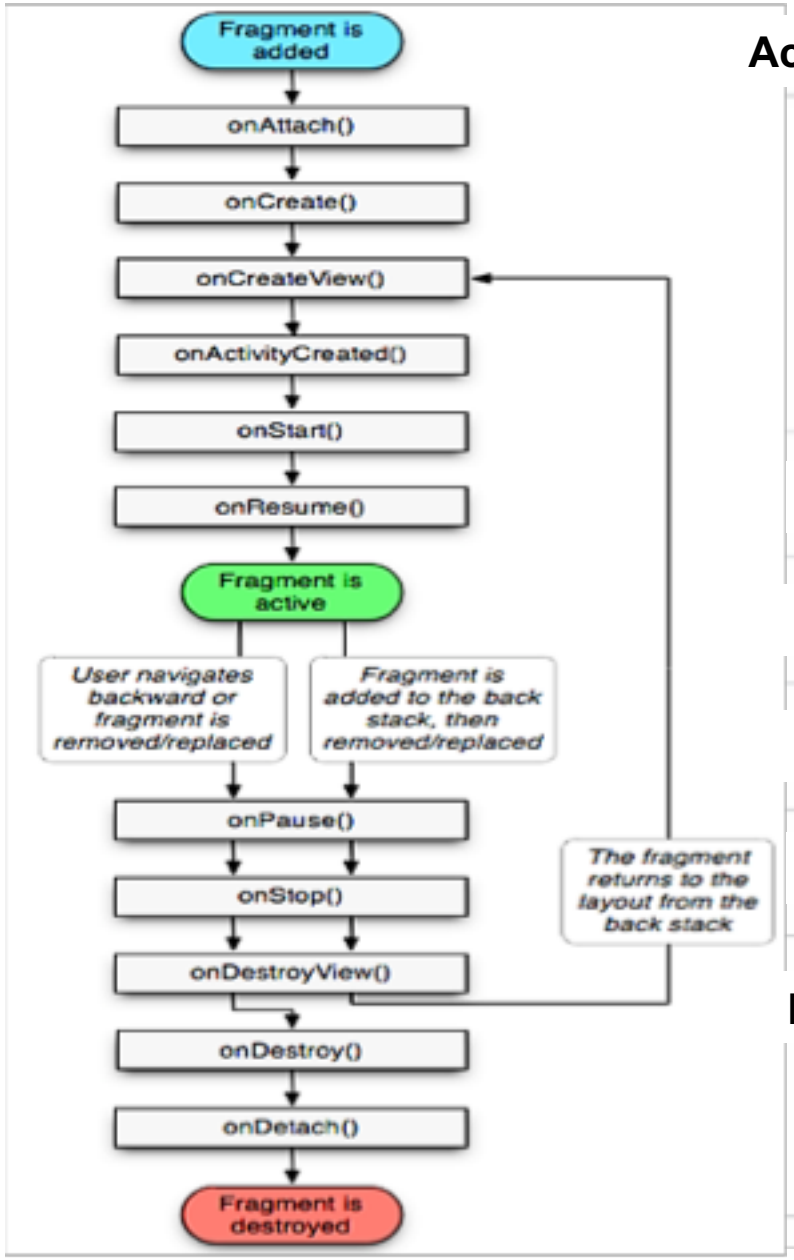
Criteria for Android repair system:

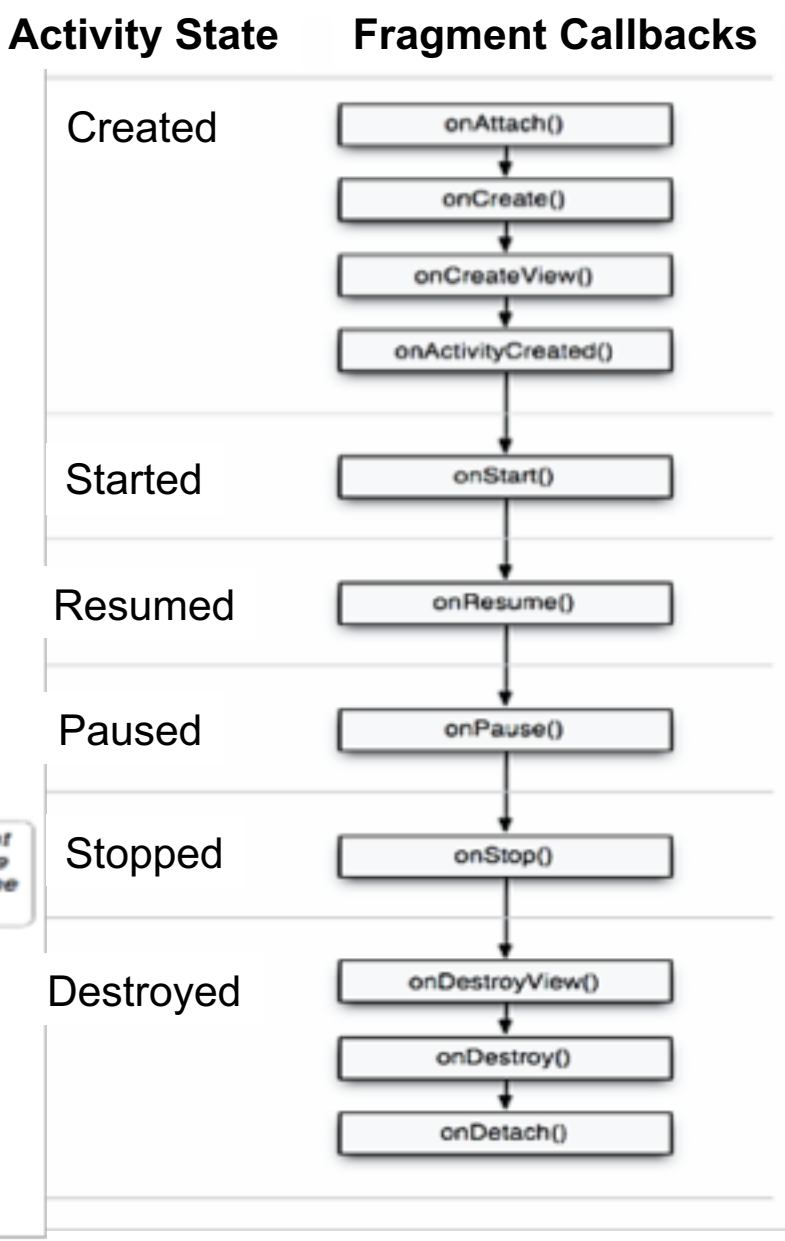
- ✓ Could be used by any smartphone user
  - ✓ Doesn't require source code
  - ✓ No prior knowledge of Android app
  - ✓ No prior experience of running tests

Background: Activity/Fragment



Complexity of Android Activity/Fragment Lifecycle





What are the common causes of crashes in Android apps?

- Obtain popular Android apps written in Java from 

- For each app, search for closed bug reports
  - >7500 bug reports
- Filter crash-related bug reports
  - 1155 bug reports
  - ➢ 15% of bug reports in Android apps are crash-related
- Filter bug reports with bug-fixing commits
  - 107 GitHub Issues from 15 apps

What lead to crashes in Android apps?

Category	Specific reason	Description	GitHub Issues (%)	Frequent Exception Type	Category Total (%)
Lifecycle	Configuration changes	activity recreation during configuration changes	5.61	NullPointer	14.02
	Stateloss	transaction loss during commit	2.80	IllegalState	
	GetActivity	activity-fragment coordination	2.80	IllegalState	
	Activity backstack	inapproapriate handling of activity stack	1.87	IllegalArgument	
	Save instance	uninitialized object instances in onSaveInstance() callback	0.93	IllegalState	
Resource	Resource-related	resource type mismatches	10.28	NullPointer	16.82
	Resource limit	limited resources	4.67	OutOfMemory	
	Incorrect resource	retrieve a wrong resource id	1.87	SQLite	
Callback	Activity-related	missing activities	7.48	NullPointer	17.76
	View-related	missing views	6.54	NullPointer	
	Intent-related	missing intents	3.74	NullPointer	
	Unhandled callbacks	missing callbacks	2.80	NullPointer	
Others	Missing Null-check	missing check for null object reference	12.15	NullPointer	52.34
	External Service/Library	defects in external service/library	8.41	NullPointer	
	Workaround	temporary fixes for defect	4.67	IndexOutOfBound	
	API changes	API version changes	2.80	SQLite	
	Others	project-specific defects	24.30	-	

Common root causes of crashes in apps:

- Lifecycle-related (14.02%)
- Resource-related (16.82%)

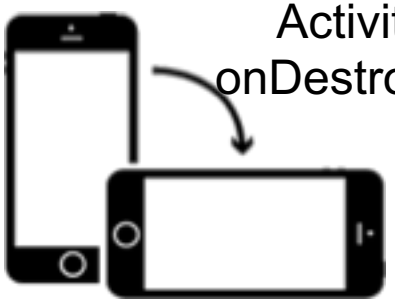
Could be automatically repaired

- Workaround: 4.67 %
- Most common exceptions
  - NullPointerException (40.19%)
  - IllegalStateException (7.48%)

Lifecycle-aware Repair Operators

Operator	Description
S1: GetActivity-check	Insert a condition to check whether the activity containing the fragment has been created.
S2: Retain object	Store object and load it when configuration changes
S3: Replace resource id	Replace resource id with another id of same type.
S4: Replace method	Replace the current method call with another method call with similar name and compatible parameter types.
S5: Replace cast	Replace the current type cast with another compatible type.
S6: Move stmt	Removes a statement and add it to another location.
S7: Null-check	Insert condition to check if a given object is null.
S8: Try-catch	Insert try-catch blocks for the given exception.

Lifecycle-aware Repair Operator: Retain stateful object



Activity re-created:
onDestroy()→onCreate()

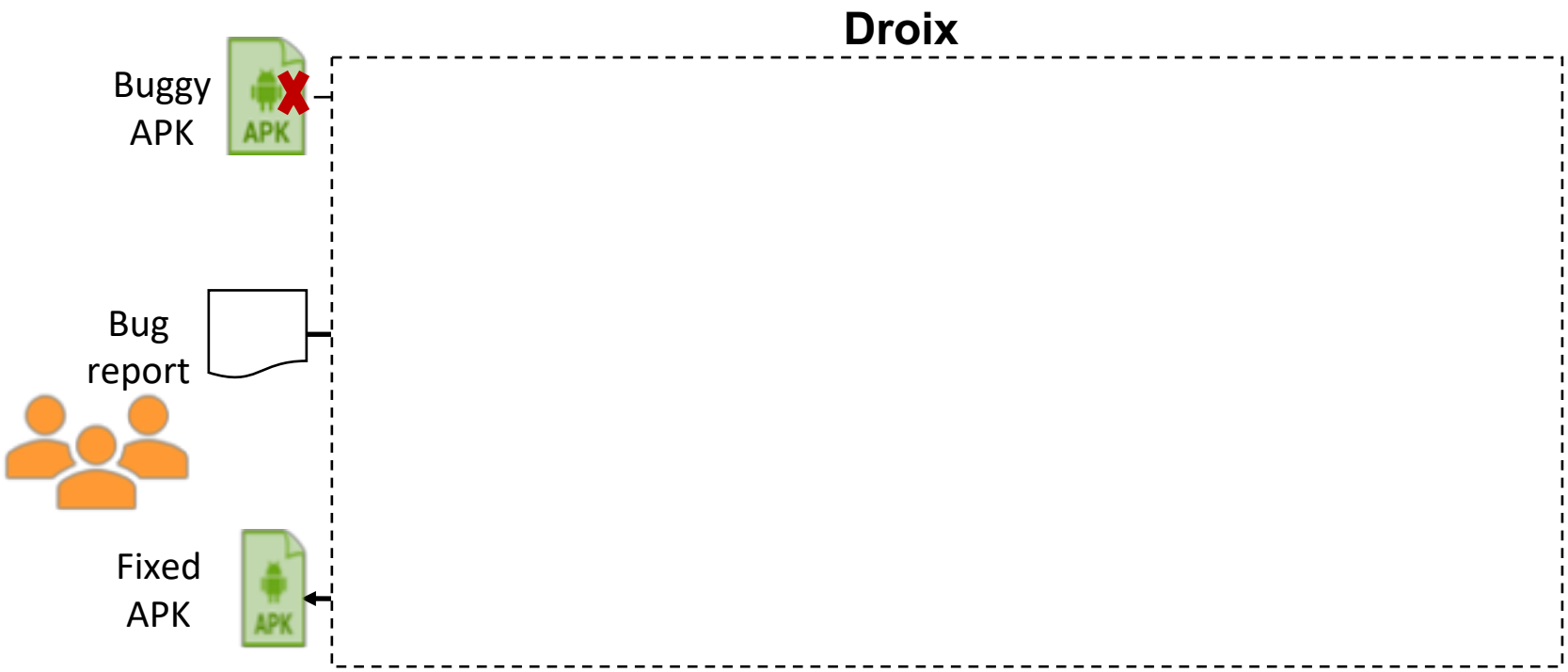
```
public void onCreate(Bundle savedInstanceState) {…
+   setRetainInstance(true);// retain this fragment
}

// new field for saving the object
+ private static Option saveOption;

public View onCreateView(LayoutInflater inflater,
    ViewGroup container, Bundle savedInstanceState) {
// saving and loading the object
+   if(option!=null){
+      saveOption = option;
+   }else{
+      option = saveOption;
+   }
✖    switch (option.getButtonStyle()){
```

1

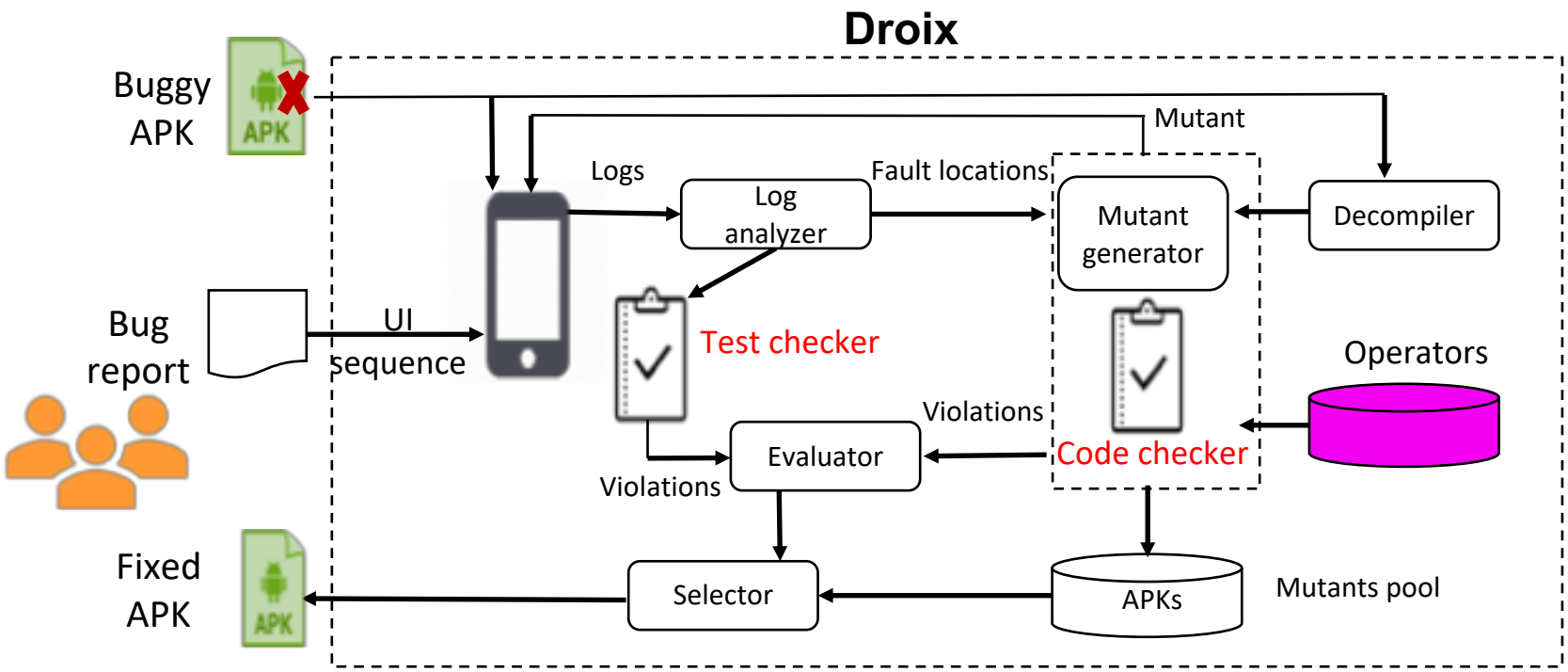
2

3

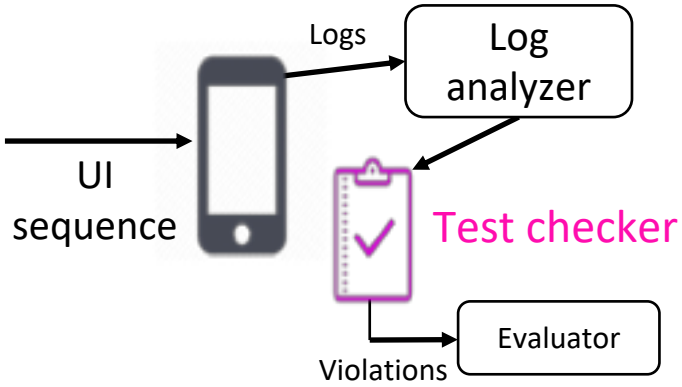
Android Apps Repair System (Droix)



Android Apps Repair System (Droix)

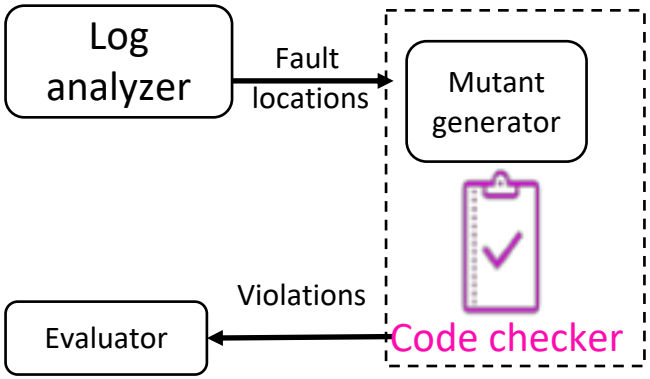


Test-Level Properties Checking



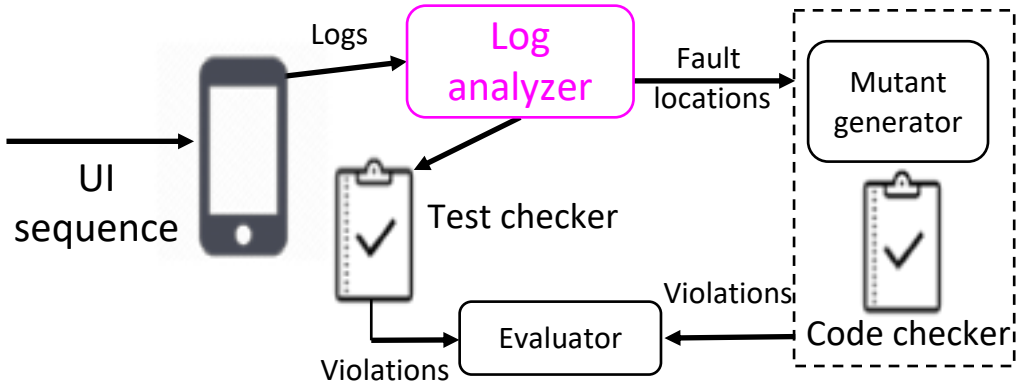
1. Record activity transitions in logs during test replay
2. Given activity transitions *current-state*→*next-state*, check for violations to Android activity/fragment lifecycle management rules

Code-level Properties Checking



For each program transformation by the mutant generator, check if it is valid in terms of compilation errors and coding conventions.

Locating the fault



- ✓ Do not required source code & heavy test suite
  - Log analyzer extracts stack trace information:
    - Exception Type
    - Lines in code where exception is thrown
    - Method calls in the stacktrace
  - Log analyzer extracts callbacks invoked during execution of UI sequence

Code-level & Test-level Properties in *Droix*

Level	Type	Description
Code-level	Well-formedness	Compilable and structural type of program matches with the context of selected operator.
	Bug hazard	Transformation violates Java exception-handling best practices.
	Exception Type	Transformation matches given exception type.
Test-level (Android-specific)	Lifecycle	Event transition matches with the activity/fragment lifecycle model.
	Activity-Fragment	Interaction between a fragment and its parent activity matches the activity-fragment coordination model
	Commit	Commit of fragment's transactions in allowed states.

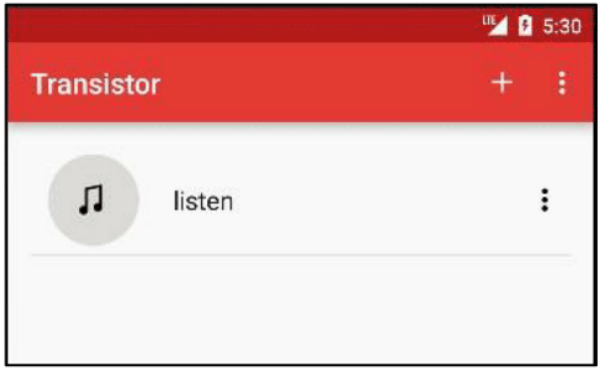
Bug hazard: "What not to do when handling exception?"
❖ Similar concepts as *anti-patterns [FSE'16]*

Searching for Patches

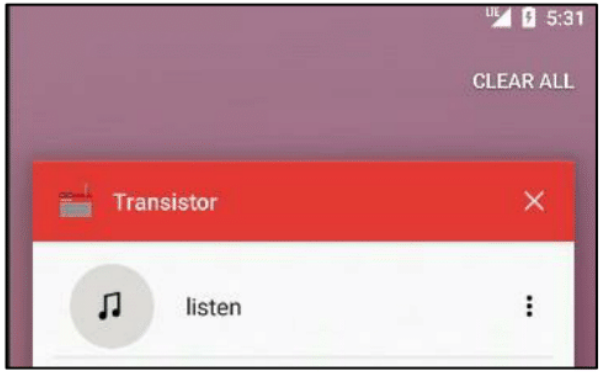
- $(\mu + \lambda)$ Evolutionary Algorithm, μ=40, λ=20
- Code-level & Test-level Properties are divided into:
  - Hard Constraints: eliminate patches if property is violated
    - Well-formedness
    - Bug hazard: inserting try-catch block for runtime errors
  - Soft Constraints: possible property violation
- Fitness Function *f*:

  f = Minimize # of violations for soft constraints

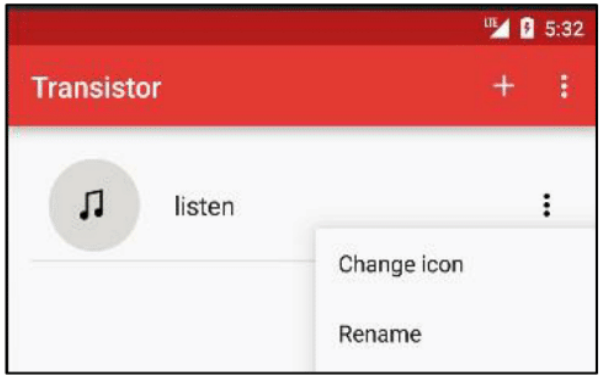
Example: Transistor



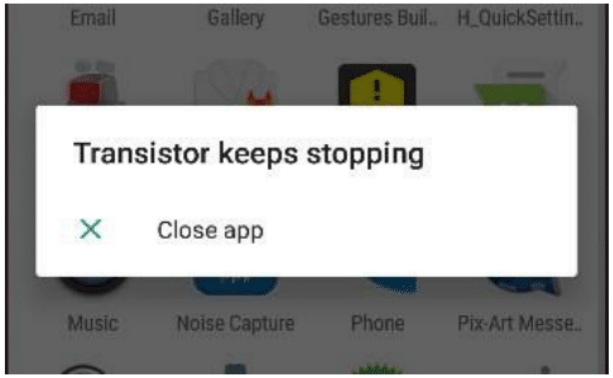
(a) Open Transistor



(b) Press back



(C) Open again and change an icon

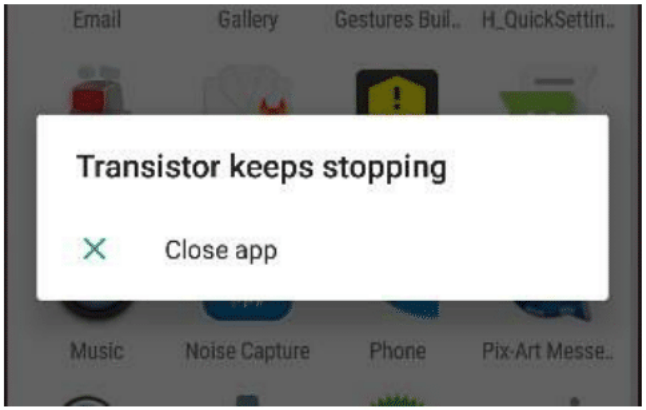


(d) Crashed with a notification

```
FATAL EXCEPTION: MAIN
PROCESS: ORG.Y20K.TRANSISTOR, PID: 2416
JAVA.LANG.ILLEGALSTATEEXCEPTION:
   FRAGMENT MAINACTIVITYFRAGMENT{82E1BEC}
            NOT ATTACHED TO ACTIVITY
```

- Fragment is detached from the previous activity during app termination & should be attached to new activity in the restarting app.

Example: Transistor



(d) Crashed with a notification

Developer's patch

```
- startActivityForResult ( pickImageIntent , REQUEST_LOAD_IMAGE);
+ mActivity.startActivityForResult ( pickImageIntent , REQUEST_LOAD_IMAGE);
```

❖ Reuse old activity (`mActivity`)

Droix's patch

```
+ if ( getActivity() !=null )
    startActivityForResult ( pickImageIntent , REQUEST_LOAD_IMAGE);
```

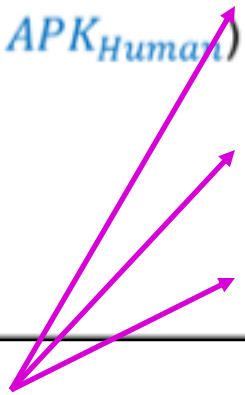
❖ Check if activity containing the fragment has been created.

Which patch is better

?

How to compare two patches?

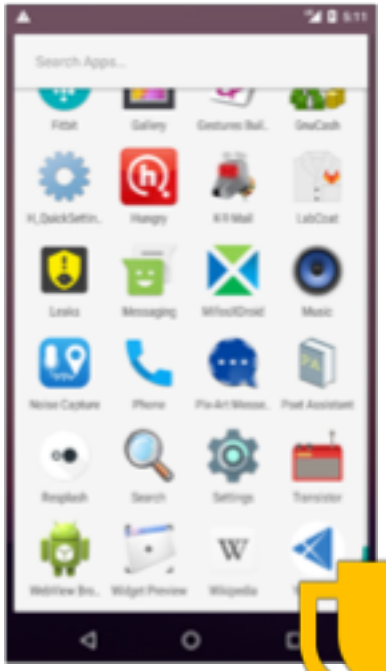
Level	Patch Quality	Meaning
Source-level (Src_{Droix} vs. Src_{Human})	Syntactically Equiv.	Are Src_{Droix} and Src_{Human} exactly the same patch?
	Semantically Equiv.	Do Src_{Droix} and Src_{Human} convey the same meaning?
UI-level (APK_{Droix} vs. APK_{Human})	UI-behavior Equiv.	Do APK_{Droix} and APK_{Human} behaves the same?
	Incorrect	Do APK_{Droix} introduce undesirable behavior?
	Better	Is APK_{Droix} better than APK_{Human} in terms of held-out test?

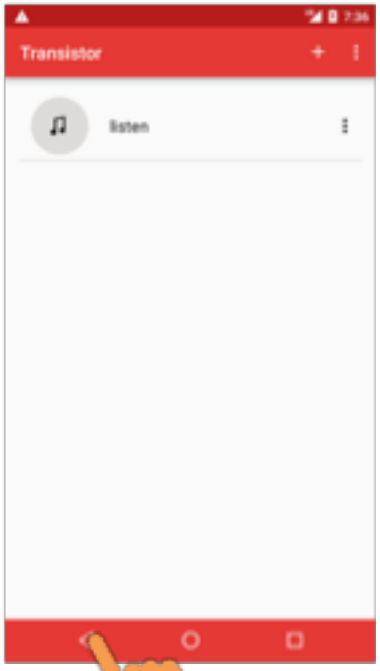


Newly added classification: allow more detailed comparison at the GUI level

Which patch is better?

Patch generated by Droix





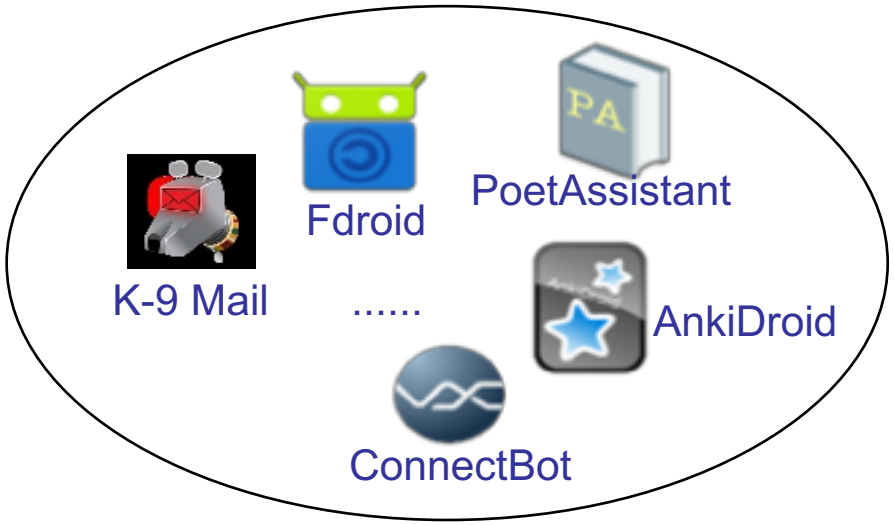
Patch crafted by human

- <17minutes to fix

- 2 days to fix
- Resolved 9 months later

Empirical Evaluation of Droix

Benchmark: *Droixbench*



24 crashes in **15** mobile apps

Evaluation results

- Repaired 12 crashes
- Comparing with developer's repair
  - 1 better ✔
  - 7 syntactic equivalent ✔
  - 1 semantic equivalent ✔
  - 3 UI-behavior equivalent ✔

Summary

- Android repair system that could repair crashes based on a single UI sequence
- Instead of relying on test cases, we use code-level and test-level properties
- Propose a set of lifecycle-aware repair operators
- *Droixbench*: benchmark with reproducible crashes in Android apps, extracted from GitHub