

Understanding and Detecting Evolution-Induced Compatibility Issues in Android Apps

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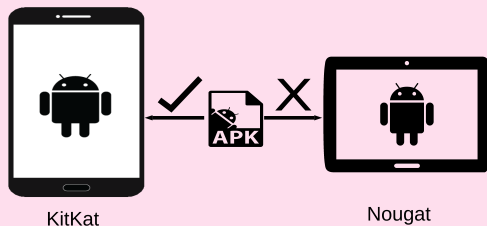
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Corresponding author

Evolution-Induced Compatibility Issues in Android Apps

- Evolution-Induced Compatibility Issues:



- Hot topic on internet forum, but not well understood.

- ⊙ **RQ1: Root Cause.**
 - What are the root causes of evolution-induced compatibility issues?
- ⊙ **RQ2: Issue Severity.**
 - How common are these issues in real Android Apps?
- ⊙ **RQ3: Issue Fixing Patterns.**
 - How do Android developers fix evolution-induced compatibility issues in practice?

- 11 Android SDK versions (with the Support Library).

Level	Version	Dist.	Level	Version	Dist.
16	4.1.2_r2.1	1.7%	23	6.0.1_r9	28.1%
17	4.2.2_r1.2b	2.6%	24	7.0.0_r7	22.3%
18	4.3_r3.1	0.7%	25	7.1.2_r9	6.2%
19	4.4_r1.2.0.1	12.0%	26	8.0.0_r9	0.8%
21	5.0.2_r3	5.4%	27	8.1.0_r9	0.3%
22	5.1.1_r9	19.2%			

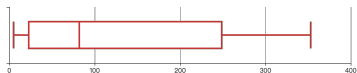
- Large set of third-party Apps from AndroZoo: 4,697/8,047

⊙ Manually inspected Apps from F-Droid: 10/1,425

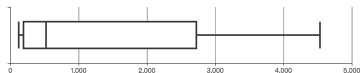
APP	Release	KLOC	# SDK_INTs
org.telegram.messenger	4.6.0a	324.2	531
com.poupa.vinylmusicplayer	0.16.4.4	35.8	209
org.glucosio.android	1.3.0-FOSS	8.2	195
com.amaze.filemanager	3.2.1	30.3	185
im.vector.alpha	0.8.1	52.5	185
com.github.axet.maps	8.1.0-4-Google	120.9	179
com.biglybt.android.client	1.1.4	483.8	173
eu.kanade.tachiyomi	0.6.8	2.7	165
org.bottiger.podcast	0.160.2	41.9	165
es.usc.citius.servando.calendula	2.5.3	26.3	154

Finding: Root Cause

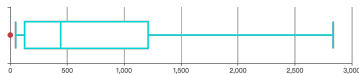
- ⦿ **Finding 1:** Android SDK version evolution leads to significant API changes.



(d) Type



(e) Method



(f) Field

Figure 1: Differences between adjacent SDK versions.

- ⦿ **Finding 2:** Android Support Library provides support for less than 23% of the new introduced APIs.

Table 1: API changes supported by the Android Support Library.

Adjacent Levels	#Supported / #New introduced		
	Type	Method	Field
17vs18	0/67	0/744	0/571
18vs19	6/122	75/1,044	91/813
19vs21	11/265	136/3,383	3/3,022
21vs22	0/10	4/154	0/64
22vs23	2/152	2/1,970	0/823
23vs24	102/355	1,100/4,605	179/3,267
24vs25	1/5	7/132	0/60
25vs26	164/357	2,424/4,450	261/1,350

Finding: Root Cause

- ⊙ **Finding 3:** Without considering API behavioral changes, **86%** of Apps can directly run on the next Android version without any modification. Thus, evolution-induced compatibility issues are mainly introduced from API behavioral changes and new features in later SDK versions.

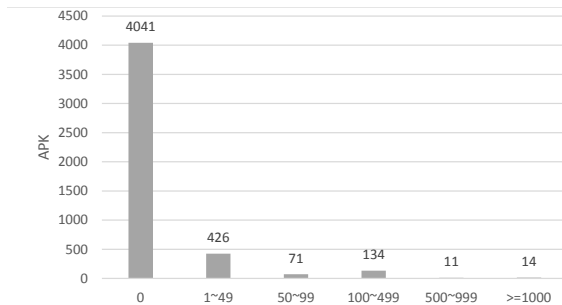


Figure 2: Distribution of Apps using abandoned APIs.

- ⦿ **Finding 4:** 91.84% of Apps write specific code to address evolution-induced compatibility issues.

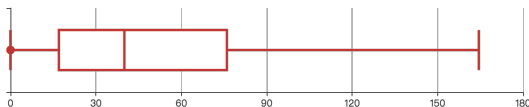


Figure 3: SDK_INT usage counts in Apps

Finding: Issue Severity

- ⦿ **Finding 5:** Less than 6.74% APIs are frequently used, and SDK_INT is the most frequently used field.

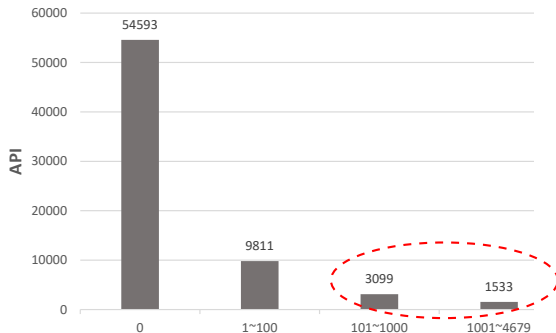


Figure 4: Distribution of APIs by usage counts.

Finding: Issue Fixing Patterns

- ⊙ **Finding 6:** most fixing patterns are very simple, complicated patterns are rare.
- ⊙ **Finding 7:** The most common practice (88.65% of usages) checks the underlying SDK version by comparing the variable `SDK_INT` directly with a constant API level value.

Listing 1: Common practice to address evolution-induced incompatibility issues.

```
1  if (SDK_INT >= 18) {  
2      // let it finish up first with what it's doing  
3      handlerThread.quitSafely();  
4  } else  
5      handlerThread.quit();
```

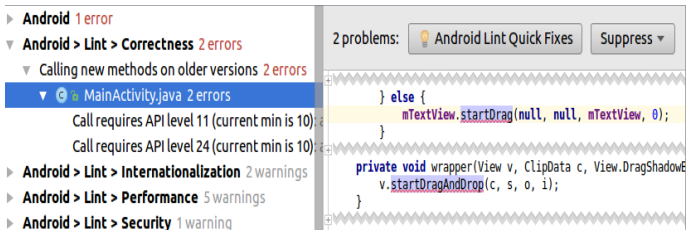
Example: Incompatible API usages

- ⊙ 91.84% Apps checking the underlying SDK version.
- ⊙ Checking process is error-prone and leads to incompatible API usages

```
1 // minSdkVersion: 10; targetSdkVersion 27.
2 public class MainActivity extends Activity {
3     private TextView mView;
4     protected void onCreate(Bundle bundle) {
5         ...
6         if (Build.VERSION.SDK_INT >= 24)
7             wrapper(mView, c, s, null, i);
8         else
9             mView.startDrag(c, s, null, i); // API1 [11,23]
10    }
11    → private wrapper(View v, ClipData c, ...) {
12        v.startDragAndDrop(c, s, o, i); // API2 [24,27]
13    }
14 }
```

Detecting incompatible API usages

⦿ Android Lint:



⦿ IctApiFinder:

```
1  app-debug.apk minSdkVersion: 10, targetSdkVersion: 27
2  BUG: <android.widget.TextView: boolean startDrag(android.content.ClipData, android.view.
3      View$DragShadowBuilder, java.lang.Object, int)> called in <com.example.hedj.sdkinttest.
4      MainActivity: void onCreate(android.os.Bundle)> on line 9 not in [10]
5
6  reachable paths:
7      <dummyMainClass: void dummyMainMethod(java.lang.String[])>
8      --><com.example.hedj.sdkinttest.MainActivity: void onCreate(android.os.Bundle)>
```

Implementation

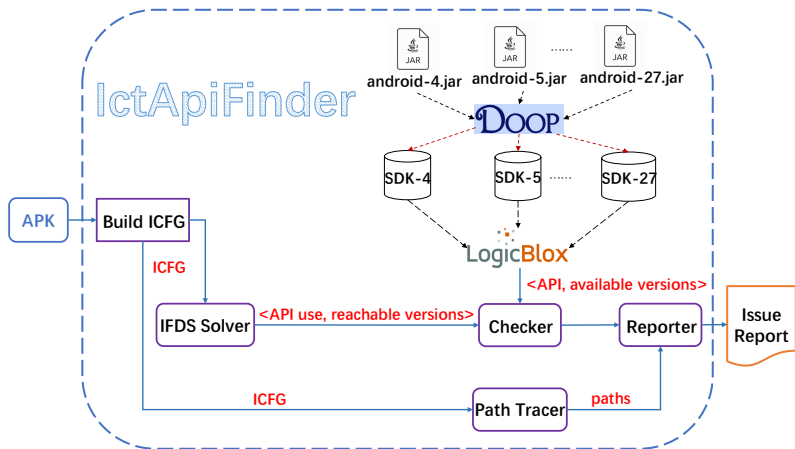
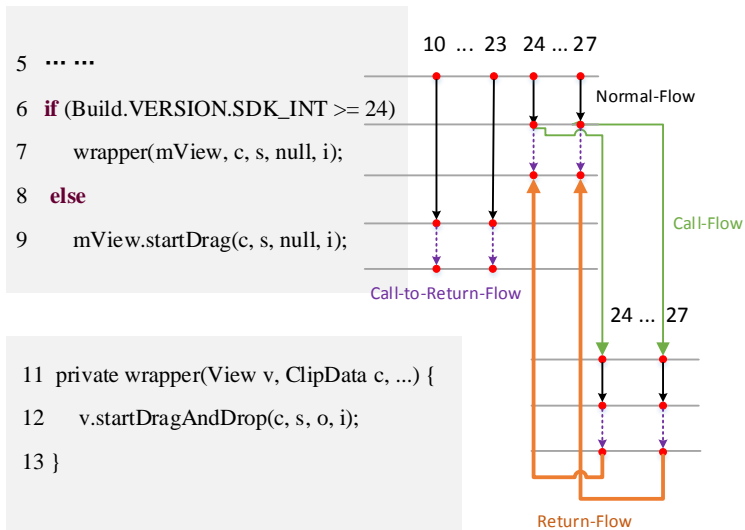


Figure 5: IctApiFinder Architecture.

Illustration example

- using IFDS to calculate the reachable Android OS versions for each API.



Evaluation: precision

- ⊙ IctApiFinder finds incompatible API usages in 361 out of 1,425 F-Droid Apps.
- ⊙ IctApiFinder reduces the false positive rate of Android Lint by **82.1%**.

ID	APP Name	Version	Lint	Finder
1	com.github.premnirmal.tickerwidget	2.4.04	17	3
2	de.christinecoenen.code.zapp	1.10.0	21	1
3	ca.rmen.android.networkmonitor	1.30.0	46	13
4	com.easytarget.micopi	3.6.11	2	1
5	com.prhlt.aemus.Read4SpeechExperiments	1.1	1	1
6	com.vonglasow.michael.qz	1.1	32	7
7	com.xargsgrep.portknocker	1.0.11	44	17
8	com.ymber.eleven	1.0	15	9
9	com.zegoggles.smssync	1.5.11-beta7	5	3
10	de.devml.muzei.bingimageofthedayartsources	1.4	37	37
11	de.kromke.andreas.unpopmusicplayerfree	1.41	29	14
12	it.feio.android.omninotes.foss	5.4.3	37	28
13	jackpal.androidterm	1.0.70-rebuild	52	14
14	jonas.tool.saveForOffline	3.1.6	3	1
15	net.opendasharchive.openarchive.release	0.0.17-alpha-1	12	8
16	org.servalproject	0.93	5	1
17	org.openintents.notepad	1.5.4	4	3
18	org.sensors2.osc	0.2.0	25	14
19	org.smssecure.smssecure	0.16.8-unstable	93	5
20	org.softeng.slartus.forpdaplus	3.4.8.2	732	37

Evaluation: Usefulness

- © 5 of 13 reported Apps confirmed by developers, 3 of them already been fixed.

ID	APP Name	IctApiFinder	TP	FP
1	com.github.premnirmal.tickerwidget	3	3	0
2	de.christinecoenen.code.zapp	1	0	1
3	ca.rmen.android.networkmonitor	13	12	1
4	com.easytarget.micopi	1	0	1
5	com.prhlt.aemus.Read4SpeechExperiments	1	0	1
6	com.vonglasow.michael.qz	7	7	0
7	com.xargsgrep.portknocker	17	13	4
8	com.yMBER.eleven	9	9	0
9	com.zegoggles.smssync	3	0	3
10	de.devMil.muzei.bingimageofthedayartsource	37	37	0
11	de.kromke.andreas.unpopmusicplayerfree	14	0	14
12	it.feio.android.omninotes.foss	28	24	4
13	jackpal.androidterm	14	0	14
14	jonas.tool.saveForOffline	1	1	0
15	net.opendasharchive.openarchive.release	8	0	8
16	org.servalproject	1	1	0
17	org.openintents.notepad	3	2	1
18	org.sensors2.osc	14	0	14
19	org.smssecure.smssecure	5	2	3
20	org.softEg.slartus.forpdaplus	37	35	2

Example: jonas.tool.saveForOffline

- ⊙ minSdkVersion: 16
- ⊙ API “setMediaPlaybackRequiresUserGesture” introduced after 17.
- ⊙ browsing off-line pages on GALAXY S3:

时间	PID	级别	Tag	日志内容
03-30 23:38:34.495	12952	I	SurfaceFlinger	SurfaceFlinger : eMagnificationFactorChanged. magnificationFactor=1.0
03-30 23:38:34.495	12952	I	SurfaceFlinger	SurfaceFlinger : eZoomPositionChanged. zoomX=0.0 zoomY=0.0
03-30 23:38:34.510	23932	I	am_on_paused_called	jonas.tool.saveForOffline.MainActivity
03-30 23:38:34.525	13043	I	am_restart_activity	[1122667056,5jonas.tool.saveForOffline/ViewActivity]
03-30 23:38:34.580	23932	I	dalvikvm	Could not find method android.webkit.WebSettings.setMediaPlaybackRequiresUserGesture, referenced from method jonas.tool.saveForOffline.ViewActivity.setupWebView
03-30 23:38:34.580	23932	W	dalvikvm	VFY: unable to resolve virtual method 254: Landroid/webkit/WebSettings;setMediaPlaybackRequiresUserGesture (Z)V
03-30 23:38:34.645	23932	I	webclipboard	clipservice: android.sec.clipboard.ClipboardExManager@42460010
03-30 23:38:34.665	23932	W	dalvikvm	threadid=1: thread exiting with uncaught exception (group=0x416d92a0)
03-30 23:38:34.670	23932	E	AndroidRuntime	FATAL EXCEPTION: main
03-30 23:38:34.670	23932	E	AndroidRuntime	java.lang.NoSuchMethodError: android.webkit.WebSettings.setMediaPlaybackRequiresUserGesture
03-30 23:38:34.670	23932	E	AndroidRuntime	at jonas.tool.saveForOffline.ViewActivity.setupWebView(ViewActivity.java:125)
03-30 23:38:34.670	23932	E	AndroidRuntime	at jonas.tool.saveForOffline.ViewActivity.onCreate(ViewActivity.java:87)
03-30 23:38:34.670	23932	E	AndroidRuntime	at android.app.Activity.performCreate(Activity.java:5206)
03-30 23:38:34.670	23932	E	AndroidRuntime	at android.app.Instrumentation.callActivityOnCreate(Instrumentation.java:1083)
03-30 23:38:34.670	23932	E	AndroidRuntime	at android.app.ActivityThread.performLaunchActivity(ActivityThread.java:2064)
03-30 23:38:34.670	23932	E	AndroidRuntime	at android.app.ActivityThread.handleLaunchActivity(ActivityThread.java:2125)
03-30 23:38:34.670	23932	E	AndroidRuntime	at android.app.ActivityThread.access\$600(ActivityThread.java:140)

Example: com.xargsgrep.portknocker

- ⦿ minSdkVersion: 10
- ⦿ external component “LocalStorageProvider”.
- ⦿ its father, “DocumentsProvider”, introduced after level 19.

The screenshot shows a GitHub issue page for the repository 'xargsgrep / PortKnocker'. The issue title is 'incompatible API use in your code. #17'. The issue was opened by 'jay2013' 4 hours ago and has 2 comments. The first comment, from 'jay2013', describes a problem where the app's minSdkVersion is 10, but an external component 'com.ianhanniballake.localstorage.LocalStorageProvider' extends from 'DocumentsProvider', which was introduced in SDK level 19. The second comment, from 'TDFKAOIII', responds that the user is correct and that Android Studio is also showing a warning that minSdkVersion should be 19. The right sidebar shows 'Assignees' (none), 'Labels' (none), 'Projects' (none), 'Milestone' (none), 'Notifications' (Unsubscribe), and '2 participants'.

xargsgrep / PortKnocker

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incompatible API use in your code. #17

Edit New Issue

Open jay2013 opened this issue 4 hours ago - 2 comments

jay2013 commented 4 hours ago • edited

Hi,
Our tool detect this app's apk file from f-droid.org(version: 1.0.11) and find several potential bugs. We already check them but we cannot make 100% sure that they are definitely bugs. So we need your help.

We find component "com.ianhanniballake.localstorage.LocalStorageProvider" in AndroidManifest.xml is actually from an external library. This class extends from DocumentsProvider which is added into SDK since level 19, while your app's minSdkVersion is 10. So this is very likely to cause your app crash.

please help to check. Thanks very much.

Dongjie He

TDFKAOIII commented 2 hours ago

Hi,
yes, I think you are right. Android studio is also indicating in a warning that minSdkVersion shall be 19. Currently 14 is set. Need to be fixed.
Cheers, TDFKAOIII

Assignees
No one assigned

Labels
None yet

Projects
None yet

Milestone
No milestone

Notifications
Unsubscribe
You're receiving notifications because you authored the thread.

2 participants

Example: org.servalproject

- ⦿ minSdkVersion: 8
- ⦿ API “String(byte[],int,int,Charset)” introduced after level 9.

servalproject / batphone

Code Issues 30 Pull requests 2 Projects 0 Insights

incompatible API use in your code. #135

Closed jay2013 opened this issue 12 days ago · 2 comments

jay2013 commented 12 days ago

Hi, we find that constructor of Class String <java.lang.String: void (byte[],int,int,java.nio.charset.Charset)> no exist in SDK level 8, the documentation of SDK change says it is added in level 9.

However, in your source code, you called this api in method <org.servalproject.system.bluetooth.BlueToothControl: java.lang.String encodeName(byte[])>. We notice that your app's minSdkVersion is 8, so it will be a bug when others run your app on a mobile device with sdk level 8.

BUG Detail:
<java.lang.String: void (byte[],int,int,java.nio.charset.Charset)> called in <org.servalproject.system.bluetooth.BlueToothControl: java.lang.String encodeName(byte[])> on line 399 not in [8]

please help to check. Thanks very much.

Dongjie He

lakeman commented 5 hours ago

Simple enough to fix. But I haven't seen any crash bugs from this.

lakeman closed this in 05e784e 5 hours ago

Constructor new String(...Charset) was only added in API9, Fixes #135

development

lakeman committed 5 hours ago

1 parent 35a723c commit 05e784e

Showing 1 changed file with 20 additions and 2 deletions.

```
22 app/src/main/java/org/servalproject/system/bluetooth/BlueToothControl.java
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