



Android reverse engineering: understanding third-party applications

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Who I am?



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Agenda

- Reverse engineering: definition and objectives
- Application analysis workflow
- Malware identification in Android apps

Reverse engineering: definition and objectives

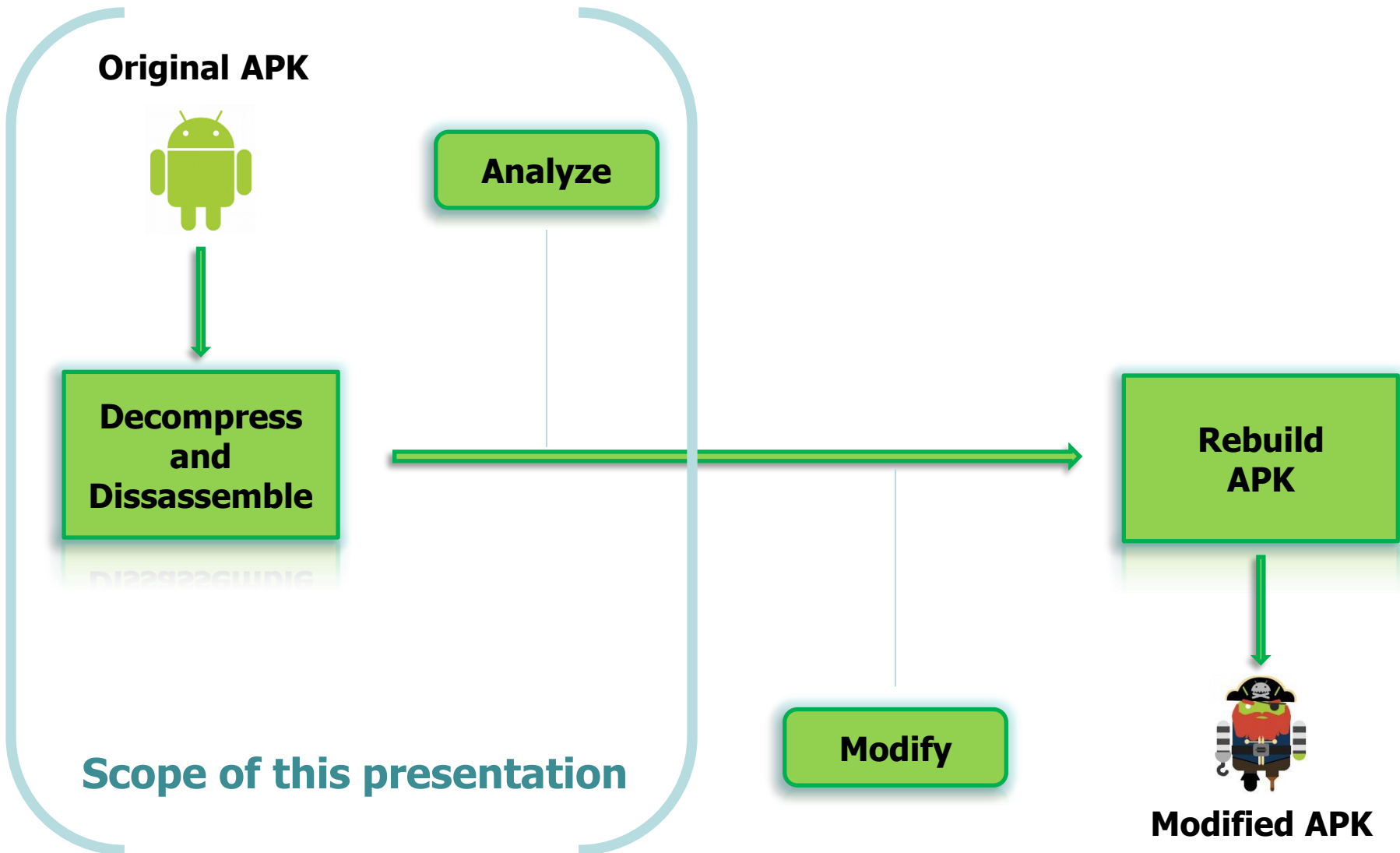
■ Definition

- ▶ Refers to the process of analyzing a system to identify its components and their interrelationships, and create representations of the system in another form or a higher level of abstraction. [1]

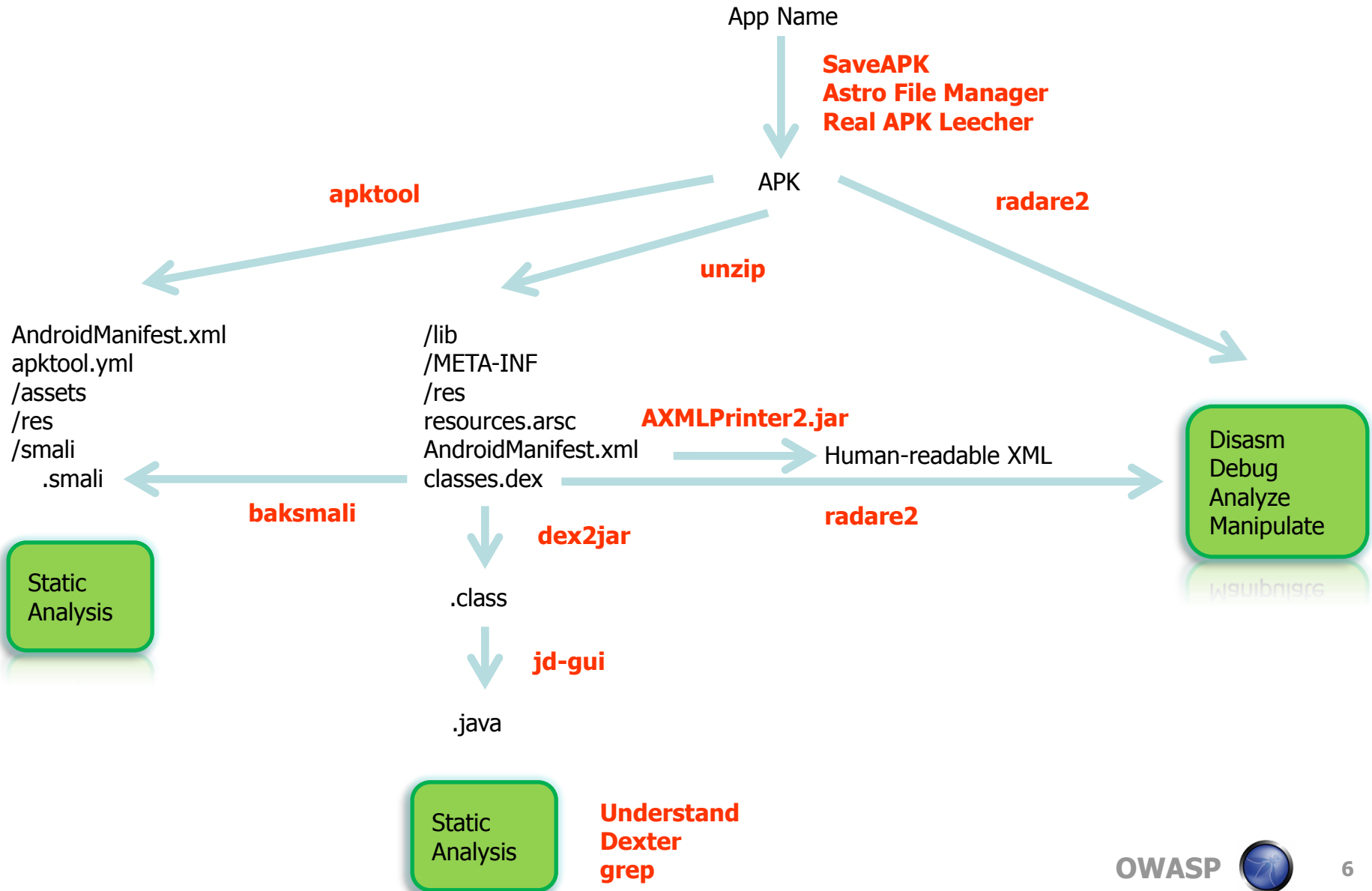
■ Objectives

- ▶ The purpose of reverse engineering is not to make changes or to replicate the system under analysis, but to **understand** how it was built.

Application analysis workflow



Application analysis workflow



Application analysis workflow

■ Static Analysis Tools for Android Apps

TOOL	DESCRIPTION	URL
Dexter	Static android application analysis tool	https://dexter.bluebox.com/
Androguard	Analysis tool (.dex, .apk, .xml, .arsc)	https://code.google.com/p/androguard/
smali/baksmali	Assembler/disassembler (dex format)	https://code.google.com/p/smali/
apktool	Decode/rebuild resources	https://code.google.com/p/android-apktool/
JD-GUI	Java decompiler	http://java.decompiler.free.fr/?q=jdgui
Dedexer	Disassembler tool for DEX files	http://dedexer.sourceforge.net/
AXMLPrinter2.jar	Prints XML document from binary XML	http://code.google.com/p/android4me/
dex2jar	Analysis tool (.dex and .class files)	https://code.google.com/p/dex2jar/
apkinspector	Analysis functions	https://code.google.com/p/apkinspector/
Understand	Source code analysis and metrics	http://www.scitools.com/
Agnitio	Security code review	http://sourceforge.net/projects/agnitiotool/

Application analysis workflow

■ Others (necessary) tools

TOOL	DESCRIPTION	URL
Android SDK	Tools to build, test, and debug apps	http://developer.android.com/sdk/index.html
--- emulator	Virtual mobile device	developer.android.com/tools/help/emulator.html
--- adb	Android debug bridge	developer.android.com/tools/help/adb.html
A.R.E.	Android Reverse Engineering VM	https://redmine.honeynet.org/projects/are/wiki

Malware identification in Android apps

■ Malware definition

- ▶ Malware is a piece of code which changes the behavior of either the operating system kernel or some security sensitive applications, without a user consent and in such a way that it is then impossible to detect those changes using a documented features of the operating system or the application.[2]
- ▶ A malware is any **malicious code** or piece of software that is designed to perform functions without the consent of the user.

Malware identification in Android apps

■ Techniques for introducing malware

- ▶ Exploit any vulnerability in the web server hosting the official store
- ▶ Use the official store to post apps containing malware
- ▶ Install not malicious app that, at some point, install malicious code
- ▶ Use alternatives[3] to official stores to post apps containing malware

Malware identification in Android apps

■ A practical example

■ Some considerations

- ▶ The analyzed app are in the Play Store
- ▶ The published application does not exploit (supposedly) any vulnerability, but can contains malicious code that exploits the user's trust[4]
- ▶ We will only use static analysis
- ▶ We will analyze Java source code
- ▶ We will use the Android Emulator[5]

Malware identification in Android apps

■ What do we need?



... and motivation!

Malware identification in Android apps

Let's see an example...

Malware identification in Android apps

■ Identify a possible malicious application

▶ App with unnecessary permissions

- A wallpaper that requires "SEND SMS MESSAGES"
- A calculator that requires "DIRECTLY CALL PHONE NUMBERS"
- ...

▶ Google:

- +"send sms messages" +"wallpaper" +site:"play.google.com"

Malware identification in Android apps

■ Identify a possible malicious application

▶ Example: "Pipe Mania Droid Lite"

- <https://play.google.com/store/apps/details?id=bridge.pipe.lite>

THIS APPLICATION HAS ACCESS TO THE FOLLOWING:

YOUR MESSAGES

RECEIVE TEXT MESSAGES (SMS)

Allows the app to receive and process SMS messages. This means the app could monitor or delete messages sent to your device without showing them to you.

SEND SMS MESSAGES

Allows the app to send SMS messages. This may result in unexpected charges. Malicious apps may cost you money by sending messages without your confirmation.

NETWORK COMMUNICATION

FULL NETWORK ACCESS

Allows the app to create network sockets and use custom network protocols. The browser and other applications provide means to send data to the internet, so this permission is not required to send data to the internet.

PHONE CALLS

READ PHONE STATUS AND IDENTITY

Allows the app to access the phone features of the device. This permission allows the app to determine the phone number and device IDs, whether a call is active, and the remote number connected by a call.

STORAGE

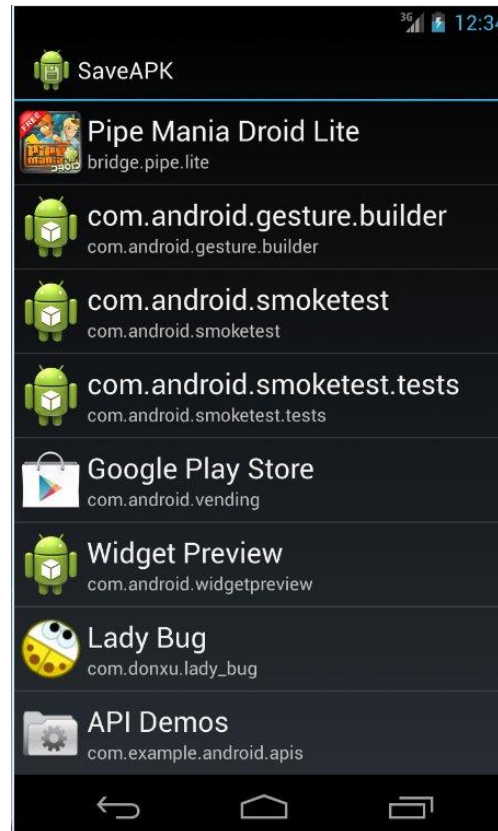
MODIFY OR DELETE THE CONTENTS OF YOUR USB STORAGE

Allows the app to write to the USB storage.

Malware identification in Android apps

■ Obtaining the APK file

- ▶ Using the SaveAPK tool (requires IO File Manager)



Malware identification in Android apps

■ Decompress the APK file

- ▶ unzip Pipe\ Mania\ Droid\ Lite.apk

■ Verify the permissions and receivers

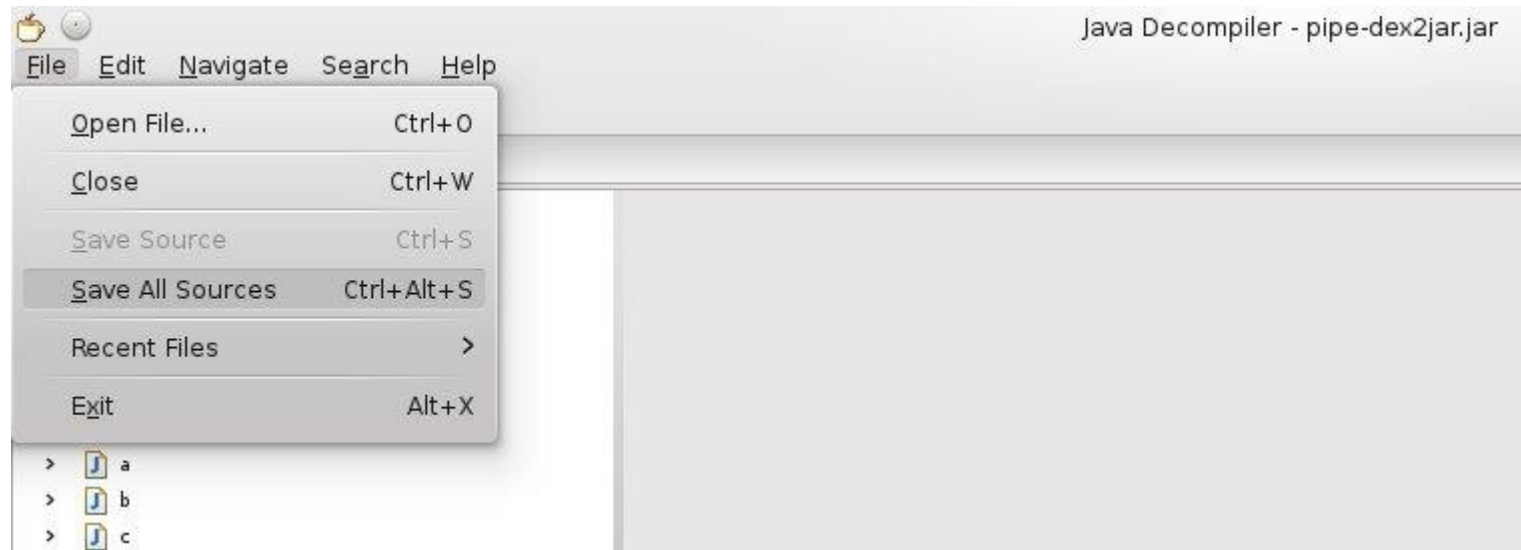
- ▶ java -jar AXMLPrinter2.jar AndroidManifest.xml > out

```
<receiver
  android:name="com.fortumo.android.BillingSMSReceiver"
  >
  <intent-filter
    >
    <action
      android:name="android.provider.Telephony.SMS_RECEIVED"
    >
    </action>
  </intent-filter>
</receiver>
```

```
<uses-permission
  android:name="android.permission.RECEIVE_SMS"
  >
</uses-permission>
<uses-permission
  android:name="android.permission.SEND_SMS"
  >
</uses-permission>
```

Malware identification in Android apps

- Convert from Dalvik EXecutable to Java classes
 - ▶ d2j-dex2jar.sh pipe.apk
- Decompile Java classes and download source code
 - ▶ jd-gui pipe-dex2jar.jar

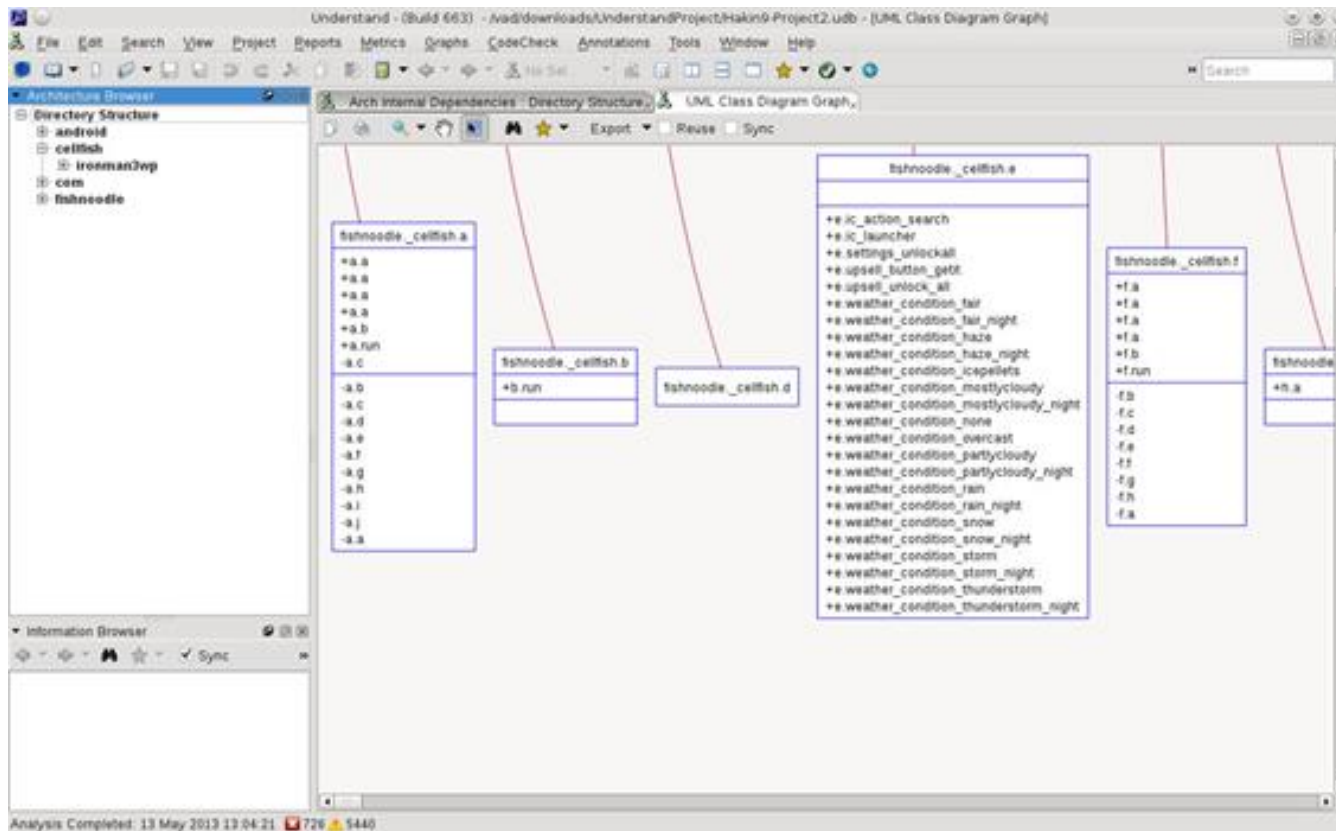


Malware identification in Android apps

- Decompress the source code
 - ▶ unzip pipe-dex2jar-src.zip
- Search sensitive strings
 - ▶ grep -i telephonymanager -r *
- Analyze the code
 - ▶ With tools
 - ▶ Manually
- Identifies malicious code

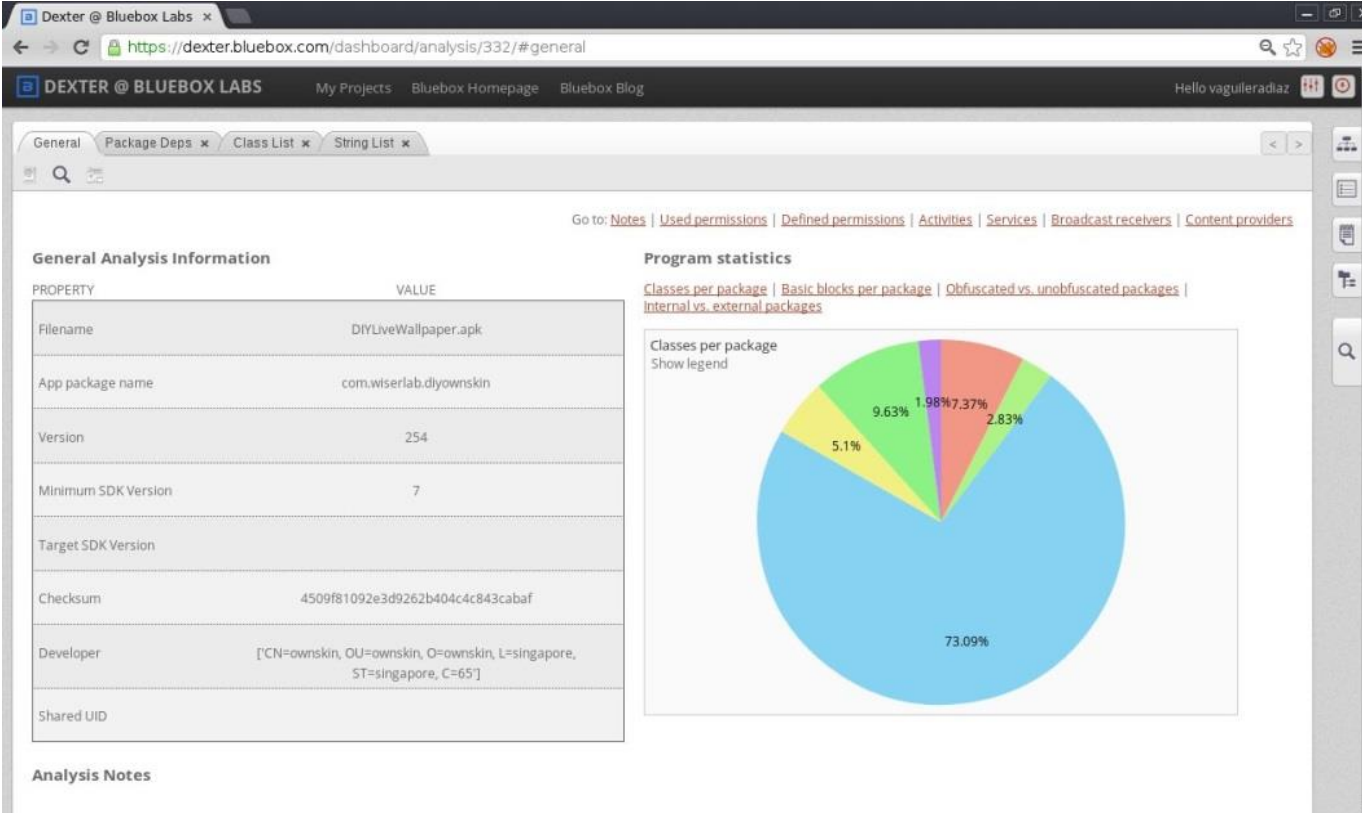
Malware identification in Android apps

■ “Understand” tool



Malware identification in Android apps

■ “Dexter” online service



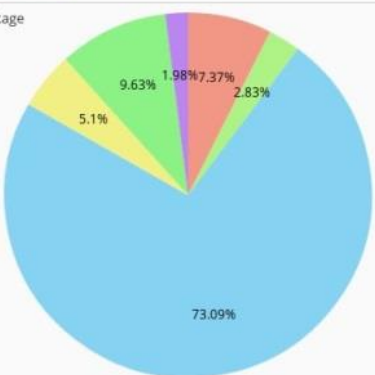
The screenshot displays the Dexter online service dashboard. The browser address bar shows the URL <https://dexter.bluebox.com/dashboard/analysis/332/#general>. The dashboard includes a navigation menu with options like 'General', 'Package Deps', 'Class List', and 'String List'. The main content area is divided into two sections: 'General Analysis Information' and 'Program statistics'.

General Analysis Information

PROPERTY	VALUE
Filename	DIYLiveWallpaper.apk
App package name	com.wiserlab.diyownskin
Version	254
Minimum SDK Version	7
Target SDK Version	
Checksum	4509f81092e3d9262b404c4c843cabaf
Developer	[CN=ownskin, OU=ownskin, O=ownskin, L=singapore, ST=singapore, C=65]
Shared UID	

Program statistics

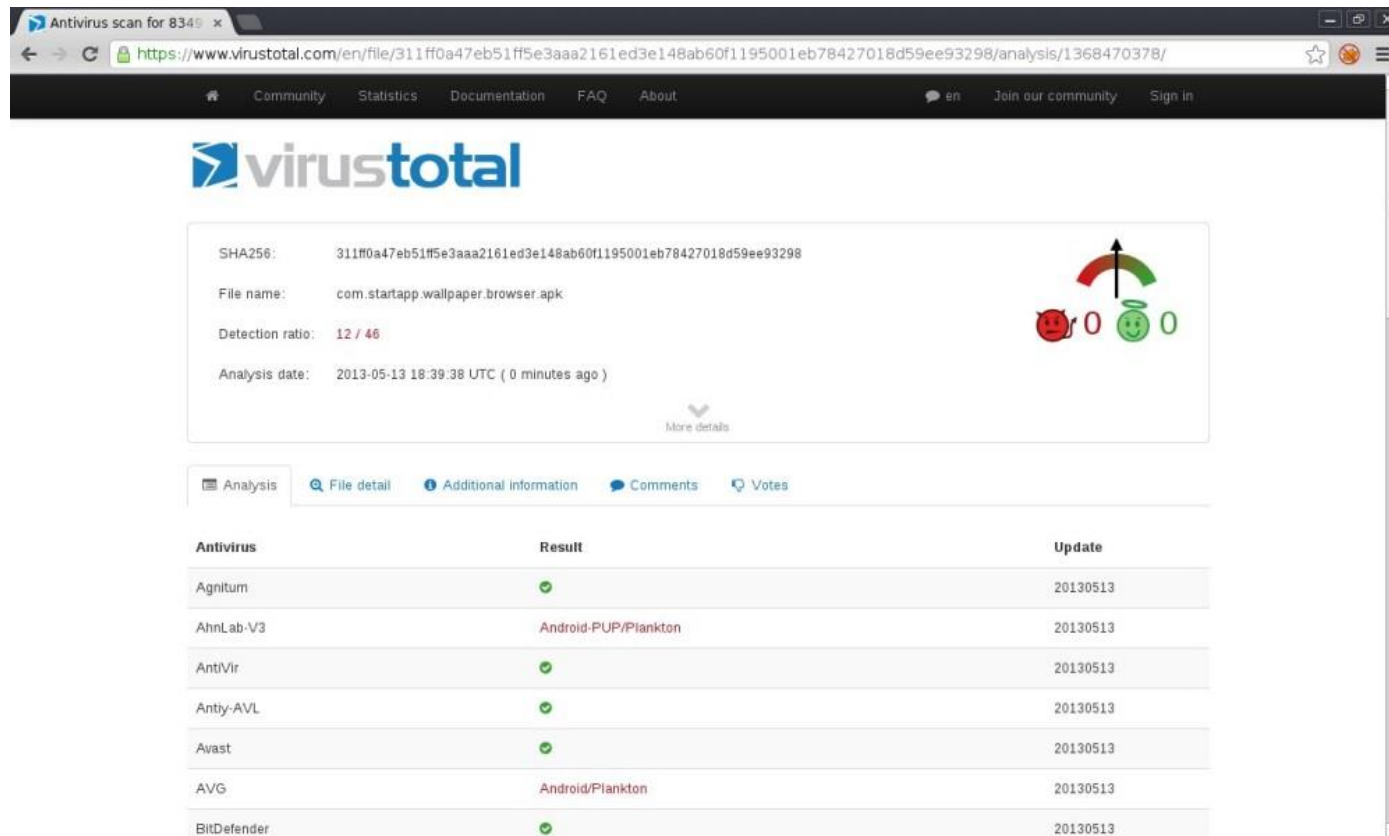
Classes per package
Show legend



Percentage
73.09%
9.63%
5.1%
2.83%
7.37%
1.98%

Malware identification in Android apps

■ “virustotal.com” online service



The screenshot shows a web browser window displaying the VirusTotal analysis page for a file. The browser's address bar shows the URL: <https://www.virustotal.com/en/file/311ff0a47eb51ff5e3aaa2161ed3e148ab60f1195001eb78427018d59ee93298/analysis/1368470378/>. The page features the VirusTotal logo and a summary box with the following information:

- SHA256: 311ff0a47eb51ff5e3aaa2161ed3e148ab60f1195001eb78427018d59ee93298
- File name: com.startapp.wallpaper.browser.apk
- Detection ratio: 12 / 46
- Analysis date: 2013-05-13 18:39:38 UTC (0 minutes ago)

To the right of the summary box is a colorful gauge showing a detection ratio of 12/46, with a red smiley face and a green smiley face, both with a '0' next to them. Below the summary box is a 'More details' link. The page has a navigation menu with tabs for Analysis, File detail, Additional information, Comments, and Votes. Below the navigation menu is a table of antivirus engine results:

Antivirus	Result	Update
Agnitum	✓	20130513
AhnLab-V3	Android-PUP/Plankton	20130513
AntiVir	✓	20130513
Anty-AVL	✓	20130513
Avast	✓	20130513
AVG	Android/Plankton	20130513
BitDefender	✓	20130513

References

- [1] "Reverse Engineering and Design Recovery: A Taxonomy". Elliot J. Chikofsky, James H. Cross.
- [2] "Introducing Stealth Malware Taxonomy". J. Rutkowska.
- [3] "Alternative markets to the Play Store".
<http://alternativeto.net/software/android-market/>
- [4] "Security features provided by Android".
<http://developer.android.com/guide/topics/security/permissions.html>
- [5] "Using the Android Emulator".
<http://developer.android.com/tools/devices/emulator.html>

References

[6] “Android malware database”

<http://code.google.com/p/androguard/wiki/DatabaseAndroidMalwares>

Thank's!

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