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CODE BLUE 2016

Security in the IoT World: Analyzing the Security of Mobile Apps for Automobiles ** Supplement **

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Evaluating and Scoring the Risk of Vulnerabilities

CVSS c3 base score of the found vulnerabilities

- **What is CVSS?**
  - CVSS is the abbreviation for the "Common Vulnerability Scoring System".
  - It is one of the methods that is a generic and open to evaluating a risk of vulnerability.
  - v3 is focused on characteristics of vulnerable component compared to V2 for considering a scope of influence by the vulnerability.
  - To know details of CVSS, see also references page.

Vulnerability #1:
HTTP communication that contains user information

Base Score
7.3 (High)

Note:
- An attacker is possible to obtain some user information and modify the communication data, but they would not be a serious impact to the component directly.

Metrics	Assigned
Attack Vector (AV)	Network
Attack Complexity (AC)	Low
Privileges Required (PR)	None
User Interaction (UI)	None
Scope (S)	Unchanged
Confidentiality (C)	Low
Integrity (I)	Low
Availability (A)	Low

Vulnerability #2:
Server certificate validation flaw

Base Score
6.4 (Medium)

Note:
- The app has a potential to be MITM attacked because it does not validate an SSL server certificate.
- There is a potential that an attacker intercepts a communication data that should be protected (e.g., authenticates credential).

Metrics	Assigned
Attack Vector (AV)	Adjacent
Attack Complexity (AC)	High
Privileges Required (PR)	None
User Interaction (UI)	Required
Scope (S)	Unchanged
Confidentiality (C)	High
Integrity (I)	High
Availability (A)	Low

Why did we assign "Required" to User Interaction?
- The app does not communicate to a server on HTTPS until a user taps the "login" button.
- Auto login will be performed if a user configures own.

The First Step for Reverse Engineering an Android App

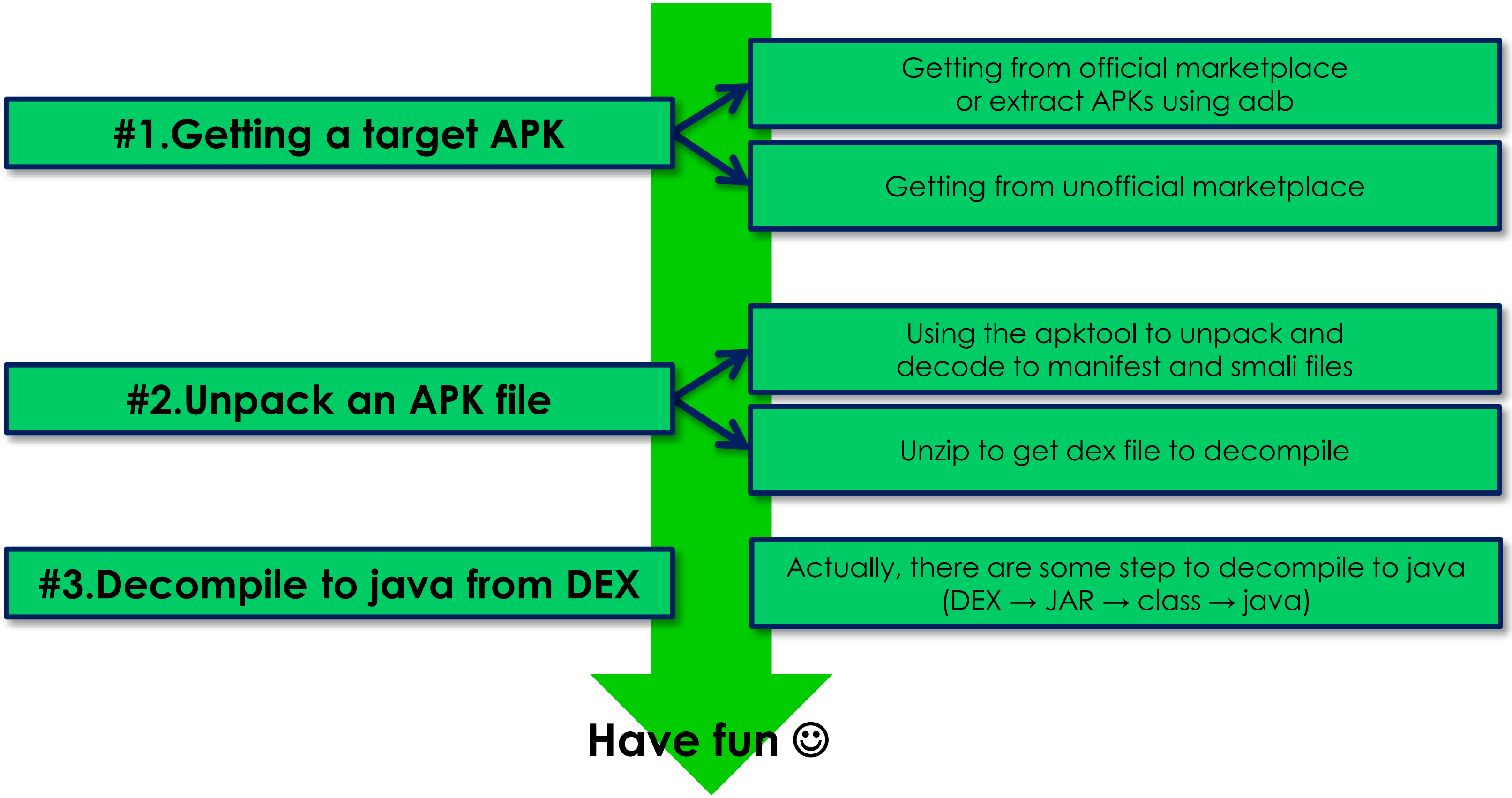
How to reverse engineering an Android app

- At the CODE BLUE 2016, I did not talk detail about how to reverse engineering the apps that were detected critical vulnerabilities by AndroBugs.

- In this paper, I introduce some tools used for reverse engineering an Android app.

A Flow of reverse engineering an Android app

- There are 3 steps to reverse engineering an Android app.



#1.Getting a target APK

Getting from official marketplace or extract APKs using adb

Getting from unofficial marketplace

#2.Unpack an APK file

Using the apktool to unpack and decode to manifest and smali files

Unzip to get dex file to decompile

#3.Decompile to java from DEX

Actually, there are some step to decompile to java (DEX → JAR → class → java)

Have fun ☺

#1. Getting a target APK file

- There are 2 ways to get an APK file.
  - Extract from a device using adb (Android Debug Bridge).
  - Download from an unofficial marketplace and so on.

- To use adb, you need to install Android SDK in advance.

- If you use adb in Windows OS, I recommend to install a grep-like command because it helps to search a target APK using adb.

#1. Getting a target APK file (cont.)

- **Step1. Check the installed packages in a device.**
  - "pm list packages" is able to enumerate packages that are in a target device.
  - "-f" option is output packages associated file.

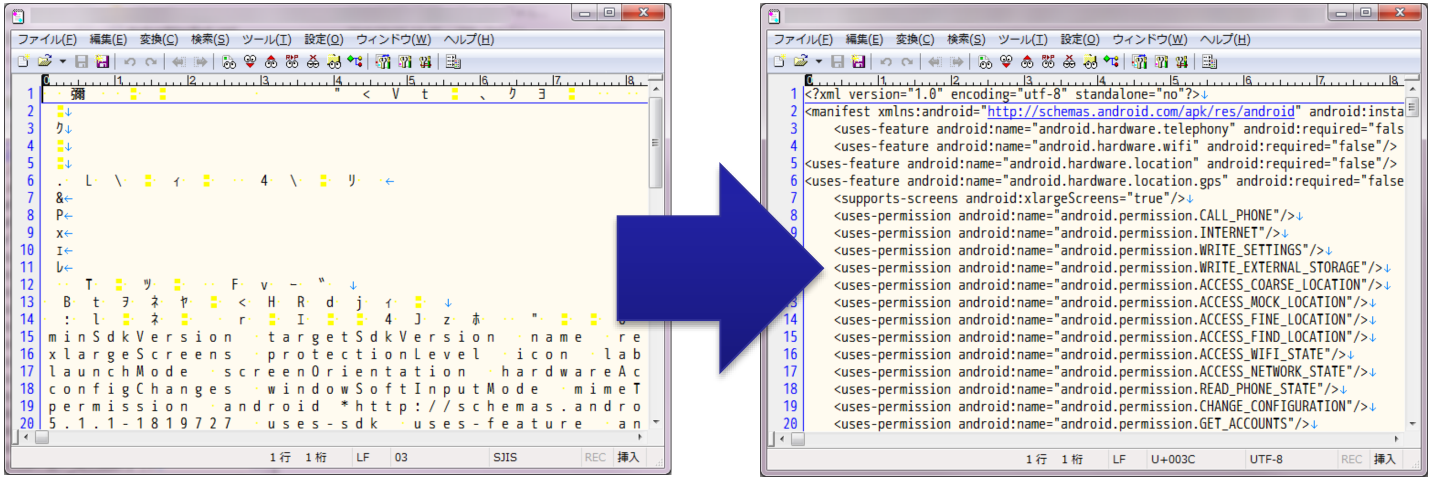
```
jcnuts@jcnuts:~$ adb shell pm list packages -f | grep google
package:/data/app/com.google.android.apps.books-1.apk=com.google.android.apps.books
package:/data/app/com.google.android.apps.docs-1.apk=com.google.android.apps.docs
```

- **Step2. Download a target package (APK) from a device.**
  - "pull" command is able to download (pull) a package to your PC.

```
jcnuts@jcnuts:~/re_apks$ adb pull /data/app/com.google.android.apps.maps-2.apk
953 KB/s (28180726 bytes in 28.863s)
jcnuts@jcnuts:~/re_apks$ ls
com.google.android.apps.maps-2.apk
jcnuts@jcnuts:~/re_apks$
```

#2. Unpack an APK file

- APK can unzip the same as ZIP.
  - However, most of the files that you are obtained by unzipping are a binary format that is hard to analyze☹
- The apktool provide some features you to analyze more easily.
  - Decoding a resources and manifest file.
  - Baksmaling a dex file.


ファイル(F) 編集(E) 変換(C) 検索(S) ツール(T) 設定(O) ウィンドウ(W) ヘルプ(H)
1行 1桁 LF 03 SJIS REC 挿入
1行 1桁 LF U+003C UTF-8 REC 挿入

```
m i n S d k V e r s i o n   t a r g e t S d k V e r s i o n   n a m e   r e
x l a r g e S c r e e n s   p r o t e c t i o n L e v e l   i c o n   l a b
l a u n c h M o d e   s c r e e n O r i e n t a t i o n   h a r d w a r e A c
c o n f i g C h a n g e s   w i n d o w S o f t I n p u t M o d e   m i m e T
p e r m i s s i o n   a n d r o i d  * h t t p : / / s c h e m a s . a n d r o
5 . 1 . 1 - 1 8 1 9 7 2 7   u s e s - s d k   u s e s - f e a t u r e   a n
```

```
<?xml version="1.0" encoding="utf-8" standalone="no"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android" android:insta
    <uses-feature android:name="android.hardware.telephony" android:required="fals
    <uses-feature android:name="android.hardware.wifi" android:required="false"/>
<uses-feature android:name="android.hardware.location" android:required="false"/>
<uses-feature android:name="android.hardware.location.gps" android:required="false
    <supports-screens android:xlargeScreens="true"/>
    <uses-permission android:name="android.permission.CALL_PHONE"/>
    <uses-permission android:name="android.permission.INTERNET"/>
    <uses-permission android:name="android.permission.WRITE_SETTINGS"/>
    <uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE"/>
    <uses-permission android:name="android.permission.ACCESS_COARSE_LOCATION"/>
    <uses-permission android:name="android.permission.ACCESS_MOCK_LOCATION"/>
    <uses-permission android:name="android.permission.ACCESS_FINE_LOCATION"/>
    <uses-permission android:name="android.permission.ACCESS_FIND_LOCATION"/>
    <uses-permission android:name="android.permission.ACCESS_WIFI_STATE"/>
    <uses-permission android:name="android.permission.ACCESS_NETWORK_STATE"/>
    <uses-permission android:name="android.permission.READ_PHONE_STATE"/>
    <uses-permission android:name="android.permission.CHANGE_CONFIGURATION"/>
    <uses-permission android:name="android.permission.GET_ACCOUNTS"/>
```

#2. Unpack an APK file (cont.)

- apktool is available to download from the following link: https://ibotpeaches.github.io/Apktool/

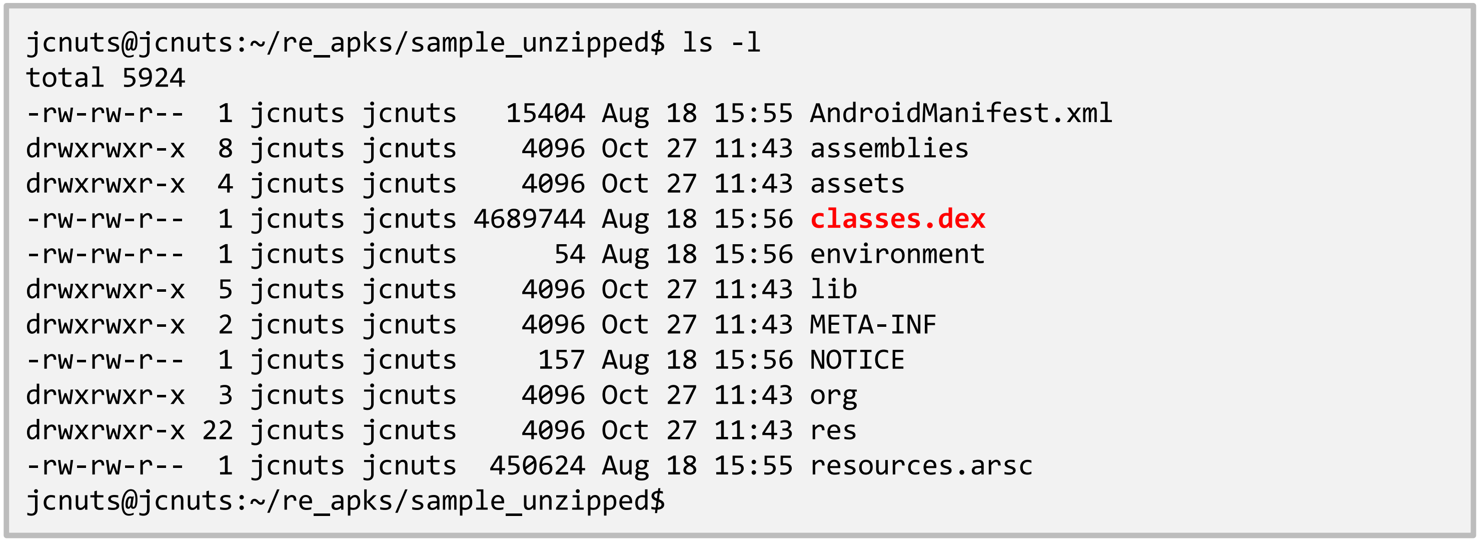
```
jcnuts@jcnuts:~/re_apks$ apktool d sample.apk
I: Using Apktool 2.0.0-RC2 on sample.apk
I: Loading resource table...
I: Loading resource table...
I: Decoding AndroidManifest.xml with resources...
I: Loading resource table from file: /home/jcnuts/apktool/framework/1.apk
I: Regular manifest package...
I: Decoding file-resources...
I: Decoding values */* XMLs...
I: Baksmaling classes.dex...
Cleaning up unclosed ZipFile for archive /home/jcnuts/apktool/framework/1.apk
I: Copying assets and libs...
I: Copying unknown files...
I: Copying original files...
jcnuts@jcnuts:~/re_apks$
```

- You can skip this process if you do not need resource and manifest files for reverse engineering.

#3. Decompile to java from DEX

- There are some steps to get to java source code.

- **Step1. Get a DEX from APK**
  - You can find a DEX file in the folder that has been created when unzipped an APK.



```
jcnuts@jcnuts:~/re_apks/sample_unzipped$ ls -l
total 5924
-rw-rw-r--  1 jcnuts jcnuts   15404 Aug 18 15:55 AndroidManifest.xml
drwxrwxr-x  8 jcnuts jcnuts    4096 Oct 27 11:43 assemblies
drwxrwxr-x  4 jcnuts jcnuts    4096 Oct 27 11:43 assets
-rw-rw-r--  1 jcnuts jcnuts 4689744 Aug 18 15:56 classes.dex
-rw-rw-r--  1 jcnuts jcnuts      54 Aug 18 15:56 environment
drwxrwxr-x  5 jcnuts jcnuts    4096 Oct 27 11:43 lib
drwxrwxr-x  2 jcnuts jcnuts    4096 Oct 27 11:43 META-INF
-rw-rw-r--  1 jcnuts jcnuts     157 Aug 18 15:56 NOTICE
drwxrwxr-x  3 jcnuts jcnuts    4096 Oct 27 11:43 org
drwxrwxr-x 22 jcnuts jcnuts    4096 Oct 27 11:43 res
-rw-rw-r--  1 jcnuts jcnuts  450624 Aug 18 15:55 resources.arsc
jcnuts@jcnuts:~/re_apks/sample_unzipped$
```

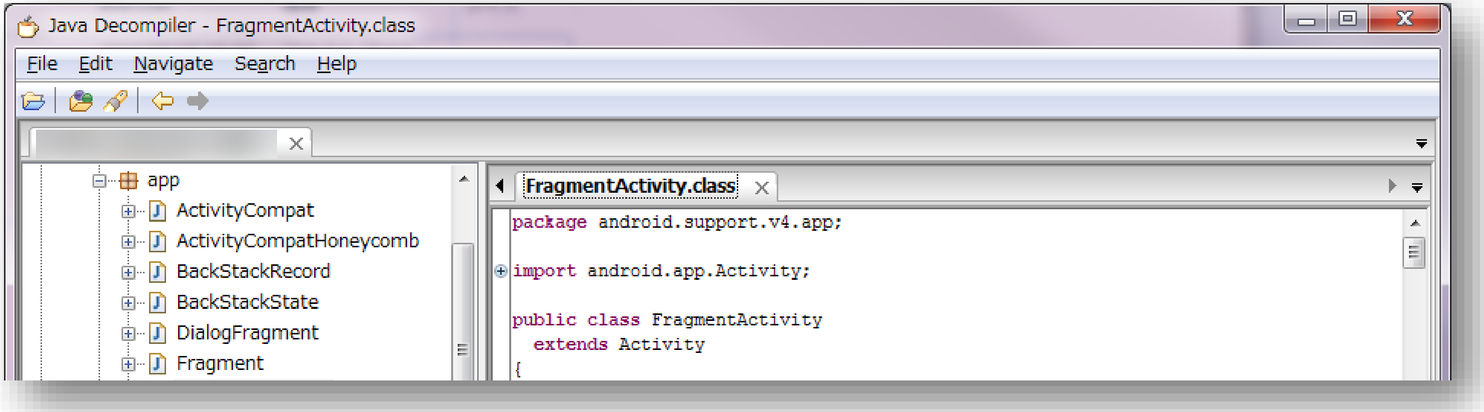
#3. Decompile to java from DEX (cont.)

- **Step2. Convert to JAR from DEX**
  - Use a dex2jar to convert to JAR from DEX.
  - dex2jar is available to download the following link: https://github.com/pxb1988/dex2jar

```
jcnuts@jcnuts:~/re_apks/sample_unzipped$ ls -l
total 10448
-rw-rw-r--  1 jcnuts jcnuts   15404 Aug 18 15:55 AndroidManifest.xml
drwxrwxr-x  8 jcnuts jcnuts    4096 Oct 27 11:43 assemblies
drwxrwxr-x  4 jcnuts jcnuts    4096 Oct 27 11:43 assets
-rw-rw-r--  1 jcnuts jcnuts 4689744 Aug 18 15:56 classes.dex
-rw-rw-r--  1 jcnuts jcnuts 4630701 Oct 27 11:49 classes-dex2jar.jar
-rw-rw-r--  1 jcnuts jcnuts      54 Aug 18 15:56 environment
drwxrwxr-x  5 jcnuts jcnuts    4096 Oct 27 11:43 lib
drwxrwxr-x  2 jcnuts jcnuts    4096 Oct 27 11:43 META-INF
-rw-rw-r--  1 jcnuts jcnuts     157 Aug 18 15:56 NOTICE
drwxrwxr-x  3 jcnuts jcnuts    4096 Oct 27 11:43 org
drwxrwxr-x 22 jcnuts jcnuts    4096 Oct 27 11:43 res
-rw-rw-r--  1 jcnuts jcnuts  450624 Aug 18 15:55 resources.arsc
jcnuts@jcnuts:~/re_apks/sample_unzipped$
```

#3. Decompile to java from DEX (cont.)

- **Step3. Get class files from JAR**
  - Unzip a JAR (JAR can unzip the same as ZIP) to get class files.
- **Step4. Decompile to java from class files.**
  - Use a Java Decompiler (JD-GUI) to decompile to java from class files.
  - Java Decompiler is available to download from the following link: http://jd.benow.ca/



```
package android.support.v4.app;

import android.app.Activity;

public class FragmentActivity
  extends Activity
{
```

#4. What to do next?

- In this step, you ought to have already got java, smali, decoded manifest file.
  - Therefore, the next step you should be finding analysis entry point.

- **How do I find an analysis entry point?**
  - There are various ways to find it.
  - Deeper analysis often may be dependent on the intuition and experience (more knowledges of vulnerability and how to exploit them).

- **The following examples do not depend on the intuition and experience so much☺**
  - Use vulnerability scanners like AndroBugs, they would help to find an entry point for analysis.
  - To understand common vulnerabilities, read “Android Application Secure Design/Secure Coding Guidebook”.

Introduction of other tools and distributions

- **Androguard (https://github.com/androguard/androguard)**
  - Androguard is analysis tool for Android apps that is written in full python.
  - AndroBugs that I introduced at CODE BLUE also uses Androguard.
  - Androguard might help to an automation of analysis to an Android app.

- **Santoku Linux (https://santoku-linux.com/)**
  - Santoku Linux is one of Linux distribution for mobile forensics, analysis and security testing.
  - It was presented at RSA Conference 2014
  - Most of the famous tools that help you to forensics, analysis and security testing to a mobile device and an app are pre-installed in Santoku Linux.

Conclusions

- **The risk score of vulnerabilities that I found was high.**
  - However, the results are only the base score.
  - In generally, risk score will shift to low score finally by consideration of the temporal score and the environmental score.
- **Reverse engineering of an Android app is not so hard.**
  - There is a lot of information on the Internet.
  - There is a lot of helpful tools for analysis.
  - But deeper analysis may need the intuition and experience.
- **The analysis automation also would be possible.**
  - Most of the tools provide command line execution.
  - For example, Androguard is utilized in various analysis tools. (e.g., Cuckoo, Viper, AndroBugs etc,…)

References

- 共通脆弱性評価システム CVSS v3概説
  - https://www.ipa.go.jp/security/vuln/CVSSv3.html
- Common Vulnerability Scoring System, V3 Development Update
  - https://www.first.org/cvss
- Dalvik bytecode
  - https://source.android.com/devices/tech/dalvik/dalvik-bytecode.html
- Cuckoo Sandbox
  - https://cuckoosandbox.org/
- Viper
  - http://www.viper.li/
- AndroBugs
  - https://github.com/AndroBugs/AndroBugs_Framework

- If you want to know how to use Androguard, try seeing the following link:
- Part 1 – Reverse engineering using Androguard
  - http://www.technotalkative.com/part-1-reverse-engineering-using-androguard/