Automatic Android Malware Analysis

Contents

1 Introduction

1.1 APK file

Android Application Package(APK) is the file format used for an android application. It contains all the resources required for an application to run on android operating system. Its basically a zip file or a jar file with extension of ".apk"[1].

1.1.1 APK file contents

Normally an apk file contains following files or folders:

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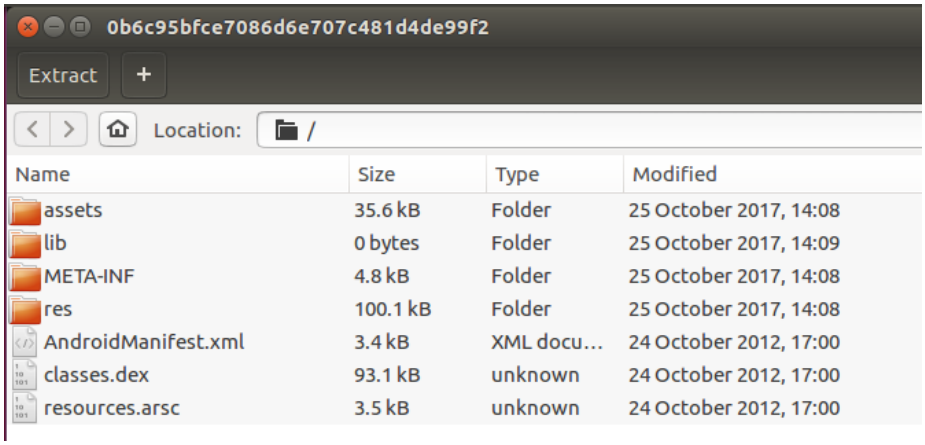

Figure 1: Files inside an APK

- **assets/:** It provides a way to include arbitrary files like text, xml, fonts, music and video in your application and allow you to access your data raw/untouched. AssetManager is used to read this data[2]. Due to raw access sometimes this directory contains executable payloads and dynamically loaded code. One interesting usage is storing Dex files in it to avoid its reverse engineering. [3]

- **lib/:** This directory is for natively compiled code. This directory contains a subdirectory for each platform type, like armeabi, armeabi-v7a, arm64-v8a, x86, x86_64, and mips [1]. This code is run directly on CPU and have access to android API using Java Native Interface(JNI). Natively compiled code is more suitable for CPU intensive jobs because of less overhead and good performance of programming language like c/c++. Most of the android static analysis tools work on Java level- that is, they process either the decompiled Java source code or Dalvik Byte Code[4].

This rises several interesting scenarios in which malware authors can avoid detection, can redistributing benign applications with malicious injections or completely modifying behavior of an application. Readers interested in this topic are encouraged to have a look at [4]. Android NDK can be used to compile native code for android.

compile hello world in c for android in apendix

- **META-INF/:** This directory contains the following three files:
  1. **MANIFEST.MF:** Its a text file and contains a list and base64 encoded SHA-1 hashes of all files included in the APK.
  2. **CERT.SF:** This file again contain a list of all files but this time with the base64 encoded SHA-1 hashes of the corresponding lines in the MANIFEST.MF file. It also contain based64 encoded SHA-1 hash of MANIFEST.MF file.
  3. **CERT.RSA:** It contains developers public signature, used for validation of upgrades. Its basically singed content of CERT.SF file along with public key to validate the contents.

- **res/:** This directory contain resource which are not compiled into "resources.arsc" (see below) [1]. These resources can be accessed from inside the application code using resource ID. All resource IDs are defined in "R" class of the project. Application developers can specify alternate resources to support specific device configurations e.g, alternative drawable resources for different screen sizes, alternative strings for different languages etc.

- **AndroidManifest.xml:** Every application must have an AndroidManifest.xml file. This file provide essential information about the application like entry points, package name, components, permissions, minimum level of Android API, libraries, intents etc. For static analysis purposes a lot of information can be extracted from this file.

- **classes.dex:** This is the most important file insude an apk. It contains classes compiled in the DEX file format which can be understood by the Dalvik/ART virtual machine [1]. In the next section we will describe this file in more details.

- **resources.arsc:** This file contain compiled resources. This file contains the XML content from all configurations of the res/values/ folder. The packaging tool extracts this XML content, compiles it to binary form, and archives the content. This content includes language strings and styles, as well as paths to content that is not included directly in the resources.arsc file, such as layout files and images [1]. These resources can also be accessed using the "R" class.

1.2 Dex file

Dex file is the heart of an android application. First Java source code of an application is compiled to Java byte code (".class" extension). Then this Java byte code is compiled to Dalvik Byte Code or Dalvik Executable(DEX) using Dex-compiler or dexer tool. This code is then executed on Dalvik Virtual Machine (deprecated) or in case of Android Runtime (ART), this code is compiled at install time to the native code.

1.2.1 Dex file format

In this section we will briefly discuss the file format for dex files. For more in depth and up to date specifications readers are encouraged to have a look at android official documentation on dex format [5]. A more graphical representation of dex file is shown in Figure 2.

structure of Dex file

1.2.2 Multiple Dex files in single APK

Android app (APK) files contain executable bytecode files in the form of Dalvik Executable (DEX) files, which contain the compiled code used to run your app. The Dalvik Executable specification limits the total number of methods that can be referenced within a single DEX file to 65,536including Android framework methods, library methods, and methods in your own code. This limit is referred to as the '64K reference limit'

Cite https://developer.android.com/studio/build/multidex.html

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Versions of the platform prior to Android 5.0 (API level 21) use the Dalvik runtime for executing app code. By default, Dalvik limits apps to a single classes.dex bytecode file per APK.Multidex support library can be used to workaround this limitation. Android 5.0 (API level 21) and higher uses a runtime called ART which natively supports loading multiple DEX files from APK files

Cite https://developer.android.com/studio/build/multidex.html

. Because of this support its not uncommon these days to come across APKs that contain multiple dex files e.g, Facebook, instagram etc.

TODO: Write introduction section after the significant part of report is done and the structure is more clear

Discuss static analysis and dynamic analysis

To be done later, In this chapter we include the problem statement, See fh kiel project report structure for missing parts.

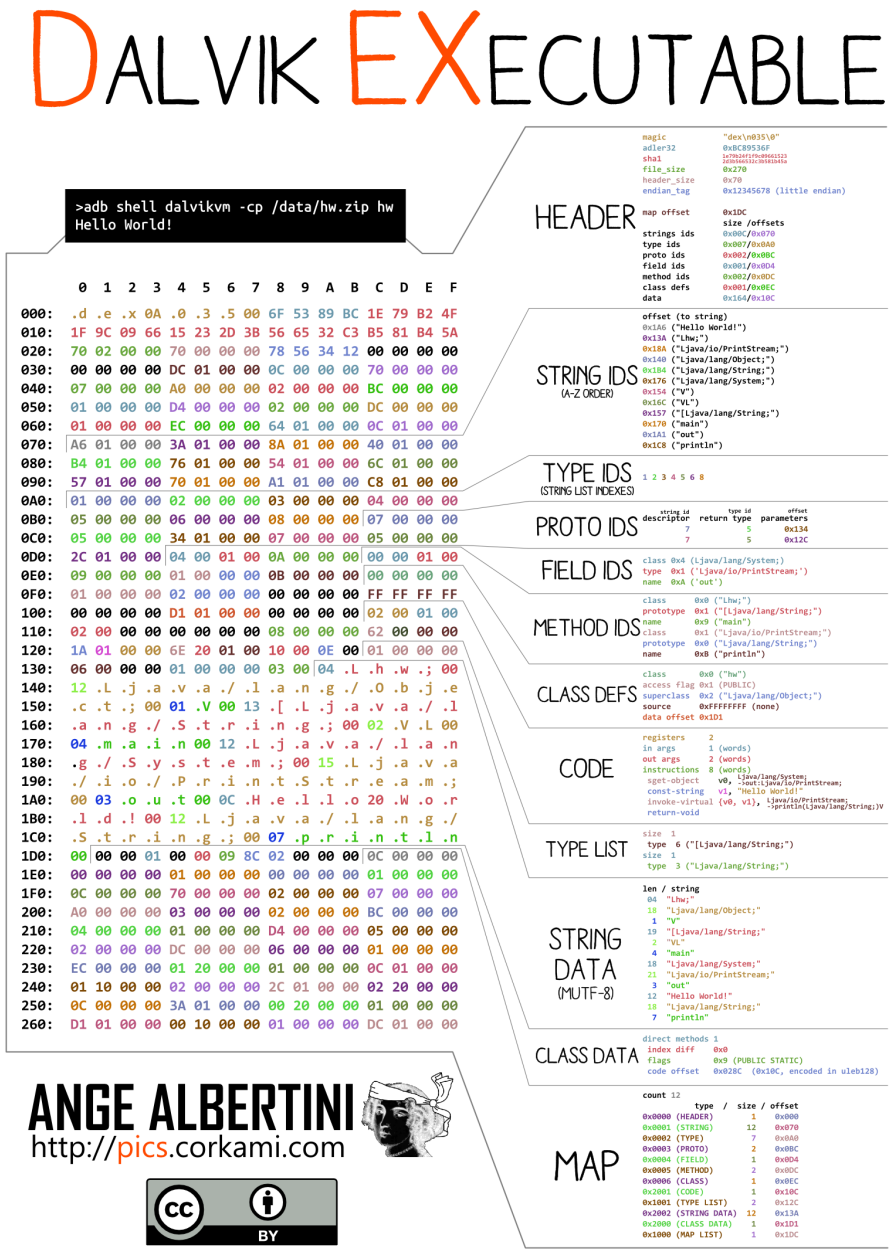

Figure 2: Dex file format [6]

change table to multipage table

Add information about Janus vulnerability to make the reading interesting

Name	Format	Description
header	header_item	The header contain information about how the dex file is organized, sizes of different sections inside the dex file, size of dex file, size of data section, version of dex format etc.
string_ids	list of string_id_items	Its a list of string identifiers. These are identifiers for all the strings used by this file e.g, class names, method names, constant objects. Each item points to a location in data section (see below) where the original string is stored.
type_ids	list of type_id_items	This list contain type identifiers for all types (classes, arrays or primitive types) referred to by this file, whether defined in the file or not. The actual identifier string is stored in data section. Items in this list points to items in string_ids list and which in turn points to type identifier string stored in data section.
proto_ids	list of proto_id_items	Its a method prototype identifier list. Each item of this list contain three elements: • **shorty_idx** Points to string_id_item of shorty descriptor for this prototype • **return_type_id** Specify return type by pointing to corresponding type_id _item • **parameter_off** Offset from start of file to the list of parameter types for this prototype. It must point to location in data section. The data there should be in "type_list" format. This value would be zero in case no parameters.
field_ids	list of field_id_items	These are identifiers for all fields referred to by this file, whether defined in the file or not.
method_ids	list of method_id_items	These are identifiers for all methods referred to by this file, whether defined in the file or not.
class_defs	list of class_def_items	The classes must be ordered such that a given class's superclass and implemented interfaces appear in the list earlier than the referring class. Furthermore, it is invalid for a definition for the same-named class to appear more than once in the list.
call_site_ids	list of call_site_id_items	These are identifiers for all call sites referred to by this file, whether defined in the file or not.
method_handles	list of method_handle_items	A list of all method handles referred to by this file, whether defined in the file or not. This list is not sorted and may contain duplicates which will logically correspond to different method handle instances.

2 Static Analysis

There are several static analysis tools available for APKs, each one having its own strengths and weaknesses.

Add some info about common tools

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2.1 Apktool

APKTool is one of the major reverse engineering tool for android applications.

Add more info

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2.2 Androguard

Introduce androguard

Androguard is an open source tool written in python for analyzing android applications. Its been in a several of tools including Virustotal and Cuckoodroid among others. It can process APK files, dex files or odex files. It can disassemble Dex/Odex files to smali code and can decompile Dex/Odex to Java code. The classes in androguard can be generally divided into two categories: Classes used for parsing and the analysis classes. We will go into more details about these classes but first we will show some basic usage of androguard.

TODO: Do androguard basic usage examples

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Discuss the changes we made including normalization, canonical hasing for similarity search

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Discuss the info we are extracting from apks for platform

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TODO: Do androguard comparison apks to see how many functions has added and how many removed, make a table out of it

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Usage of androguard for extracting features for AI/ML, prepare for talk in AIOLI-FFM group

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Ask lukas for some results from platform

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Improvements in androguard

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3 Dynamic Analysis: Cuckoo-droid based on Cuckoo sandbox

Introduction to cuckoodroid

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Fixing cuckoodroid

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Persistent root problem

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4 Dynamic Analysis: Anti-Emulator Detection

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Common methods employed for emulator detection, some literature

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Good and bad uses of anti-emulator detection

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Testing results of cuckoodroid against common emulator detection methods

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Adding some new anti-emulator detection features to cuckoodroid

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result of analysis before and after

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