



DEPARTMENT OF INFORMATICS

TECHNISCHE UNIVERSITÄT MÜNCHEN

Master's Thesis in Informatics

**Analysis of Android Cracking Tools and
Investigations in Counter Measurements
for Developers**

Johannes Neutze, B. Sc.





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**Analyse von Android Crackingtools und Untersuchung
geeigneter Gegenmaßnahmen für Entwickler**

Author:	Johannes Neutze, B. Sc.
Supervisor:	Prof. Dr. Uwe Baumgarten
Advisor:	Nils Kannengießer, M. Sc.
Submission Date:	March 15, 2015



I confirm that this master's thesis in informatics is my own work and I have documented all sources and material used.

Munich, March 15, 2015

Johannes Neutze, B. Sc.

Acknowledgments

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Assumptions

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Abstract

<http://users.ece.cmu.edu/~koopman/essays/abstract.html> Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

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Glossary

.class Java Byte Code produced by the Java compiler from a .java file.

.dex Dalvik Byte Code file, translated from the Java bytecode. Dalvik Executables are designed to run on system with memory or processor constraints. For example, the .dex file of the Phone application is inside the system/app/Phone.apk.

.odex Optimized Dalvik Byte Code file are Dalvik Executables optimized for the current device the application is running on. For example, the .odex file of the Phone application is system/app/Phone.odex.

ADB The Android Debug Bridge is a command-line application providing different debugging tools.

APK An Android Application Package is the file format used for distributing and installing applications on the Android operating system. It contains the applications assets, code (.dex file), manifest and resources.

assembler .

disassembler .

Acronyms

.dex Dalvik EXecutable file.

.odex Optimized Dalvik EXecutable file.

ADB Android Debug Bridge.

APK Android Application Package.

SDK Software Development Kit.

TUM Technische Universität München.

1 Introduction

This is my real text! Rest might be copied or not be checked!

1.1 Licensing

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Was ist licensing?

Ziele von Licensing

was für möglichkeiten gibt es (lvl, amazon, samsung)

1.2 Motivation

This is my real text! Rest might be copied or not be checked!

Piracy

lose money from sale/IAP

lose ad revenues

others earn the money - ad ID replacement

no control at all when cracked and in other markets -> no fixes/updates (<https://youtu.be/TNnccRimhsI?t=>

for user: when downloading pirated apk, no idea what they changed (malware, stealing data, privacy, permissions)

wont notice any difference since in background

unpredicted traffic for your server, be prepared to block pirated traffic

cracking can lead to bad user experience, e.g. copied apps, mostly for paid apps

awesome algorithms can be stolen

similar problems with inapp billing

best way to counter: license verification libraries

encryption can be dumped from memory

generell piracy!!!

enthält als Abschluss SCOPE

1.3 Related Work

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related work

2 Foundation

Before discussing the counter measurements, necessary basics have to be explained. This includes piracy in general as well as its relationship with Android.

2.1 Software Piracy

This is my real text! Rest might be copied or not be checked!

<http://www.xda-developers.com/piracy-testimonies-causes-and-prevention/>

2.1.1 Overview

This is my real text! Rest might be copied or not be checked!

Definition of Software Piracy?

This is my real text! Rest might be copied or not be checked!

History of Software Piracy

This is my real text! Rest might be copied or not be checked!

Forms of Software Piracy

This is my real text! Rest might be copied or not be checked!

Release Groups, blackmarket, app beispiele, foren etc

2.1.2 Threat to Developers

This is my real text! Rest might be copied or not be checked!

schaeden für entwickler (ad id klau,)

2.1.3 Risks to Users

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malware, bad user experience

It is not unlikely for a malware developer to abuse existing applications by injection of malicious functionalities and consequent redistribution of the trojanized versions C.A.

CastilloandMobileSecurityWorkingGroupMcAfee,\T1\textquotedblleftAndroidmalwarepast, present,andfuture,\T1\textquotedblright2011.

2.1.4 Piracy on Android

This is my real text! Rest might be copied or not be checked!

Poor model, since self-signed certificates are allowed, 27 <http://newandroidbook.com/files/Andevcon-Sec.pdf>

<http://www.fiercedevolver.com/story/preventing-android-applications-piracy-possible-requirements>

2012-08-14 piracy umfrage on android

übergehen zu wie android funktioniert und warum es dort piracy gibt

2.2 Android

flow wie funktioniert android und warum ist es so einfach zu piraten

This is my real text! Rest might be copied or not be checked!

https://net.cs.uni-bonn.de/fileadmin/user_upload/plohmann/2012-Schulz-Code_Protection_in_Android.pdf

2.2.1 Introduction

This is my real text! Rest might be copied or not be checked!

What is Android? Where is it used? When was it founded? Who does it belong to?

platform developed by the "Android Open Source Project" -> official website?
currently one of the main operating systems for mobile devices -> quelle
focussed on simplicity for users, install of apps etc -> quelle
riesiger markt

2.2.2 Evolution of the Android Compiler

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2.2.3 Build Process of Android Applications

This is my real text! Rest might be copied or not be checked!

für 4.1 erklären, bild <http://developer.android.com/tools/building/index.html>

Aufbau APK erklären

many steps and tools until the APK is build and ready to be deployed
applications are written in the Java programming language by the developer, code is available in .class files

step 1: Java files which will be compiled into .class files by a Java Compiler, similar to a Java program build process, class files contain Java bytecode representing the compiled application, optional step apply a Java Obfuscator

step 2: transformation from Java bytecode into Dalvik bytecode, see oben, dx programm from android sdk (due to it is necessity for building an application for the Android platform), output saved in singel .dex file

Android applications are written in the Java [11] programming language and deployed as files with an ".apk" suffix, later called APK. It is basically a ZIP-compressed file and contains resources of the application like pictures and layouts as well as a dex file

This dex file, saved as "classes.dex", contains the program code in form of Dalvik bytecode. Further explanations on this bytecode format are given in section 3.2. The content of the APK is also cryptographically signed, which yields no security improvement but helps to distinguish and confirm authenticity of different developers of Android applications.

Die apk kann dann per adb, market oder direkt installiert werden

Within the installation process, every installed application gets its own unique user ID (UID) by default. This means that every application will be executed as a separate system user. -> QUELLE/SINN?

2.2.4 Original Copy Protection

This is my real text! Rest might be copied or not be checked!

It replaces the old system copy protection system, wherein your APKs would be put in a folder that you can't access. Unless you root. Oh, and anyone who can copy that

APK off can then give it to someone else to put on their device, too. It was so weak, it was almost non-existent.

kann mit root umgangen werden

Im original vom Markt direkt heruntergeladen und dann wird sie an den ort geschoben und kann nicht mehr zugegriffen werden -> rechte etc, QUELLE

2.2.5 Root on Android

This is my real text! Rest might be copied or not be checked!

what is it? how is it achieved? what can i do with it? (good/bad sides)

Android insecure, can be rooted and get apk file <http://androidvulnerabilities.org/all> search for root

2.3 License Verification Libraries

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spreading causes giant market (zahlen) -> google play with big financial value (zahlen)

je größer der markt desto attraktiver für cracker da auch mehr leute die app ggfs gecracked runterladen würden (genauere argumente)

deswegen auch gesteigertes interesse bei developern ihre app und IP zu schützen da wie oben gesehen die original copyprotection ausgehebelt ist, muss etwas neues her auch für den markt leiter sit es interessant

This chapter contains the LVL which will be looked at

What is a lvl? why are they used? connection to store

<http://www.digipom.com/how-the-android-license-verification-library-is-lulling-you-into-a> dependent on store

major players have own stores and thus own lvl

Since the original approach of subsection 2.2.4 was voided, another method had to be introduced. First looks great, puts the copy protection inside the app, a form of DRM communicate with server, authorize use of application

does not prevent user from copying/transferring app, but copy useless since the app does run without the correct account

google die ersten, andere folgen, anfangs problem, dass dadurch nur durch google store geschützt war, grund dafür dass evtl ein programmierer in meinen store kommt

2.3.1 Amazon

This is my real text! Rest might be copied or not be checked!

amazon drm kiwi

Implementation

This is my real text! Rest might be copied or not be checked!

done by amazon packaging tool

release <http://www.androidheadlines.com/2010/10/amazon-send-developers-a-welcome-package.html>

<https://developer.amazon.com/public/support/submitting-your-app/tech-docs/submitting-your-app>

Functional Principle

This is my real text! Rest might be copied or not be checked!

sis is text was sind voraussetzungen? amazon app, account active der die app hat

Example

This is my real text! Rest might be copied or not be checked!

anhand eigener app

2.3.2 Google

This is my real text! Rest might be copied or not be checked!

License Verification Library

<http://www.digipom.com/how-the-android-license-verification-library-is-lulling-you-into-a-related> <https://developers.google.com/games/services/android/antipiracy>

<http://android-developers.blogspot.de/2010/09/securing-android-lvl-applications.html>

<http://developer.android.com/google/play/licensing/overview.html>

problem <http://daniel-codes.blogspot.de/2010/10/true-problem-with-googles-license.html>

The LVL library only works on apps sold through Google's Android Market Release

<http://android-developers.blogspot.de/2010/07/licensing-service-for-android.html>

Implementation

This is my real text! Rest might be copied or not be checked!
sis is text

Functional Principle

This is my real text! Rest might be copied or not be checked!
how does google license check work <http://android.stackexchange.com/questions/22545/how-does-google-plays-market-license-check-work>
sis is text
was sind voraussetzungen? googel acc auf dem smartphone welcher die app gekauft hat

bild <http://android-developers.blogspot.de/2010/07/licensing-service-for-android.html>

Example

This is my real text! Rest might be copied or not be checked!
anhand eigener app

2.3.3 Samsung

This is my real text! Rest might be copied or not be checked!
Zirconia <http://developer.samsung.com/technical-doc/view.do?v=T000000062L>

Implementation

This is my real text! Rest might be copied or not be checked!
sis is text <http://developer.samsung.com/technical-doc/view.do?v=T000000062L>

Functional Principle

This is my real text! Rest might be copied or not be checked!
sis is text
was sind voraussetzungen?

Example

This is my real text! Rest might be copied or not be checked!

anhand eigener app

<http://developer.samsung.com/technical-doc/view.do?v=T0000000062L>

2.4 Analysis

The Cracking Tool has to alter an application's behaviour by applying patches only to the Android Application Package (APK) file, since it is the only source of code on the phone. This is the reason for the investigations to start with analysing the APK. This is done using static analysis tools. The aim is to get an accurate overview of how the circumventing of the license verification mechanism is achieved. This knowledge is later used to find counter measurements to prevent the specific Cracking Tool from succeeding.

The reengineering has to be done by using different layers of abstraction. The first reason is because it is very difficult to conclude from the altered bytecode, which is not human-readable, to the new behaviour of the application. The second reason is because the changes in the Java code are interpreted by the decompiler, which might not reflect the exact behaviour of the code or even worse, cannot be translated at all.

These problems are encountered by analysing the different abstraction levels of code as well as different decompilers.

was ist reengineering? wie funktioniert es? was ist das ziel?

reverse engineering process makes use of a whole range of different analysis methodologies and tools.

only consider static analysis tools

IN ORDER TO GET FULL OVERVIEW DEX/SMALI/JAVA -> WARUM?

WAS MACHEN DIE TOOLS IM ALLGEMEINEN? WOZU BENUTZEN WIR SIE?

<https://mobilesecuritywiki.com/>

https://net.cs.uni-bonn.de/fileadmin/user_upload/plohmann/2012-Schulz-Code_Protection_in_Android.pdf

main tools

Getting an APK

In the following there will be an example application to generalise the procedure. The application is called `LicenseTest` and has for our purpose a license verification library included (Amazon, Google or Samsung).

In order to analyse an APK, it has to be pulled from the Android device onto the computer. First the package name of the app has to be found out. This can be done by using the Android Debug Bridge (ADB). Entering example 1 returned example 2

```
adb shell pm list packages -f | example 2 enthält return von 1
adb pull /data/app/me.neutze.licensetest-1/ /Downloads
```

Dex

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mein custom script erklären

jedes tool:

woher kommt es?

wozu wurde es erfunden?

wer hat es erfunden? quelle

blabla von der seite

wozu benutze ich es?

welches abstrahierungslevel

beispiel

additional features?

WARUM SCHAUEN WIR ES UNS AN?

wo findet man es?

welches level?

vorteil

blabla aus dem internet

ggf bezug zu DALVIK/buildprocess The Dalvik Virtual Machine (DVM) provides also the ability to call native functions within shared objects out of the Dalvik bytecode. When speaking of reverse engineering an Android application we mostly mean to reverse engineer the bytecode located in the dex file of this application.

```
a6 8e 15 00 bd 8e 15 00 d5 8e 15 00 f0 8e 15 00 | ..... |
```

Code Snippet 2.1: Quelle

Smali Code

This is my real text! Rest might be copied or not be checked!

<https://github.com/JesusFreke/smali>

Smali code is the generated by disassembling Dalvik bytecode using baksmali. The result is a human-readable, assembler-like code

The smali [7] program is an assemblerhas own disassembler called "baksmali" can be used to unpack, modify, and repack Android applications interesting part for obfuscation and reverse engineering is baksmali. baksmali is similar to dexdump but uses a recursive traversal approach to find instructions vorteil? -> So in this approach the next instruction will be expected at the address where the current instruction can jump to, e.g. for the "goto" instruction. This minimizes some problems connected to the linear sweep approach. baksmali is also used by other reverse engineering tools as a basic disassembler

selbe wie dex, jedoch human readable, no big difference

wo findet man es?

wie ist es erstellt?

informationsverlust?

vorteil

blabla aus dem internet

jedes tool:

woher kommt es?

wozu wurde es erfunden?

wer hat es erfunden? quelle

blabla von der seite

wozu benutze ich es?

welches abstrahierungslevel

beispiel

additional features?

ggf bezug zu DALVIK/buildprocess

wo findet man es?

welches level?

vorteil

blabla aus dem internet

Java

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probleme des disassemblers erklären
interpretations sache
deswegen zwei compiler
unterschiedliche interpretation resultiert in flow und auch ob sies können ist unterschiedlich

ectl unterschiede/vor-nachteile
ggf bezug zu DALVIK/buildprocess (Java wird disassembled und dann assembler)

Androguard

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<https://github.com/androguard/androguard>
powerful analysis tool is Androguard
includes a disassembler and other analysis methods to gather information about a program
Androguard helps an analyst to get a good overview by providing call graphs and an interactive interface -> habe nur CLI benutzt
The integrated disassembler also uses the recursive traversal approach for finding instructions like baksmali, see section 2.2
one most popular analysis toolkits for Android applications due to its big code base and offered analysis methods -> quelle, warum

jedes tool:
woher kommt es?
wozu wurde es erfunden?
wer hat es erfunden? quelle
blabla von der seite
wozu benutze ich es?
welches abstrahierungslevel
beispiel
additional features?

jadx

This is my real text! Rest might be copied or not be checked!

<https://github.com/skylot/jadx>
jedes tool:
woher kommt es?
wozu wurde es erfunden?
wer hat es erfunden? quelle
blabla von der seite
wozu benutze ich es?
welches abstrahierungslevel
beispiel
additional features?

Comparison of Code

This is my real text! Rest might be copied or not be checked!
needed to see differences before and after cracking tool

diff is used

<https://wiki.ubuntuusers.de/diff>
-N: Treat absent files as empty; Allows the patch create and remove files.
-a: Treat all files as text; Allows the patch update non-text (aka: binary) files.
-u: Set the default 3 lines of unified context; This generates useful time stamps and context.
-r: Recursively compare any subdirectories found; Allows the patch to update subdirectories.
script erklären

wo findet man es?
welches level?
vorteil
blabla aus dem internet

3 Cracking Android Applications with LuckyPatcher

This is my real text! Rest might be copied or not be checked!

There are plenty of applications which can be used to modify Android apps. This thesis focuses on the on on device cracking application LuckyPatcher, especially on its license verification bypassing mechanism.

3.1 What is LuckyPatcher and what is it used for?

This is my real text! Rest might be copied or not be checked!

wer hat ihn geschrieben?
auf welcher version basiere ich
su nicht vergessen
was kann er alles
was schauen wir uns an?

LuckyPatcher is described as following on the official webpage: "Lucky Patcher is a great Android tool to remove ads, modify apps permissions, backup and restore apps, bypass premium applications license verification, and more. To use all features, you need a rooted device." [1]

install apk from palystore -> have root -> open lucky -> chose mode

LuckyPatcher is an Android Cracking Tool which can be downloaded at <http://lucky-patcher.netbew.com/>.

similar cracking tools:
or manual: decompile and edit what ever you want

3.2 Modus Operandi

This is my real text! Rest might be copied or not be checked!

wo arbeitet er?
warum dex und nicht odex anschauen?
patterns und patching modes grob erklären (modi von luckypatcher die verschiedene operationen (pattern) auf app anwenden) => vorgehensweise zur

Since the code is modified directly a static analysis is sufficient.

UM ES EINFACHER ZU MACHEN, KEINE ODEX (WARUM), APK CREATEN UND AUF EINEM NORMALEN HANDY INSTALLIEREN(dann sieht man dass man die app wem anders gecracked geben kann - ringschluss blackmarket)

3.3 What are Patching Modi are there and what do they do?

This is my real text! Rest might be copied or not be checked!

kombination von patterns.

welche modes gibt es? welche patterns benutzen sie?

welche apps getestet und welche results?

3.4 What patterns are there and what do they do?

This is my real text! Rest might be copied or not be checked!

was greift jedes pattern an? wie wird der mechanismus ausgeklingt? was ist das result?

3.5 Learnings from LuckyPatcher

This is my real text! Rest might be copied or not be checked!

was fällt damit weg?

erklären warum (2) 5.1.2 Opaque predicates zb nicht geht, da auf dex ebene einfach austauschbar

simple obfuscation for strings? x -> string (damit name egal)

4 Counter Measurements for Developers

Now that the functionality of LuckyPatcher is analyzed, it is time to investigate in possible solutions for developers. Counter measurements preventing the cracking app from circumventing the license check mechanism are addressed in four different ways. The first chapter covers functions to discover preconditions in the environment cracking apps use to discover weaknesses or need to be functional. The second chapter uses the acquired knowledge about LuckyPatcher to modify the code resulting in the patching being unsuccessful. In the third chapter presents methods to prevent the reengineering of the developer's application and thus the creation of custom cracks. Further hardware and external measurements are explained in the fourth chapter.

general suggestions by google <http://android-developers.blogspot.de/2010/09/securing-android-lvl-applications.html>

4.1 Tampering Protection

This is my real text! Rest might be copied or not be checked!

Environment and Integrity Checks, wenn die umgebung falsch ist, kann die app verändert werden. deswegen von vornherein ausschließen, dass die bedingungen dafür gegeben sind.

siehe masterarbeit 2

mechanisms should work for amazon/lvl/samsung -> beweis! (amazon die signature den die seite vorgibt?)

force close im falle von falschem outcome, entspricht nicht android qualität <http://developer.android.com/distribute/essentials/quality/core.html> aber so wird es dem user klarer dass seine application gecracked ist. harmlosere variante dialog anzeigen oder element nicht laden.

es gibt verschieden punkte um die integrity der application sicherzustellen. dies beinhaltet die umgebung debugg oder rootzugriff, die suche nach feindliche installierte applicationen oder checks nach der rechtmäßigen installation und rechtmäßigen code.

4.1.1 Prevent Debuggability

This is my real text! Rest might be copied or not be checked!

WAS IST DIE IDEE DAHINTER? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

der debug modus kann dem angreifer informationen/logs über die application geben während diese läuft, aus diesen informationen können erkenntnisse über die funktionweise geben die für einen angriff/modifikation gewonnen werden können. aus diesen informationen können dann patches für software wie lucky patcher entwickelt werden, da man die anzugreifenden stellen bereits kennt. kann erzwungen werden indem man das debug flag setzt (wo ist es, wie kann es gesetzt werden) um dies zu verhindern kann gecheckt werden ob dieses flag forciert wird und gegebenenfalls das laufen der application unterbinden

```
14 public static boolean isDebuggable(Context context) {  
15     boolean debuggable = (0 != (context.getApplicationInfo().flags & ApplicationInfo.  
16         FLAG_DEBUGGABLE));  
17  
18     if (debuggable) {  
19         android.os.Process.killProcess(android.os.Process.myPid());  
20     }  
21     return debuggable;  
22 }
```

Code Snippet 4.1: asd[1]

Code Snippet /refCode Snippet: luckycode zeigt eine funktion die auf den debug modus prüft. Dazu werden zuerst in zeile 15 die appinfo auf das debug flag überprüft. ist dieses vorhanden, ist die variable debuggable true. in diesem fall wird dann die geschlossen

4.1.2 Root Detection

This is my real text! Rest might be copied or not be checked!

WAS IST DIE IDEE DAHINTER? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

<http://stackoverflow.com/questions/10585961/way-to-protect-from-lucky-patcher-play-licen>

```
16 public static boolean findBinary(Context context, final String binaryName) {  
17     boolean result = false;  
18     String[] places = {  
19         "/sbin/",  
20         "/system/bin/",  
21         "/system/sbin/",  
22         "/data/local/sbin/",  
23         "/data/local/bin/",  
24         "/system/sd/sbin/",  
25         "/system/bin/failsafe/",  
26         "/data/local/"  
27     };  
28  
29     for (final String where : places) {  
30         if (new File(where + binaryName).exists()) {  
31             result = true;  
32             android.os.Process.killProcess(android.os.Process.myPid());  
33         }  
34     }  
35  
36     return result;  
37 }
```

Code Snippet 4.2: Partial Listing

SafetyNet provides services for analyzing the configuration of a particular device, to make sure that apps function properly on a particular device and that users have a great experience. <https://developer.android.com/training/safetynet/index.html>

Checking device compatibility with safetynet

Unlocked bootloader doesn't matter. Can't have root installed initially. Has to be a stock / signed ROM. https://www.reddit.com/r/Android/comments/3kly2z/checking_device_compatibility_with_safetynet/

4.1.3 LuckyPatcher Detection

This is my real text! Rest might be copied or not be checked!

WAS IST DIE IDEE DAHINTER? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

As the example shows, this check is not only a solution to prevent the application from running when LuckyPatcher is present on the device. The screening can be expanded to check for the installation of any other application, like black market apps or other cracking tools as the code example Code Example 4.5 shows.

<http://stackoverflow.com/questions/13445598/lucky-patcher-how-can-i-protect-from-it>
<http://android-onex.blogspot.de/2015/07/anti-piracy-software-activated-solved.html>

```
9  public static boolean checkInstall(final Context context) {
10      boolean result = false;
11      String[] luckypatcher = new String[]{
12          // Lucky patcher
13          "com.dimonvideo.luckypatcher",
14          // Another lucky patcher
15          "com.chelpus.luckypatch",
16          // Black Mart alpha
17          "com.blackmartalpha",
18          // Black Mart
19          "org.blackmart.market",
20          // Lucky patcher 5.6.8
21          "com.android.vending.billing.InAppBillingService.LUCK",
22          // Freedom
23          "cc.madkite.freedom",
24          // All-in-one Downloader
25          "com.allinone.free",
26          // Get Apk Market
27          "com.repodroid.app",
28          // CreeHack
29          "org.creeplays.hack",
30          // Game Hacker
31          "com.baseappfull.fwd"
32      };
33
34      for (String string : luckypatcher) {
35          if(checkInstallerName(context, string)){
36              result = true;
37          }
38
39          if (result) {
40              android.os.Process.killProcess(android.os.Process.myPid());
41          }
42      }
43
44      return result;
45  }
46
47  private static boolean checkInstallerName(Context context, String string) {
48      PackageInfo info;
49      boolean result = false;
50  }
```

```
51     try {
52         info = context.getPackageManager().getPackageInfo(string, 0);
53
54         if (info != null) {
55             android.os.Process.killProcess(android.os.Process.myPid());
56             result = true;
57         }
58
59     } catch (final PackageManager.NameNotFoundException ignored) {
60     }
61
62     if (result) {
63         android.os.Process.killProcess(android.os.Process.myPid());
64     }
65     return result;
66 }
67 }
```

Code Snippet 4.3: Partial Listing

4.1.4 Sideload Detection

This is my real text! Rest might be copied or not be checked!

WAS IST DIE IDEE DAHINTER? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

<http://stackoverflow.com/questions/10809438/how-to-know-an-application-is-installed-from>

```
15 public class Sideload {
16     private static final String PLAYSTORE_ID = "com.android.vending";
17     private static final String AMAZON_ID = "com.amazon.venezia";
18     private static final String SAMSUNG_ID = "com.sec.android.app.samsungapps";
19
20     public static boolean verifyInstaller(final Context context) {
21         boolean result = false;
22         final String installer = context.getPackageManager().getInstallerPackageName(context.
23             getPackageName());
24
25         if (installer != null) {
26             if (installer.startsWith(PLAYSTORE_ID)) {
27                 result = true;
28             }
29             if (installer.startsWith(AMAZON_ID)) {
30                 result = true;
31             }
32             if (installer.startsWith(SAMSUNG_ID)) {
```

```
32         result = true;
33     }
34 }
35 if(!result){
36     android.os.Process.killProcess(android.os.Process.myPid());
37 }
38
39 return result;
40 }
```

Code Snippet 4.4: Partial Listing

4.1.5 Signature

This is my real text! Rest might be copied or not be checked!

<http://developer.android.com/tools/publishing/app-signing.html>

<http://forum.xda-developers.com/showthread.php?t=2279813&page=5>

CONTRA

Local Signature Check

This is my real text! Rest might be copied or not be checked!

WAS IST DIE IDEE DAHINTER? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

local check whether signature is allowed

once in code

save to use signature in code?

```
51 public static boolean checkAppSignature(final Context context) {
52     //Signature used to sign the application
53     static final String mySignature = "...";
54     boolean result = false;
55
56     try {
57         final PackageInfo packageInfo = context.getPackageManager().getPackageInfo(context.
58             getPackageName(), PackageManager.GET_SIGNATURES);
59
60         for (final Signature signature : packageInfo.signatures) {
61             final String currentSignature = signature.toCharsString();
62             if (mySignature.equals(currentSignature)) {
```



```
62         result = true;
63     }
64 }
65 } catch (final Exception e) {
66     android.os.Process.killProcess(android.os.Process.myPid());
67 }
68
69 if (!result) {
70     android.os.Process.killProcess(android.os.Process.myPid());
71 }
72
73 return result;
74 }
```

Code Snippet 4.5: Partial Listing

Remote Signature Verification and Remote Code Loading

This is my real text! Rest might be copied or not be checked!

WAS IST DIE IDEE DAHINTER? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

certificate an server, get signature and send to server
content direkt von server laden (e.g. all descriptions, not sure if dex possible)
maps checks for signature?
e.g. account auf seite erstellen, encrypted dex ziehen der von loader stub geladen wird
(like packer) kann wiederum dann gezogen werden und dann als custom patch verteilt werden

4.2 LVL Modifications

This is my real text! Rest might be copied or not be checked!

siehe masterarbeit 2 <http://www.digipom.com/how-the-android-license-verification-library-is>
What can I do?

Google's License Verification Library is modified in a way

4.2.1 Modify the Library

This is my real text! Rest might be copied or not be checked!

google

WAS IST DIE IDEE DAHINTER? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

4.2.2 Checken ob ganzer code abläuft und dann nacheinander elemente aktivieren

This is my real text! Rest might be copied or not be checked!

WAS IST DIE IDEE DAHINTER? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

master1 - testen

damit die ganzen blöcke durchlaufen werden müssen

4.2.3 dynamische Codegeneration

This is my real text! Rest might be copied or not be checked!

WAS IST DIE IDEE DAHINTER? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

4.3 Preventing Reengineering

This is my real text! Rest might be copied or not be checked!

Application developers are interested in protecting their applications. Protection in this case means that it should be hard to understand what an application is doing and how its functionalities are implemented.

Reverse engineering of Android applications is much easier than on other architectures -> high level but simple bytecode language

Obfuscation techniques protect intellectual property of software/license verification

possible code obfuscation methods on the Android platform focus on obfuscating Dalvik bytecode -> limitations of current reverse engineering tools

<https://blog.fortinet.com/post/how-android-malware-hides>

<http://www.hotforsecurity.com/blog/mobile-app-development-company-fights-off-android-malware>

html

4.3.1 Basic Breaks for Common Tools

This is my real text! Rest might be copied or not be checked!

pros and cons sagen?

<https://github.com/strazzere/APKfuscator>

<http://www.strazzere.com/papers/DexEducation-PracticingSafeDex.pdf>

<https://youtu.be/Rv8DfXNYnOI?t=811>

Filesystem

This is my real text! Rest might be copied or not be checked!

make classname to long

<https://youtu.be/Rv8DfXNYnOI?t=985> works except for the class
breaks only baksmali

Inject bad OPcode or Junkbytes

This is my real text! Rest might be copied or not be checked!

JUNKBYTES

use bad opcode in deadcode

code runs but breaks tools

put it into a class you do not use -> care proguard, it will not use it since it is not
included

-> fixed...

<https://youtu.be/Rv8DfXNYnOI?t=1163>

reference not inited strings

<https://youtu.be/Rv8DfXNYnOI?t=1459>

Throw exceptions which are different in dalvik than in java

This is my real text! Rest might be copied or not be checked!

recursive try/catch? -> valid dalvik code

<https://youtu.be/Rv8DfXNYnOI?t=1650>

Increase headersize

This is my real text! Rest might be copied or not be checked!

you have to edit every other offset as well
<https://youtu.be/Rv8DfXNYnOI?t=1890>
dexception, dex within a dex by shifting
this is a packer/encrypter
slowdown automatic tools
<https://youtu.be/Rv8DfXNYnOI?t=1950>

Endian Tag

This is my real text! Rest might be copied or not be checked!
reverse endian
breaks tools works on device (odex)
lot work for little gain
<https://youtu.be/Rv8DfXNYnOI?t=2149>

4.3.2 Optimizers and Obfuscators

This is my real text! Rest might be copied or not be checked!
Obfuscators/Optimizers definition
remove dead/debug code
potentially encrypt/obfuscate/hide via reflection
<https://youtu.be/6vFcEJ2jg0w?t=243>

definition obfuscation, was macht es, wie funktioniert es, wer hat es erfunden, wie wendet man es an

"hard to reverse engineer" but without changing the behavior of this application, was heißt hard to reverse

Obfuscation cannot prevent reverse engineering but can make it harder and more time consuming. We will discuss which obfuscation and code protection methods are applicable under Android and show limitations of current reverse engineering tools

The following optimizers/obfuscators are common tools. (dadrin dann verbreitung preis etc erklären)

Proguard

This is my real text! Rest might be copied or not be checked!

<https://youtu.be/6vFcEJ2jg0w?t=419>

WER HAT ES HERGESTELLT? WAS IST ES? WAS SIND DIE FEATURES? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

ProGuard is an open source tool which is also integrated in the Android SDK <http://proguard.sourceforge.net/> <http://developer.android.com/sdk/index.html>
was ist proguard? was macht er? -> ProGuard is basically a Java obfuscator but can also be used for Android applications because they are usually written in Java // feature set includes identifier obfuscation for packages, classes, methods, and fields
was kann er noch? -> Besides these protection mechanisms it can also identify and highlight dead code so it can be removed in a second, manual step. Unused classes can be removed automatically by ProGuard.
easy integration -> how

<http://developer.android.com/tools/help/proguard.html>
optimizes, shrinks, (barely) obfuscates -> free, reduces size, faster
gutes bild <https://youtu.be/TNnccRimhsI?t=1360>

removes unnecessary/unused code

merges identical code blocks

performs optimizations

removes debug information

renames objects

restructures code

removes line numbers -> stacktrace annoying

<https://youtu.be/6vFcEJ2jg0w?t=470>

-> hacker factor 0

does not really help

googles commentar <http://android-developers.blogspot.de/2010/09/proguard-android-and-licens.html>

eine art result bzw zusammenfassung -> Without proper naming of classes and methods it is much harder to reverse engineer an application, because in most cases the identifier enables an analyst to directly guess the purpose of the particular part. The program code itself will not be changed heavily, so the obfuscation by this tool is very limited.

Dexguard

This is my real text! Rest might be copied or not be checked!

WER HAT ES HERGESTELLT? WAS IST ES? WAS SIND DIE FEATURES? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

master2
OVERVIEW
son of proguard
the standard protection
optimizer
shrinekr
obfuscator/encrypter, does not stop reverse engineering
<https://youtu.be/6vFcEJ2jg0w?t=643>
WHAT DOES IT DO
everything that proguard does
automatic reflection
string encryption
asset/library encryption
class encryption(packign)
application tamper protection
file->automatic reflection->string encryption->file
<https://youtu.be/6vFcEJ2jg0w?t=745>
class encryption= packer, unpackers do it most of the time in few seconds, aber aufwand auf handy, nicht so einfach wie pattern in luckypatcher
CONS
may increase dex size, memory size; decrease speed
removes debug information
string, etc encryption
best feature: automatic reflection with string encryption
reversible with moderate effort
hacker protection factor 1

RESULT -> UNTERSCHIED ZU DEN VORHERIGEN -> The obfuscation methods used in Allatori(dexguard) are a superset of ProGuards so it is more powerful but does not prevent an analyst from disassembling an Android application.

Allatori

This is my real text! Rest might be copied or not be checked!

WER HAT ES HERGESTELLT? WAS IST ES? WAS SIND DIE FEATURES? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

<http://www.allatori.com/clients/index.php>

Allatori is a commercial product from Smardec.

Besides the same obfuscation techniques like ProGuard, shown in section 2.1, Allatori also provides methods to modify the program code. Loop constructions are dissected in a way that reverse engineering tools cannot recognize them. This is an approach to make algorithms less readable and add length to otherwise compact code fragments. Additionally, strings are obfuscated and decoded at runtime. This includes messages and names that are normally human readable and would give good suggestions to analysts.

cannot recognize them. WHAT DOES IT

name obfuscation

control flow flattening/obfuscation

debug info obfuscation

string encryption

RESULT

decreases dex size, memory, increases speed

removes debug code

not much obfuscation

Proguard+string encryption

easily reversed

hacker protection factor 0.5

<https://youtu.be/6vFcEJ2jg0w>

https://net.cs.uni-bonn.de/fileadmin/user_upload/plohmann/2012-Schulz-Code_Protection_in_Android.pdf

Allatori [6] is a commercial product from Smardec. Besides the same obfuscation techniques like ProGuard, shown in section 2.1, Allatori also provides methods to modify the program code. Loop constructions are dissected in a way that reverse engineering tools cannot recognize them. This is an approach to make algorithms less readable and add length to otherwise compact code fragments. Additionally, strings are obfuscated and decoded at runtime. This includes messages and names that are normally human

readable and would give good suggestions to analysts. The obfuscation methods used in Allatori are a superset of ProGuards so it is more powerful but does not prevent an analyst from disassembling an Android application

Allatori. Allatori obfuscator. Visited: May, 2012. [Online]. Available: <http://www.allatori.com/doc.html>

RESULT -> UNTERSCHIED ZU DEN VORHERIGEN -> The obfuscation methods used in Allatori are a superset of ProGuards so it is more powerful but does not prevent an analyst from disassembling an Android application.

4.3.3 Protectors and Packers

This is my real text! Rest might be copied or not be checked!
from malware

APKprotect

This is my real text! Rest might be copied or not be checked!

WER HAT ES HERGESTELLT? WAS IST ES? WAS SIND DIE FEATURES? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

stub fixes broken code which is normally not translated by tools, breaks static analysis

<https://youtu.be/6vFcEJ2jg0w?t=347>

<https://youtu.be/6vFcEJ2jg0w>

chinese protector

also known as dexcrypt, appears active but site down, clones might be available

anti-debug, anti-decompile, almost like a packer

string encryption

cost ???

tool mangles code original code

-modifies entrypoint to loader stub

-prevents static analysis

during runtime loader stub is executed

-performs anti-emulation

-performs anti-debugging

-fixes broken code in memory

FUNCTION

dalvik optimizes the dex file into memory ignoring bad parts

upon execution dalvik code initiates, calls the native code

native code fixes odex code in memory

execution continues as normal

RESULT

slight file size increase

prevents easily static analysis

hard once, easy afterwards

easily automated to unprotect

still has string encryption (like DexGuard, Allatori) afterwards

not much iteration in the last time, do not know if still alive

hacker protection factor 3, no public documentation, but every app is the same

Packers

This is my real text! Rest might be copied or not be checked!

break static analysis tools, you have to do runtime analysis

like UPX, stub application unpacks, decrypts, loads into memory which is normally hidden from static analysis

<http://www.fortiguard.com/uploads/general/Area41Public.pdf>

<https://books.google.de/books?id=ACjUCgAAQBAJ&pg=PA372&lpg=PA372&dq=ijiami+integrity&source=bl&ots=NTf7YaqJiZ&sig=M5GKDCcQB5dcwXR3hjtIv8pM1AA&hl=de&sa=X&ved=0ahUKEwjH3umt1b3JAhXGLA8KHYhwDGsQ6AEIMDAC#v=onepage&q=ijiami%20integrity&f=false>

<https://www.blackhat.com/docs/asia-15/materials/asia-15-Park-We-Can-Still-Crack-You-Gener.pdf>

<https://www.virusbtn.com/conference/vb2014/abstracts/Yu.xml>

https://www.virusbtn.com/pdf/conference_slides/2014/Yu-VB2014.pdf

<https://www.youtube.com/watch?v=6vFcEJ2jg0w>

<https://books.google.de/books?id=ACjUCgAAQBAJ&pg=PA372&lpg=PA372&dq=ijiami+integrity&source=bl&ots=NTf7YaqJiZ&sig=M5GKDCcQB5dcwXR3hjtIv8pM1AA&hl=de&sa=X&ved=0ahUKEwjH3umt1b3JAhXGLA8KHYhwDGsQ6AEIMDAC#v=onepage&q=ijiami%20integrity&f=false>

concept erklären und dann die Beispiele nennen, nicht mehr aktiv/gecracked aber Prinzip ist gut

examples for packers are

`hosedex2jar`

This is my real text! Rest might be copied or not be checked!

WER HAT ES HERGESTELLT? WAS IST ES? WAS SIND DIE FEATURES? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

<https://youtu.be/6vFcEJ2jg0w?t=1776>

PoC packer

<https://github.com/strazzere/dehoser/>

not available for real use

appears defunct

near zero ITW samples

mimics dexception attack from dex education 101

FUNCTION

encrypts and injects dexfile into dex header (deception)

very easy to spot

very easy to decrypt, just use dex2jar

static analysis does not work since it sees the encrypted file

on execution loader stub decrypts in memory and dumps to file system

loader stub acts as proxy and passes events to the dex file on system using a dexClassLoader

RESULT

simple PoC

slight file size increase

attempts to prevent static analysis - kind of works

lots of crashing

easily automated to unpack

easy to reverse, good for learning

hacker protection factor 0.5

Pangxie

This is my real text! Rest might be copied or not be checked!

WER HAT ES HERGESTELLT? WAS IST ES? WAS SIND DIE FEATURES? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULT AUS (EXAMPLE BILD)

<https://youtu.be/6vFcEJ2jg0w?t=1982>

anti-debug

anti-tamper

appears to be defunct product

little usage/samples ITW

FUNCTION

<https://youtu.be/6vFcEJ2jg0w?t=2040>

encrypts dex file and bundles as asset in APK

very easy to find, logcat has too much information

dalvik calls JNI layer to verify and decrypt

easy to reverse, both dalvik and native, excellent for beginners to Android and packers

aes used only for digest verification

easily automated, 0x54 always the key

or dynamically grab app_dex folder

slightly increase file size

prevents static analysis - though easy to identify

uses static 1 byte key for encryption

easily automated to unpack

very easy to reverse, good for learning

good example of an unobfuscated packer stub for cloning

hacker protection faktor 1.5

only working till <4.4

simple packer, increase encryption with key, do not just dump on filesystem

BANGLE

This is my real text! Rest might be copied or not be checked!

WER HAT ES HERGESTELLT? WAS IST ES? WAS SIND DIE FEATURES? WIE FUNKTIONIERT ES? WIE WIRD ES IMPLEMENTIERT? WIE SIEHT DAS RESULTAT AUS (EXAMPLE BILD)

anti-debugging

anti-tamper

anti-decompilation

anti-runtime injection

online only service, apk checked for malware

detected by some anti virus due to malware

cost 10k

no one has done it before...

stopped working on 4.4

FUNCTION

dalvik execution talks launched JNI

JNI launches secondary process

chatter over PTRACE between the two processes

newest process decrypts dex into memory
original dalvik code proxies everything to the decrypted dex
RESULT
well written, lots of anti-* tricks
seems to be well supported and active on development
does a decent job on online screening - no tool released for download (though things clearly to slip through)
not impossible to reverse and re-bundle packages
current weakness (for easy runtime unpacking) is having a predictable unpacked memory location
hacker protect faktor 5
probably best tool out there but lag when updating since online approval

4.4 External Improvements

This is my real text! Rest might be copied or not be checked!

4.4.1 Service-managed Accounts

This is my real text! Rest might be copied or not be checked!

<https://youtu.be/TNnccRimhsI?t=1636>

check on server what content should be returned or logic on server

kann man einen lagorithus haben um rauszufinden was man auslagern kann?

if not possible remote code loading

<https://www.youtube.com/watch?v=rSH6dnUTDZo> was ist dann geschützt? content, servers, time constrained urls, obfuscation by using reflection combined with SE -> makes slow but no static analysis

very very slow, e.g 10kHz so no big calculations possible
250bytes, 200ms

http://amies-2014.international-symposium.org/proceedings_2014/Kannengiesser_Baumgarten_Song_AmiEs_2014_Paper.pdf

4.4.2 ART endlich durchsetzen

This is my real text! Rest might be copied or not be checked!

art hat masschinen coed
wenn reengineerbar dann nicht gut
warum jetzt noch keine art apps? https://en.wikipedia.org/wiki/Android_Runtime_dex2oat

4.4.3 Secure Elements

This is my real text! Rest might be copied or not be checked!

new section trusted execution environment trusttronic letzte conference samsung
knox -> gelten eher sicher

5 Evaluation of Counter Measurements

This is my real text! Rest might be copied or not be checked!

Evaluation der vorgeschlagenen punkte mit pro cons und umsetzbarkeit

<http://forum.xda-developers.com/showthread.php?t=2279813>

This is my real text! Rest might be copied or not be checked!

5.1 Tampering Protection

just as easy to crack as LVL when you know the code
evtl create native versions because harder to crack

5.1.1 Prevent Debuggability

5.1.2 Root Detection

5.1.3 LuckyPatcher Detection

already in some roms

https://www.reddit.com/r/Piracy/comments/3gmxxun/new_way_to_disable_the_antipiracy_setting_on/

<https://github.com/AlmightyMegadeth00/AntiPiracySupport>

https://www.reddit.com/r/Piracy/comments/3eo8sj/antipiracy_measures_on_android_custom_roms/

example roms <http://www.htcmania.com/archive/index.php/t-1049040.html>

<https://forums.oneplus.net/threads/patch-disable-the-antipiracy-feature-on-all-roms-sur-334772/>

5.1.4 Sideload Detection

5.1.5 Signature Check

maps checks for signature?

<http://stackoverflow.com/questions/13582869/does-lucky-patcher-resign-the-app-it-patches->

<https://developers.google.com/android/guides/http-auth> <http://forum.xda-developers.com/showthread.php?t=2279813&page=5>

generell

self signing, kann genauso geskippt werden dann remote

wenn einmal geladen -> skippen und geladene datei als custom patch nachschieben

5.1.6 Remote Verification and Code nachladen

trotzdem doof wenn einmal geladen kann man das file extrahieren etc

5.2 LVL Modifications

This is my real text! Rest might be copied or not be checked!

reengineering kann aushebeln

5.3 Prevent Reengineering

This is my real text! Rest might be copied or not be checked!

5.3.1 Packers

already cracked https://www.google.de/search?q=hosedex2jar&oq=hosedex2jar&aqs=chrome..69i57j69i60j69i59j69i60l3.1680j0j7&sourceid=chrome&es_sm=91&ie=UTF-8

<http://www.hotforsecurity.com/blog/mobile-app-development-company-fights-off-android-malware.html>

BEISPIELBILDER!! This is my real text! Rest might be copied or not be checked!

5.4 External Improvements

sis is text

5.4.1 Service-managed Accounts

5.4.2 ART

art hat oat files aber die haben dex files

5.4.3 Secure Elements

new section trusted execution environment trusttronic letzte conference samsung knox
->gelten eher sicher

6 Conclusion

This is my real text! Rest might be copied or not be checked!

auch wichtig weil wenn crackable dann upload zu stores und dann malware
<http://www.hotforsecurity.com/blog/mobile-app-development-company-fights-off-android-malware-with-obfuscation-tool-3717.html>

6.1 Summary

This is my real text! Rest might be copied or not be checked!

sis is text alles hilft gegen lucky patcher auf den ersten blick, jedoch custom patches können es einfach umgehen -> deswegen hilft nur reengineering schwerer zu machen
every new layer is another complexity

6.2 Discussion

This is my real text! Rest might be copied or not be checked!

sis is text <http://www.digipom.com/how-the-android-license-verification-library-is-lulling->
What Google should have really done
<http://programmers.stackexchange.com/questions/267981/should-i-spend-time-preventing-piracy>
You are asking the wrong question. Technical safeguards such as proguard are a must
but are trying to solve the problem the hard way.
content driven <http://stackoverflow.com/questions/10585961/way-to-protect-from-lucky-patcher>
google sagt <http://android-developers.blogspot.de/2010/09/securing-android-lvl-applications.html>

6.3 Future Work

This is my real text! Rest might be copied or not be checked!

art?
smart cards
google vault
all papers with malware and copyright protection is interesting since they also want to
hide their code

List of Figures

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Bibliography

- [1] ChelphuS. *crapler*. URL: <http://web.archive.org/web/20080207010024/http://www.808multimedia.com/winnt/kernel.htm> (visited on 09/30/2010).

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