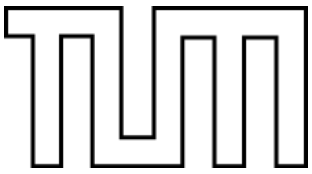


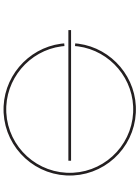
DEPARTMENT OF INFORMATICS

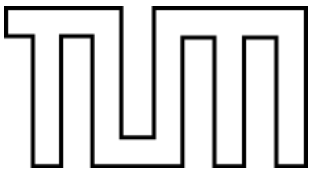
TECHNISCHE UNIVERSITÄT MÜNCHEN

Master's Thesis in Informatics

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

Johannes Neutze, B. Sc.





DEPARTMENT OF INFORMATICS

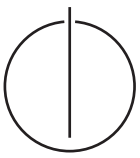
TECHNISCHE UNIVERSITÄT MÜNCHEN

Master's Thesis in Informatics

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

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

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.

Assumptions

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.

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.

Contents

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.

API 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 Ein Assembler (auch Assemblierer[1]) ist ein Computerprogramm, das Assemblersprache in Maschinensprache übersetzt, beispielsweise den Assemblersprachentext „CLI“ in den Maschinensprachentext „11111010“..

disassembler Ein Disassembler ist ein Computerprogramm, das die binär kodierte Maschinensprache eines ausführbaren Programmes in eine für Menschen lesbarere Assemblersprache umwandelt. Seine Funktionalität ist der eines Assemblers entgegengesetzt..

Acronyms

.dex Dalvik EXecutable file.

.odex Optimized Dalvik EXecutable file.

ADB Android Debug Bridge.

ADT Android Developer Tools.

AOT Ahead-Of-Time.

APK Application Programming Interface.

APK Android Application Package.

DRM Digital Rights Management.

DVM Dalvik Virtual Machine.

ELF Extensible Linking Format.

GC Garbage Collection.

JIT Just-In-Time.

JNI Java Native Interface.

JVM Java Virtual Machine.

NDK Native Development Kit.

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

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

Was ist licensing? nutzungsrecht für dritte an Intelectual property oder ähnliches unter bestimmten definierten bedingungen an authorisation by one party licensor to another party lincensee, may require paying a fee

Ziele von Licensing eigene IP schützen, vermarkten etc wikipedia

Software licensing grants right to purchase, install and use software according to vendor's license agreement protect both vendor, against piracy by stealing IP, user, fine for stealing or misuse enforce legal agreement by mechanism in software, disable or limit for users outside of bought software license different forms of license protection (account, abgescahltete features, watermark) can be circumvented, must protect by code obfuscation, license check and dialog [28]

software license is a legally binding agreement specified terms of use for an application defines the rights of software producer and end-user [34]

um das sicherzustellen haben große stores die geld damit verdienen lösungen um das sicherzustellen (lvl, amazon, samsung)

andere wehren sich schon `http://www.sueddeutsche.de/digital/illegale-kopien-von-computerspi` `2810482`viel investition, bloß android noch nciht so weit

1.2 Motivation

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

android grows thus becomes lucrative, increased interest from software pirates according to press conference google,2015-09-29, 1.4 billion active devices in last 30 days, counted in the last 30 days[7] market share 82.8 percent [19] 1.6 mio apps [41] 2013 Apple 10 billion revenue [35], 2014 overtaken by google play [24]

developers know from piracy[42] studies for plagiarism in Play Store [6] becoming more profitable [14]

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

spreading causes giant market (zahlen) -see- 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

enthält als Abschluss SCOPE

1.3 Related Work

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

many papers for better obfuscation (examples, was machen die so) in general not on how to stop an cracking application

related work

Was ist ihr problem? ziel? was machen sie dafür

Patrick Bernhard, A Security Analysis of Apps for Android Lollipop and Possible Countermeasures against Resulting Attacks [4] Alexandrina Kovacheva, Efficient Code Obfuscation for Android [23] Marius-Nicolae Muntean, Improving License Verification in Android [28]

2 Foundation

Before understanding the attack mechanisms and discussing counter measurements, necessary background knowledge has to be provided. Motivation and risks of software piracy and the basics of Android will be explained as well as existing licensing solutions and reengineering tools and methodics.

2.1 Software Piracy

In order to understand the motivation of licensing, software piracy itself and the problems and risks it causes have to be explained.

Definition of Software Piracy?

This is my real text! Rest might be copied or not be checked!
software piracy is the illegal copying of software worldwide problem 11 billion dollars lost to piracy every year easy thats why widespread [3]
refer to the unauthorized copying, distribution and selling of works in copyright
illegal copying, distributing and use of software includes casual copying of software by an individual or business software piracy hurts economy higher fees for software as result considered stealing
wikipedia Piracy is a very touchy subject on all platforms divides internet users depending on topic, see pirate bay, geolock for netflix and game of thrones developers have not many ways of moniterizing their effort and time they put into product

2.1.1 Threat to Developers

This is my real text! Rest might be copied or not be checked!
http://www.xda-developers.com/piracy-testimonies-causes-and-prevention/
scahden für entwickler (ad id klau,)

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=

awesome algorithms can be stolen

2.1.2 Risks to Users

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

easy fast search for sources can be downloaded on blackmarket apps, as blackmart[5], blackmarket websites, as crackApk[11] professional stealing

higher risk of viruses and fatal system crashes because of corrupted/defective software

werben mit "only complete applications and free", stellen so da als würden sie nur gutes wollen +for user: when downloading pirated apk, no idea what they changed (malware, stealing data,privacy, permissions)
+wont notice any difference since in backgound
+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

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.`

gefahren[6]

2.1.3 Piracy on Android

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

bytecode for other architectures as well as the little protection applied in practice, Dalvik bytecode is currently an easy target for the reverse engineer

example: todaycalendar, google+ post, 85 percent pirated, 15 percent paid[42] easy to search in google, many piracy sites

About 95 percent of the pirated copies are being installed in Russia and China (and of those, mostly China) [33] since no official Google Play in China

we made a decision in the past — obviously, we've all made games in the past — not to implement piracy protection on Android. It usually gets cracked within a day or two anyway. We can't respond to it in any way[21]

[32]

apk have to be signed, since self-signed certificates are allowed it is useless signature validation http://newandroidbook.com/files/Andevcon-Sec.pdf http://www.fiercedeveloper.com/story/preventing-android-applications-piracy-possible-requires-diliger 2012-08-14 piracy umfrage on android
übergehen zu wie android funktioniert und warum es dort piracy gibt

2.2 Android

2.2.1 Introduction

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

Android is an open source Linux-based operating system running on a large set of touchscreen devices, wearables and many more
Launched in 2007 by Google, it is designed to meet the limited computational capacity of a mobile device's hardware. The principal processor of Android devices is the ARM platform for which the operating system is optimized

AUFBAU ANDROID The underlying entity of the system is its kernel which bridges the hardware of the device and the remaining software components. Being a Linux-based kernel, it allows remote access to the device via a Linux shell as well as the execution of standard Unix commands.
A level above is the Android Runtime, which will be explained closer
At the same abstraction level as the virtual machine are the native libraries of the system. Written in C/C++, they permit low level interaction between the applications and the kernel through Java Native Interface (JNI)
The next layer is the application framework which provides generic functionality to mobile software through Android's API. The top layer of the Android OS stack is where custom applications are compiled, installed and executed.
[23]

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

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

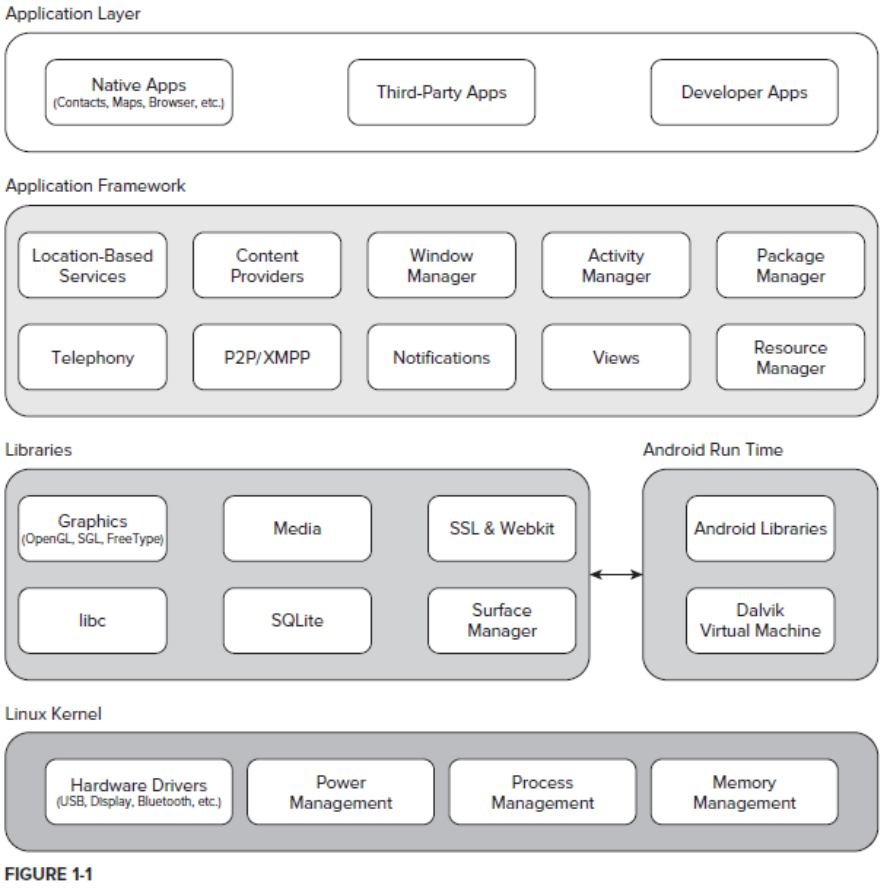


Figure 2.1: stack

2.2.2 Dalvik Virtual Machine

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

Flow what is dalvik, what is different to java, what is dex (build process), VGL `http://newandroidbook.com/files/ArtOfDalvik.pdf`

The applications for Android are written using the Java programming language.

stack abstraction is the Dalvik Virtual Machine (DVM)

DVM is highly tailored to work according to the specifications of the Android platform optimized for a slower CPU in comparison with a stationary machine andworks with relatively little RAM memory (• limited processor speed • limited RAM • no swap space • battery powered • diverse set of devices • sandboxed application runtime)[17]

DVM is register-based, differing from the standard Java Virtual Machine (JVM) which is stack-based, register-based architectures require fewer executed instructions than stack-based architectures, register-based code is approximately 25 percent larger than the stack-based, the increase in the instructions fetching time is negligible: 1.07 percent extra real machine loads[17]
the Android OS has no swap space imposing that the virtual machine works without swap. Finally, mobile devices are powered by a battery thus the DVM is optimized to be as energy preserving as possible, Except being highly efficient, the DVM is also designed to be replicated quickly because each application runs within a “sandbox”: a context containing its own instance of the virtual machine assigned a unique Unix user ID

wie der build process funktioniert wird später gesondert beschrieben, hier sagen wir einfach das ergebnis ist die dex datei

[23] [17]
DVM is - Customized optimized JVM based on Apache Harmony, - Not fully J2SE or J2ME compatible -see- Java compiles into DEX code -see- 16-bit opcodes and Register, rather than stack-based
History, Dalvík was introduced along with Android, created by Created by Dan Bornstein, Named after an Icelandic town, 2.2 brought current just in time compilation (ERKLÄREN)
Dalvik vs Java - Dalvík is a virtual machine implementation, Based on Apache Harmony, Borrows heavily from Java - Brings significant improvements over Java, in particular J2ME, Virtual Machine architecture is optimized for memory sharing, Reference counts/bitmaps stored separately from objects, Dalvik VM startup is optimized through Zygote - Java .class files are further compiled into DEX.
Overview creating APK unterschied zu java und dann auf dex?
[26]

2.2.3 Dalvik EXecutionable File

This is my real text! Rest might be copied or not be checked!
AUFBAU DEX DVM is register based. Registers are considered 32 bits wide to store values such as integers or floating point numbers. Adjacent register pairs are used to store 64-bit values
dest-then-source ordering for its arguments
there are 218 used valid opcodes in Dalvik bytecode -see- QUELLE

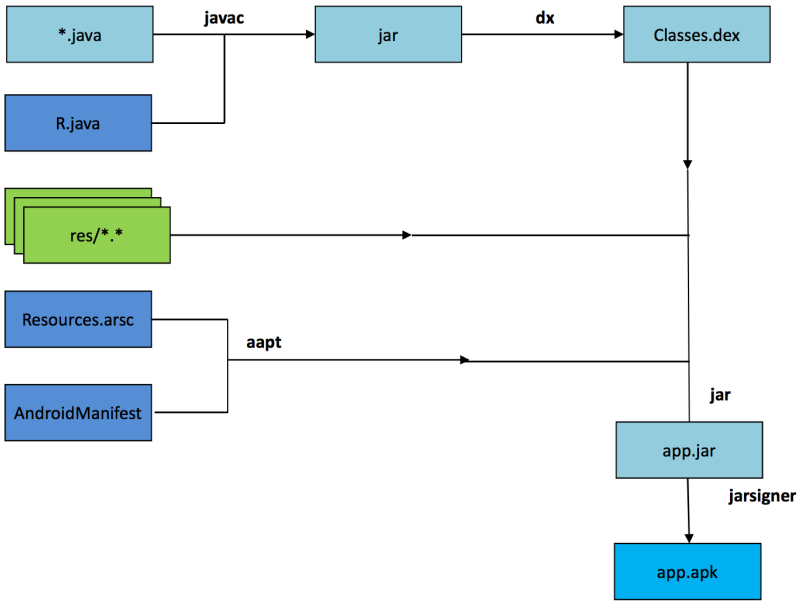


Figure 2.2: apk

Due to its simplicity over bytecode for other architectures as well as the little protection applied in practice, Dalvik bytecode is currently an easy target for the reverse engineer.

Each .class file has its own heterogeneous constant pool which may contain duplicating data, BEISPIEL, memory efficiency of a .dex file comes primarily from the type-specific constant pools used to store the data, BEISPIEL,
significantly more references within a .dex file compared to a .class file[17]
compression as efficiently as up to 44 percent of the size of an equivalent .jar archive[17]
hier noch einfach dex, später erst opcode nennen, the exact dex format will be explained in 2.4.2

[23] [17]

dx utility converts multilple class files to classes.dex, java bytecode is converted to dex bytecode, dex instructions 16bit mltiples, java 8bit constant, string,type and method pools are merged, significant savings for strings, types and methods in multiple calsses overall memory footprint diminished by about 50dex file format specified in android dcomentation -see- SOURCE

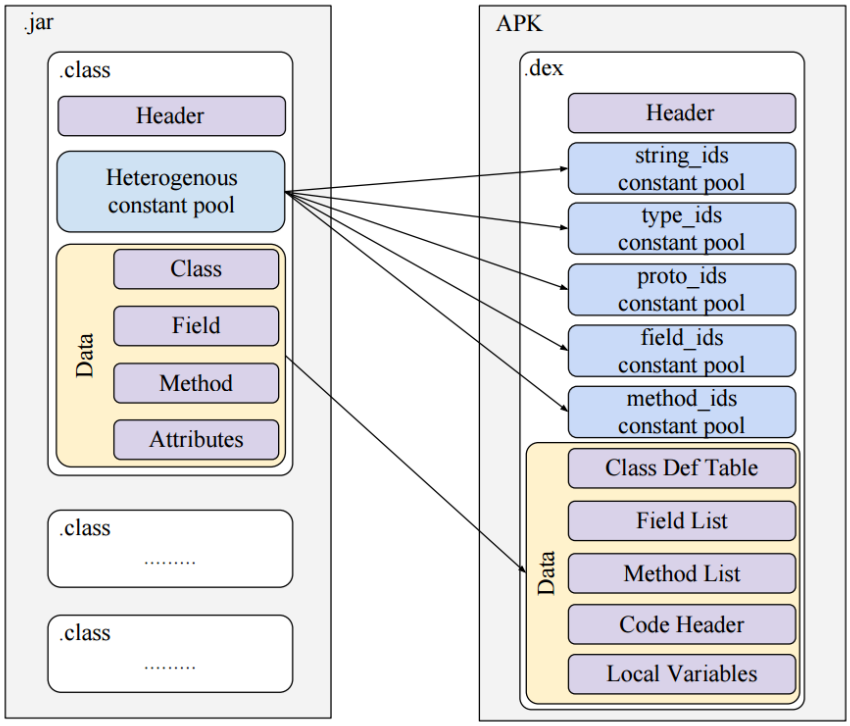


Figure 2.3: java

dex instructions refer to indexes (in pools)
de bytecode is striktly similar to java bytecode, allows for ease de/re compilation back and forth to/from java

dex vs java
java vm is stack based, dex is register based java bytecode is actually more compact than dex dex bytecode is more suited to arm architectures, mapping from dex registers to arm registers dex supports bytecode optimizations, java no, apk's calsses.dex are optimized before install, on device
[26]
AUFBAU DALVIK BYTECODE
The program code of an Android application is delivered in form of Dalvik bytecode It will be executed by the Dalvik Virtual Machine and is comparable to Java bytecode. So there is a separate optimizing step while installing an application, where the bytecode gets optimized for the underlaying architecture. The optimized form is also called

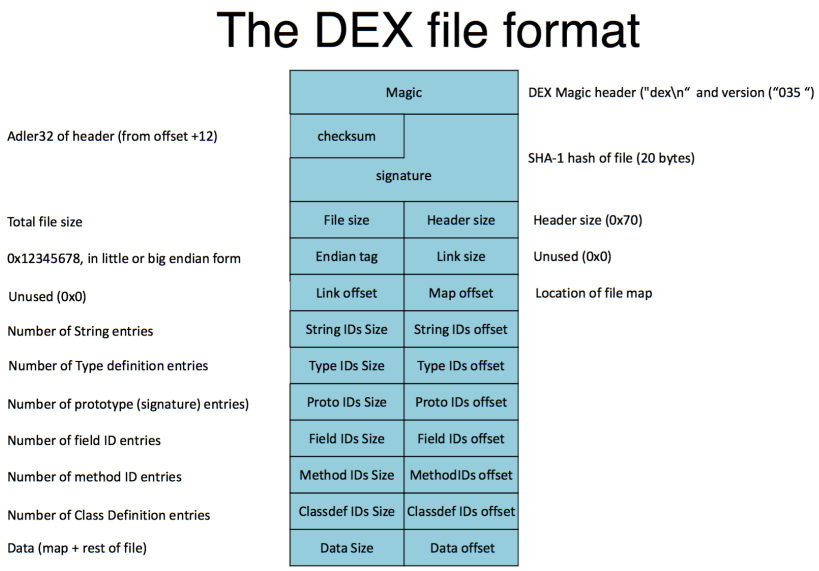


Figure 2.4: dex1

”odex”. The optimization is done by a program called ”dexopt” which is part of the Android platform. The DVM can execute optimized as well as not optimized Dalvik bytecode

unterschied `http://newandroidbook.com/files/Andevcon-DEX.pdf`

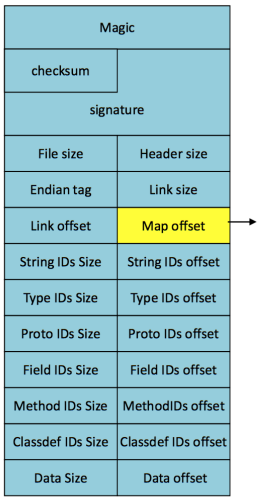
.dex file The Dalvik bytecode consists of opcodes and is thus hard to read for humans. The Cracking Tool has to modify the opcodes in order to alter the behaviour of the application. Since it is directly read by the Dalvik virtual machine, it is the single point of truth.

.odex file Dalvik bytecode of an application is normally not optimized, because it is executed by a DVM which can run under different architectures

2.2.4 Build Process of Android Applications

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

APK The file format of the install ready application is called Android Package (APK) and all the mobile software is distributed over Google Play in this format. The APK



Type	Implies	Size	Offset
0x0	DEX Header	1 (implies Header Size)	0x0
0x1	String ID Pool	Same as String IDs size	Same as String IDs offset
0x2	Type ID Pool	Same as Type IDs size	Same as String IDs offset
0x3	Prototype ID Pool	Same as Proto IDs size	Same as ProtoIDs offset
0x4	Field ID Pool	Same as Field IDs size	Same as Field IDs offset
0x5	Method ID Pool	Same as Method IDs size	Same as Method IDs offset
0x6	Class Defs	Same as ClassDef IDs size	Same as ClassDef IDs offset
0x1000	Map List	1	Same as Map offset
0x1001	Type List	List of type indexes (from Type ID Pool)	
0x1002 0x1003	Annotation set Annotation Ref	Used by Class, method and field annotations	
0x2000	Class Data Item	For each class def, class/instance methods and fields	
0x2001	Code	DexCodeItems – contains the actual byte code	
0x2002	String Data	Pointers to actual string data	
0x2003	Debug Information	Debug_info_items containing line no and variable data)	
0x2004	Annotation	Field and Method annotations	
0x2005	Encoded Array	Used by static values	
0x2006	Annotations Directory	Annotations referenced from individual classdefs	

Figure 2.5: dex2

format is a package management system based on the ZIP file archive format. CONTENT: META-INF directory: MANIFEST.MF: the Manifest file CERT.RSA: The certificate of the application. CERT.SF: The list of resources and SHA-1 digest of the corresponding lines in the MANIFEST.MF file

lib: the directory containing the compiled code that is specific to a software layer of a processor, the directory is split into the different processor types

res: the directory containing resources not compiled into resources.arsc (see below).

assets: a directory containing applications assets, which can be retrieved by AssetManager.

AndroidManifest.xml: An additional Android manifest file, describing the name, version, access rights, referenced library files for the application. This file may be in Android binary XML that can be converted into human-readable plaintext XML with tools such as AXMLPrinter2, android-apktool, or Androguard. classes.dex: The classes compiled in the dex file format understandable by the Dalvik virtual machine

resources.arsc: a file containing precompiled resources, such as binary XML for example.

BUILD PROCESS written using the Java programming language. Standard Java environment compiles each separate class in the .java source code file into a corresponding Java bytecode .class file. Each class will be compiled into a single .class file. These are later packed together in a single .jar archive file. The JVM unpacks the .class files, parses and executes their code at runtime.

On the Android platform, the build process differs after the point when the .class files have been generated. Once having the latter, they are forwarded to the “dx” tool which is part of the standard Android SDK. This tool compresses all .class files into a single classes.dex file i.e. the .dex file is the sole bytecode container for all the application’s classes. After it has been created, the classes.dex is forwarded to the ApkBuilder tool altogether with the application resources and shared object (.so) files which, if present, contain native code. As a result, the APK archive is created and the final compulsory step is its signing. Figure 1.2 shows the APK build process and the possible obfuscation manipulations which are optional during the build stages

[23] [17]
für 4.1 erklären, bild `http://developer.android.com/tools/building/index.html` `http://newandroidbook.com/files/ArtOfDalvik.pdf` seite 10

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, included in an APK in next step, possible to apply a further obfuscator operating on Dalvik bytecode(ERKLÄRUNG)
step 3: packing and signing the APK, ApkBuilder constructs an apk file out of the "classes.dex" file and adds further resources like images and ".so" files, ”.so” files are shared objects which contains native functions that can be called from within the DVM, jarsigner adds developers signature to APK(ERKLÄREN WARUM SIGNATURE NÖTIG UND WO GEPRÜFT), now the app can be installed

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. -see- QUELLE/SINN?

so why is dalvik deprecated? JIT is slow, consuming both cycles and battery power gabage collection causes hangs/jitters dalvik is 32bit, cannot beneift from 64bit architecture kitkat first introduce art, lollipop adopts it

2.2.5 ART

art introduced in kitkat 4.4, available only through developer options, declared to be preview release, own risk, very little documentation, if any in lollipop art becomes runtime of choice, supersedes dalvik, breaks compatibility with older dex, as well as itself, very little docu constantly evolving through marshmallow, major caveat : oftenc changes in between android minro versions, android optimizes apps everytime you update
art was designed to address shortcomings of dalvik: virutal machine maintenance is expensie, interpreter/jit simply arent efficient as native code, doing jit all over again on every execution is wasteful, maintenance threads require significantly mroe cpu cycles, cpu cycles translate to slower performance and shorter battery life dalvik garbage collection frequently causes hangs/jitter virtual machine architecture is 32bit only, android i sfollowing ios into 64bit space
advantages of art art mvoes compilation from Just-In-Time (JIT) to Ahead-Of-Time (AOT) VM maintenance not as expensive as dalvik, art compiles to native AOT not JIT, less maintenance threads and overhead cycles than dalvik garbage collection parallizable (foreground/background), non blocking -see- QUELLE 64bit bus some issues still exist -see- quelle
main idea of art/aot: actually compilation can be to one of two types, quick (native code), portable(llvm code) in practice preference is to compile to naitve code, portable implies another layer of IR (LLVM's bit code)
Art itself: art uses not one but two file formats art - only one file, boot.art, in /syste/framework/architecture (arm,...) oat - master file, boot.oat, in /syste/framework/architecture (arm,...) - odex files no longer optimized dex but oat, alongeside apk for system apps/frameworks, /data/dalvik-cache for 3rd party apps, still uses odex extension, now file format is elf/oat
art files is a proprietary format, poorly documented, changed format internally repeatedly art file maps in memory right before oat, which links with it contains pre-initilited

classes, objects and support structures
ART/OAT files are created (on device or on host) by dex2oat art still optimizes dex but uses dex2oat instead, odex files are actually oat files (elf shared objects WAS IST DAS), actual dex payload buried deep inside command line saved inside oat file's key value store

```
shell@flounder ~ dextra -h /system/framework/arm64/boot.oat
..
Key value store Len: 2318
          Key: debuggable      Value: false
          Key: dex2oat-cmdline  Value: --runtime-arg -Xms64m --runtime-arg -Xmx64m --image-
classes=frameworks/base/preloaded-classes
--dex-file=out/target/common/obj/JAVA_LIBRARIES/core-libart_intermediates/javalib.jar
-dex-file=out/target/common/obj/JAVA_LIBRARIES/conscrypt_intermediates/javalib.jar
--dex-file=out/target/common/obj/JAVA_LIBRARIES/okhttp_intermediates/javalib.jar
..
--dex-file=out/target/common/obj/JAVA_LIBRARIES/org.apache.http.legacy.boot_intermediates/javalib.jar
--dex-location=/system/framework/core-libart.jar
...
--dex-location=/system/framework/org.apache.http.legacy.boot.jar
--oat-symbols=out/target/product/flounder/symbols/system/framework/arm64/boot.oat
--oat-file=out/target/product/flounder/dex_bootjars/system/framework/arm64/boot.oat
--oat-location=/system/framework/arm64/boot.oat
--image=out/target/product/flounder/dex_bootjars/system/framework/arm64/boot.art --base=0x70000000
--instruction-set=arm64 --instruction-set-variant=denver64 --instruction-set-features=default
--android-root=out/target/product/flounder/system --include-patch-information --runtime-arg
-Xnorelocate --no-generate-debug-info
          Key: dex2oat-host     Value: X86_64
          Key: pic   Value: false
```

Figure 2.6: oat

art file format

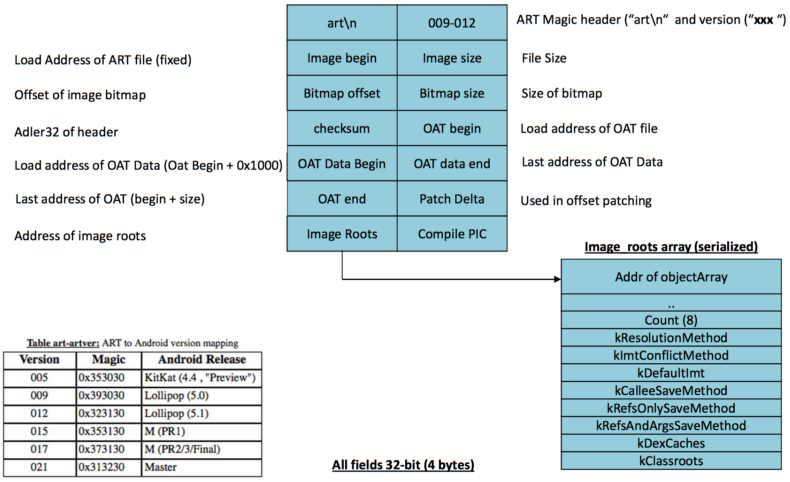


Table art-artver: ART to Android version mapping

Version	Magic	Android Release
005	0x353030	KitKat (4.4 , "Preview")
009	0x393030	Lollipop (5.0)
012	0x323130	Lollipop (5.1)
015	0x353130	M (PR1)
017	0x373130	M (PR2/3/Final)
021	0x313230	Master

Figure 2.7: art

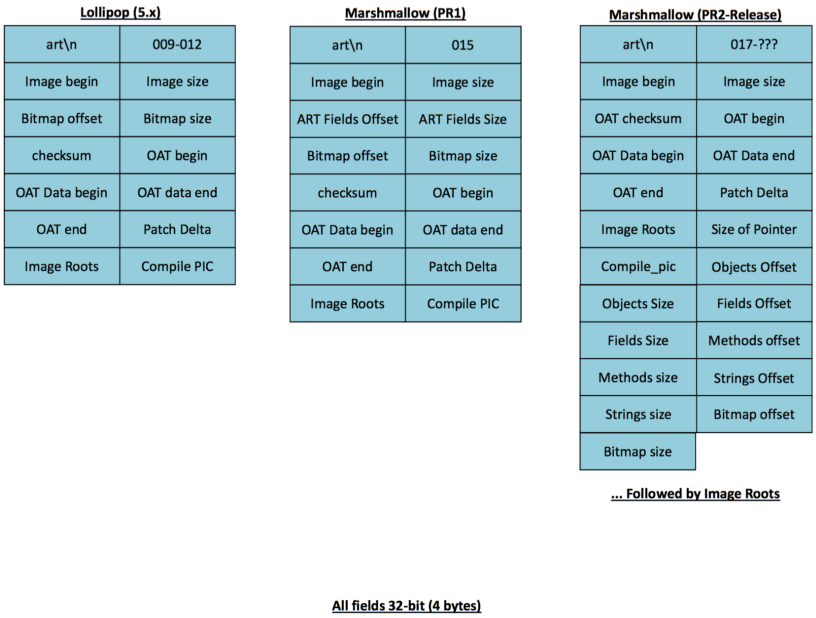


Figure 2.8: art2

the oat dexfile header oat headers are 1...n dex files, actual value given by dexfilecount field in header

finding dex in oat odex files will usually have only one (=original) dex embedded booat.oat is something else entirely, some 14 dex files the best of the android framework jars, each dex contains potentilly hundres of classes

art code generation oat method headers point to offset of native code each method has a quick or portable method header, contains mapping from virtual register to underlying machine registers each method has a quick or protable frame info, provides frame size in bytes, core register spill mask, fp register spill mask generated code uses unusual registers, especially fond of using lr as call register, still saves/restores registers so as not to violate arm conventions

art supports mutliple architectures(x86,arm/64,mips) compiler is layered architecture, using portable (llvm) adds another lvl with llvm bitcode (not in this scope)

vergleich java/dex/odex(art) code

lessons base code is dex so vm is still 32bit, no 64bit registers or operands so mapping to underlying arch inst always 64bit, there are actually a frw 64bit instructions but most

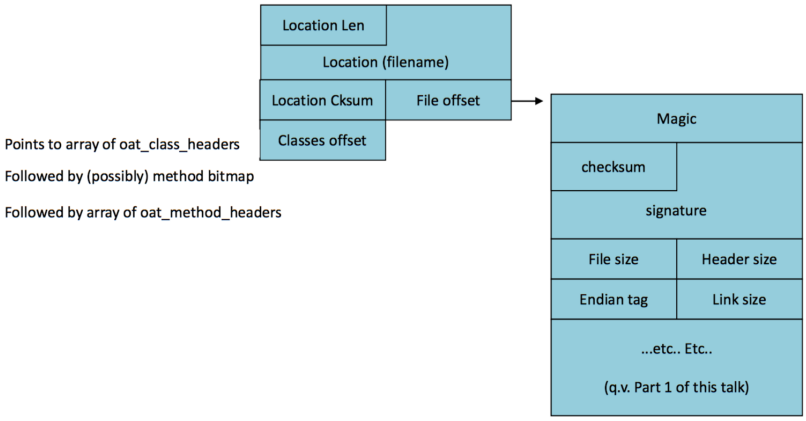


Figure 2.9: oatdex

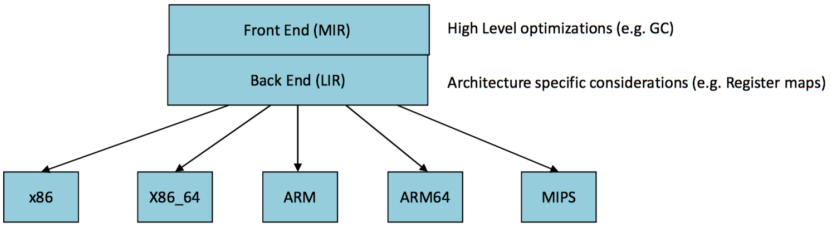


Figure 2.10: artarch

dex code doesnt use them generated code isnt always that efficient, not on same par as an optimizing antive code compiler, likely to improve with llvm optimizations overall code (determined by Mir optimizations) flow is same garbage collection, register maps, likewase same cavears: not all methods guaranteed to be compiled, reversing can be quite a pain

ART runtime threads the daemon threads are started in java by libcore, daemon class wraps thread class and provides singleton INSTANCE, do same basic operations as they did in "classic" dalvikVM, libart subree in libcore implementation slightly different

isn't android all dalvik now? art is runtime but application compile into dex, art is compiled on device during install, art binaries has dalvik embedded, some methods

may be left as dex to be interpreted, dalvik is miuch easier to debug than art –see-evaluation
[26]

2.2.6 Installation, Running and Original Copy Protection

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

Installation two steps: primary is the APK verification and secondary is the bytecode optimization
legitimate signature as well as correct classes.dex structure cannot be verified are rejected for installation by the OS
Once verified, the .dex file is forwarded for optimization: a necessary step due to the high diversity of Android running hardware (dex)-see- Dalvik executable is a generic file format which needs additional processing to achieve best performance for the concrete device architecture (odex)
optimization
step removes the classes.dex from the original APK archive and loads in memory the .odex file upon execution, occurs only once, during the initial run of the application which explains the usually slower first application launch comparing to the subsequent ones

ablauf starten von app
When an Android application is executed, the process consists of the following four parts: • Dalvik bytecode, which is located in the dex file • Dalvik Virtual Machine [13], which executes the Dalvik bytecode • Native Code, like shared objects, which is executed by the processor • Android Application Framework, which provides services for the application
[23]

unauthorized usage of an app through copy protection apk was installed in a location on the phone /data/app user could not access useless if single user can get apk and redistribute, gained by root successful as long as root was not easy for everyone -see-samsung rooting odin QUELLE, did not have too big impact as today, oneclick root kits QUELLE, standard for nexus

on install app's classes.dex is copies an optimized version (odex) to dalvik cache /data/dalvik-cache/, for faster startup (contains system apps and frameworks as well) odex erklären, byteswapping, structure realigning and memory-mapping when app is started optimized code from dalvik cache will be executed instead of apk [28]

The Android operating system is a multi-user Linux system in which each app is a different user. By default, the system assigns each app a unique Linux user ID (the ID is used only by the system and is unknown to the app). The system sets permissions

for all the files in an app so that only the user ID assigned to that app can access them Each process has its own virtual machine (VM), so an app's code runs in isolation from other apps. By default, every app runs in its own Linux process. Android starts the process when any of the app's components need to be executed, then shuts down the process when it's no longer needed or when the system must recover memory for other apps

[13]

old system was to put APK in folder user cannot access, unless you root weak, almost non-existant, anyone who can copy it can distribute it

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-existant.

kann mit root umgangen werden

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

2.2.7 Root on Android

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

what is rooting? getting root/rooting process of modifying the operation system that shipped with your device to grant you complete control over it overcome limitations by carriers/manufacturers, extend system functionality, upgrade to custom flavor root comes from Linux OS world, most privileges user on the system is called root rooting fairly simple, many videos and tutorials, sometimes oneclick tools not aproved by manufacturers or carriers, can not prevent usually exploits vulnerability in operating system code or device drivers, allows the "hacker" to upload a special program called su to the phone su provides root access to programs that request it usually superuser permissions bundled with root approve/deny requests from applications who want root replaces convetional password with approve/deny, not secure but much more convenient rooting the phone modifies the software thus can brick the phone, meaning the phone is nonfunctional since the software is broken

benefits access all files on the phone, even those which the normal user has no permissions for, modify add delete

examples modify system variables, e.g. to utilize the notification led on motorola devices which is usually disabled install custom roms [27]

android's content protection are invalid when rooted any application's data directory (or code) can be read DRm can be bypassed coupled with dex decompilkation big

problem, app can be decompiled, modded and repackaged [25]

a list of root vulnerabilities can be found on `http://androidvulnerabilities.org/all`

2.3 License Verification Libraries

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

Since the original approach of subsection 2.2.6 was voided, another method had to be introduced due to ineffectiveness and rising pressure from developer community, google as owner of android and its biggest sore released lvl - `https://developer.android.com/google/play/licensing/overview.html` auch für andere stores interessant da selbe probleme und wollen developer binden amazon (eigenes ökosystem, pushen mit underground und billigen tablets die als einstieg dienen und app store soll generieren), samsung (wollen was besonderes sein, wie apple, spezielle apps für galaxy/note devices, haben auch eigene services), gibt auch chinesische aber die nicht genau betrachtet da nur in china relevanz und westliche eher auf westlichen market (vllt besonderheiten), ausserdem proivder noch [28]

put copy protection methods into app itself, kind of DRM

First looks great, puts the copy protection inside the app, a from of DRM
communicate with server, authorize use of application
does not prevent user from copying/transfering 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 Google

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

network service, queries Licensing Server from Google check whether current user has license library provided by google transparent since google delivers code

[28]

manages a connection between your app and Google Play, performs a license check with server to see if valid license (.e.g purchased from google play) Digital Rights Management (DRM) [22]

introduced to fight piracy in Google Play, introduced 07/27/2010 simple and free service [9]

Functional Principle

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

integrate into application by developer, allows simple checking and callback process with google asks google play app whether the app was bought on the appstore by the user, takes care of the complicated process (webservice, network etc) on respond google app passes response to the callback

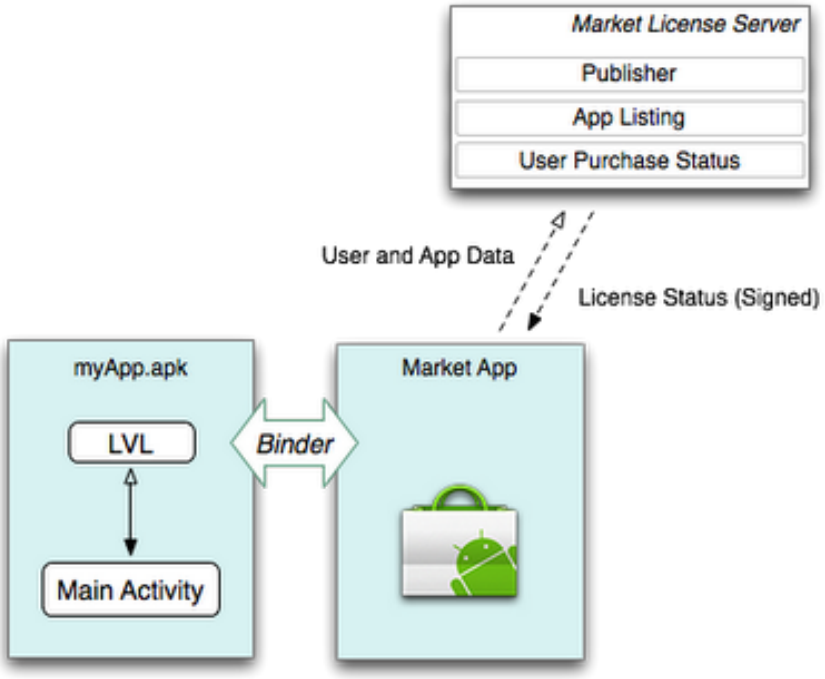


Figure 2.11: lvl [9]

determine license status of an app, licensing service needs two informaiton: - package name of app, a nunce that has to be present in every server response to esnure attacker security, callback for async handling of server respone, implemented in initial license check - user - specific info user and device such as primary google acc and imsi, collected and provided by google play - google play

security of response important every published app in playstore, play generates public/private key pair, developer gets public key public key is embedded into app google play licensing server signes response with app private key public key used to check signature of response, effective mechanism is established to ensure origin and detect tampering [28]

The information about the application, the device and the user goes off to Google's

servers. Google then checks your name against the list of people it knows have paid for the application on Google Play. (It could also check the name of the application against a list of applications it knows that you've downloaded from Google Play) If it can see that you have downloaded (and paid for) the application from Google Play it sends back that you have a license, if not then it tells the app you don't.

request starts when app initiates to service on Google Play client application Google Play sends request to licensign server and receives result google play passes it to app and app decides what happens [15]

network based service lets query trusted Google Play licensign server, determine whether application is licensed for current user based on buyers database when, and how often, you want your application to check its license control over how it handles the response, verifies the signed response data, and enforces access controls

need internet, Google account (else you werent able to buy the applciations), google play installed addng licensing to app does not affect way the app functions when run on a device that does not offer Google Play

saves license on device with timed life

replace as copy protection flexible, secure mechanism for controlling access to applciation replaces copy protection mechanism which is no longer supported that was previously offered on Google play license based model that is enforceable on all devices that have acces to google play access is not bound to characteristics of host device, but google play and licensing policy definded can be installed, manages on any device and any storage, even SD card [15]

Implementation of the License Verification Library

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

run time, set of libraries provided by google app can query Google Play licensing Server to determine the license status of user returns information on whether your user is authorized to use the app based on stored sales revords real time over network [9]

what you need

google publisher account on google play google play developer console at Services & API, app specific public key for licensing, implement it into the application copy it later into the app

[12]

- Adding the licensing permission your application's manifest

```
7  ...
8  <uses-permission android:name="com.android.vending.CHECK_LICENSE" />
9  ...
```

Code Snippet 2.1: Calling the LVL

- Implementing a Policy, provided by LVL or own - Implementing an Obfuscator, if Policy caches any license response data. **??** line 59, cannot be reused or manipulated by a root user - adding code to check license in application main activity_main [12] `https://developer.android.com/google/play/licensing/setting-up.html`
`https://developer.android.com/google/play/licensing/adding-licensing.html`

```
57          final String mAndroidId = Settings.Secure.getString(this.getContentResolver(),
58                  Settings.Secure.ANDROID_ID);
59          final AESObfuscator mObsfuscator = new AESObfuscator(SALT, getPackageName(),
                mAndroidId);
60          final ServerManagedPolicy serverPolicy = new ServerManagedPolicy(this, mObsfuscator);
61          mLicenseCheckerCallback = new MyLicenseCheckerCallback();
62          mChecker = new LicenseChecker(this, serverPolicy, BASE64_PUBLIC_KEY);
63
64          mChecker.checkAccess(mLicenseCheckerCallback);
```

Code Snippet 2.2: Calling the LVL

```
57          @Override
58          public void allow(final int reason) {
59              ...
60          }
61
62          @Override
63          public void dontAllow(final int reason) {
64              ...
65          }
66
67          @Override
68          public void applicationError(final int errorCode) {
69              ...
70          }
```

Code Snippet 2.3: Callback

2.3.2 Amazon

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

Amazon wants piece of Android pie, also earn money from selling apps, alternaticve to Google play Amazon introduced its appstore on the 03/22/2011 for Android and Fire tablets comes with own DRM which is free to enable/disable by developer[1] since the Google LVL only works with Google Play named Kiwi (taken from decompilation) store is completely independent [2]

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

high level prerequisites amazon developer account
when uploading the app, user is asked whether

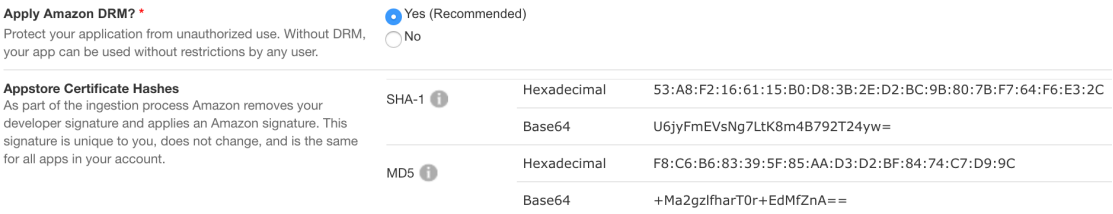


Figure 2.12: amazon

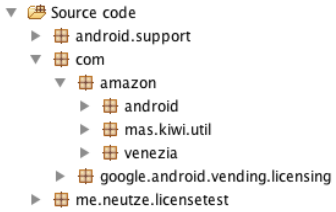


Figure 2.13: amazonFolder

different approach to perform license verification and enforce result google lvl include and integrate modified version of lvl library, not required to implement any mechanism on their own, done by amazon packaging tool when submitting can check amazon DRM (see picture), applay amazon DRm to "Protect your application from unauthorized use. Without DRM, your app can be used without restrictions by any user." as the description says "As part of the ingestion process Amazon removes your developer signature and applies an Amazon signature. This signature is unique to you, does not change, and is the same for all apps in your account." as the description says, so developer signing the application by the develoepr before submitting is not necessary, amazon decompiles apk, injects drm code, compiles it and signs it with the "amazon developer" certificate [28]

amazon appstore has to be installed the whole time and user has to be logged in order that the DRM works

Implementation of Kiwi

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

kind of wrapper no sample implementation to add by developer but inject own logic in each app (same for every app)

example shows implementation recovered by reengineering explained in 2.4 amazon drm contains numerous namespaces and calsses, most have been mangled by obfuscation tools, see proguard startup in main activity myActivity drm logic not interweaved with app logic, could only be done by a human developer anyways

[28]

```
77    public void onCreate(Bundle bundle) {
78        onCreateMainActivity(bundle);
79        Kiwi.onCreate((Activity) this, true);
80    }
```

Code Snippet 2.4: Callback

rename onCreate to onCreateMainActivity start in new onCreate, also start Kiwi.onCreate((Activity) this, true); which handles the

2.3.3 Samsung

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

Samsung as a major player in the smartphone business has also his own app store [10] Galaxy Apps by Samsung, formerly known as Samsung Apps, for devices by Samsung renamed in July 2015 called zirconia for android [30]

Functional Principle

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

library probiding reventive measure against illegal repoduction works only on samsung devices since samsung store has to be installed and logged in inspects the license of application executed to prevent illegal use checks for license from license server upon init and stores it on device for future offline check, timed life also checks if license from server if stored license has been removed or damkages, license from server unique for each device/application if app is copied to another device, application will not execute

interior process: makes query for stored licensetest if found, app can execute if not exist or invalid, infromation of device and applciation will be send to server (once stored internet connection not required anymore) if purchased for device, server returns license back to zirconia zirconia stores license on device return step 1

callback method, asynch, zirconia does not return license validity result as boolean **??** does not work if network is offline or in airplane

[30]

Implementation of Zirconia

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

java package .jar and JNI native library have to be added to project for check and query of license server zirconia needs device info and internet connection (READ_PHONE_STATE and INTERNET permission)

4 basics steps (see **??**) create

can be implemented in any stage of the application, e.g. start or when saving

[30]

```
57        final Zirconia zirconia = new Zirconia(this);
58        final MyLicenseCheckListener listener = new MyLicenseCheckListener();
59        listener.mHandler = mHandler;
60        listener.mTextView = mStatusText;
61        zirconia.setLicenseCheckListener(listener);
62        zirconia.checkLicense(false, false);
```

Code Snippet 2.5: Creating Zirconia

```
57        @Override
58        public void licenseCheckedAsValid() {
59            mHandler.post(new Runnable() {
60                public void run() {
61                  ...
62                }
63            });
64        }
65
66        @Override
67        public void licenseCheckedAsInvalid() {
68            mHandler.post(new Runnable() {
69                public void run() {
70                  ...
71                }
72            });
73        }
```

Code Snippet 2.6: Callback

2.4 Code 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.

recover the original code of an application bytecode analysis is most often used. By applying both dynamic and static techniques to detect how behavior is altered
dynamic analysis during runtime, static raw code, done by automatic tools using reverse engineering algorithms, best case whole code recovered, worst case none

When speaking of reverse engineering an Android application we mostly mean to reverse engineer the bytecode located in the dex file of this application.

The classes.dex file is a crucial component regarding the application's code security because a reverse engineering attempt is considered successful when the targeted source code has been recovered from the bytecode analysis. Hence studying the DEX file format together with the Dalvik opcode structure is tightly related to both designing a powerful obfuscation technique or an efficient bytecode analysis tool. [23]

dex to java .dex and .class are isomorphic dex debug items map dex offsets to java line numbers tools like dex2jar can easily decomile from dex to a jar extremly useful for reverse engineering, even more so useful for malice
flow from dex to java is bidirectional, decompile code back to java, remove annoyances

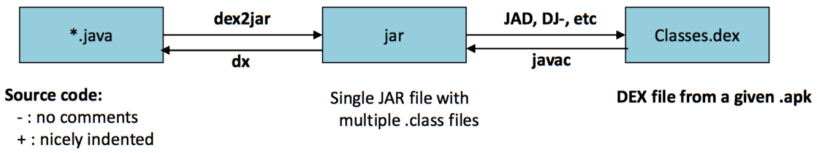


Figure 2.14: re1

like ads, registration, uncover sensitive data (app logic, secrets), replace certain classes with others (malicuous ones), recompile back to jar, then dex, put cloned/trojaned version of your app on play or other market
[26]

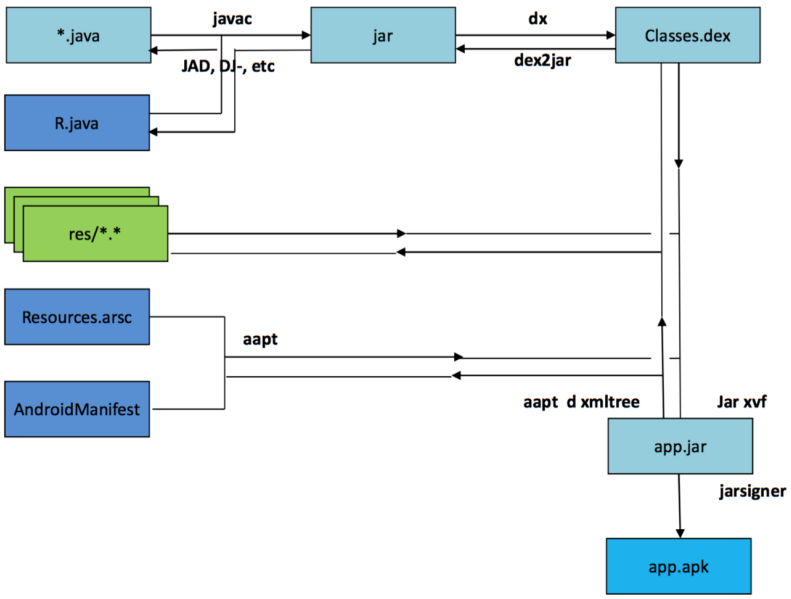


Figure 2.15: re2

android vulnerability of app is reverse engineering the source code, patching security mechanism and recompiling the app best case scenario is obtaining one to one copy of original source code since reading and understanding high level code is easiest so will the patching be reality often not possible due various protecting of source code, also unnecessary since lower level representation of source code mgiht be enough to reveal mechanism patch and compile low level code tools and documentation have matured

many tools and techniques

gaining information about a program and its implementation details, process aims at enabling an analyst to understand the concrete relation between implementation and functionality, optimal output of such a process would be the original source code of the application, not possible in general
Therefore, it is necessary for such a process to provide on the one hand abstract information about structure and inter-dependencies and on the other hand result in very detailed information like bytecode and mnemonics that allow interpretation of

implementation
hoffentlich starting points für investigations
java, e.g. read the program code faster

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 -see- 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

5 most apps are installed /data/app, android restricts access, with root possible

to get installed applications on phone use android package manager after connecting phone to computer and having Android Debug Bridge (ADB) tools installed adb shell ṕm list packages -f́(1) outputs a list of installed apps in formatf <namespace>.<appName> and an appended number "-1", each is a folder of instlaled app containing a base.apk (the application apk) example 2 enthällt return von (1)

then find app which should be transfered to computer and use adb pull /data/app/me.neutze.licensetest 1/base.apk to download app into current folder

in case you have root you can use file manager as solid explorer to access the folder directly and copy apk to user-defined location/send per mail

[28]

In the following there will be an example application to generalise the procedure. The application is called L̈icenseTeständ 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 ADB. Entering example 1 returned example 2

dann auf verschiedenen leveln anschauen mit den folgenden tools

Dex

This is my real text! Rest might be copied or not be checked!
nur dex weil die apps im moment so vorliegen
aosp-supplied dexdumo to disassemble dex
[26] always attack dex since the protection mechanism is in there (except JNI?) since apk is zip like decompression tool like 7zip can extract classes.dex from apk file
code wie er vorliegt, wenn was geändert wird wird es hier geändert
RESULT OUTPUT

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

Code Snippet 2.7: Quelle

SCRIPT (LISTING BENUTZEN UND RICHTIGE APP)
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

Smali Code

This is my real text! Rest might be copied or not be checked!
basically jasmin syntax smali, most popular Dalvik bytecode decompilers (used by multiple reverse engineering tools as a base disassembler, amongst which is the also well-known apktool) [23]
stichwort mnemonics, eine seite dex und auf der anderen seite smali, dex bytecode vs smali, Only a few pieces of information are usually not included like the addresses of instructions
unintuitive representation, deswegen smali mit corresponding mnemonics

mnemonics and vice versa is available due to the bijective mapping
correct startaddress and offset can be challenging. There are two major approaches: linear sweep disassembling and recursive traversal disassembling, The linear sweep algorithm is prone to producing wrong mnemonics e.g. when a assembler inlines data so that instructions and data are interleaved. The recursive traversal algorithm is not prone to this but can be attacked by obfuscation techniques like junkbyte insertion as discussed in section 4.4. So for obfuscation, a valuable attack vector on disassembling is to attack the address finding step of these algorithms

https://github.com/JesusFreke/smali

Smali code is the generated by disassembling Dalvik bytecode using baksmali. The result is a human-readable, assambler-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? -see- 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

RESULT OUTPUT: selbe wie dex, jedoch human readable, no big difference, nebeneinanderstellung dex/smali

SCRIPT (LISTING BENUTZEN UND RICHTIGE APP)

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

Java

This is my real text! Rest might be copied or not be checked!
dex different patterns for mobile Usage, java does not really now, thats why different java decompiler
probleme des disassemlbers 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

This is my real text! Rest might be copied or not be checked!
An analysis and disassembling tool processing both Dalvik bytecode and optimized bytecode
DAD which is also the fastest due to the fact it is a native decompiler, WAS ist dad? ERKLÄREN? .dex files was performed with DAD, the default disassembler in the androguard analysis tool, largest successful disassembly ratio
underlying algorithm is recursive traversal
androguard has a large online open-source database with known malware patterns [23]
`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 -see- 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 -see- quelle, warum

RESULT OUTPUT code Listing
SCRIPT (LISTING BENUTZEN UND RICHTIGE APP)
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

jadx

This is my real text! Rest might be copied or not be checked!
- RESULT OUTPUT code Listing
- SCRIPT (LISTING BENUTZEN UND RICHTIGE APP)
- 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?
WARUM SCHAUEN WIR ES UNS AN?
wo findet man es?
welches level?
vorteil
blabla aus dem internet

Es gibt noch mehr tools, wurden angewendet und verglichen, aber diese waren die haupttools und haben ihren dienst erfüllt

Comparison of Code

This is my real text! Rest might be copied or not be checked!
vergleich gibts guten einblick was geändert wurde und wie es auf dem gegebenem lvl funtkioniert

vergleich von original und modifizierten code einer apk auf einer code ebene
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. reason lucky ptcher is taken exremely popular and easy(no technical knowdlege except root but apps can be traded) to use and discusses a lot in android community develoeprs/users because of damage/advantage

3.1 What is LuckyPatcher and what is it used for?

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

main goal is to circumvent license verification, app should behave as it is legally aquired in app store, by user hence work normally, full features

most common way client-server license verification, app gathers info and sends to server, server checks info and depending on this sends response, finally app acts according to response code

since server is not accessible and man-in-the-middle has to break encryption, like spoofing, which is difficult (encryption in general), has to work in application

effective, popular, vielseitig (viel internet -see- quelle) high damage potential since popular, automated and general use by non professional

[28]

written by ChelpuS

for this master's thesis the version 5.9.5 written bei chelphus requires root and busybox, an application which provides standard UNIX tools for Android[36] apply patches: - Remove license check in premium apps (used to crack DRM) - remove ads -Customize and restrict permissions and activities -Create a modified app (means an APK file to install the app with a patch already applied)

not 100percent warranty that patching works due to modified libraries

erklären wie man ihn gestestet hat, woher die apps, nachgefragt ob ok etc

LuckyPatcher is described as following on the offical webpage: "Lucky Patcher is a great Android tool to remove ads, modify apps permissions, backup and restore apps,

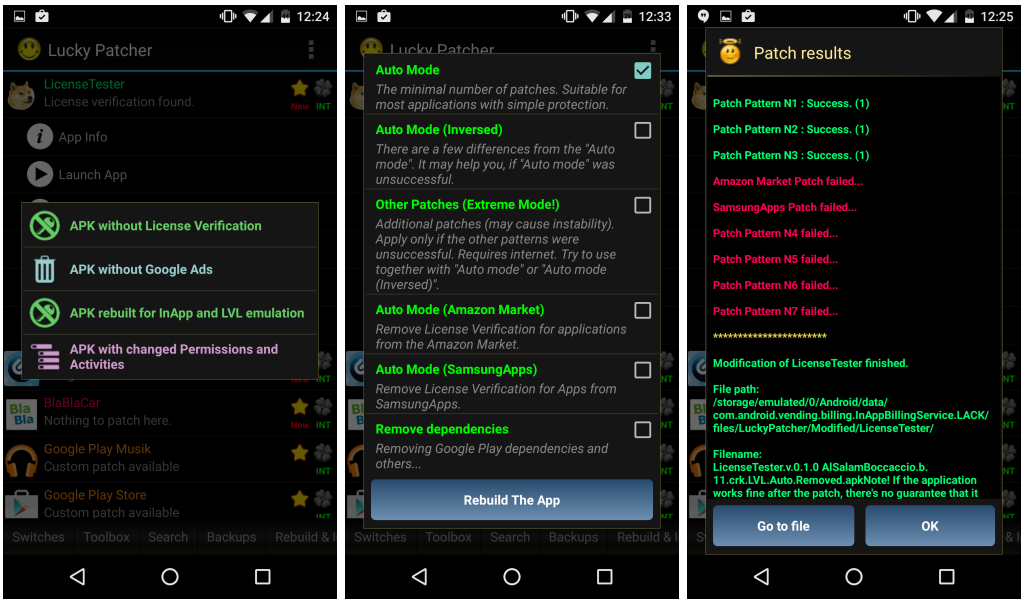


Figure 3.1: Left: Features offered LuckyPatcher
Middle: Variants to crack license verification
Right: Result after patching

bypass premium applications license verification, and more. To use all features, you need a rooted device." [8]

install apk from playstore -see- have root -see- open lucky -see- chose mode

this thesis focuses on the removing of licensing check, angewendet auf verschiedene apps aus den jeweiligen stores

3.2 Modus Operandi

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

analysis done by looking at patched applications since luckypatcher has done a lot of obfuscation etc which makes it almost impossible to undertand (tools crash, junkbyte injection, only a few giant classes in java which do not make sense, some classes not decompiled since crash, dex/smali not very useful since no names etc), poor decompilation result hard to analyze since of obfuscationa nd anti-decompilation measure

so look at cracked application in order to udnerstand how lucky aoptcher works diff between code of unpatched and patched version of application which have lvl included first it was tested with a simple app which was created and implemented lvl also for

apps from app store to see behaviour diff tool to compare code base and see positions lucky patcher attacks

multiple tools used to reverse engineer the license verification circumvention by lucky patcher (see tools from reengineering) first look at java code (higher representation, human readable), to understand what/where class/function have been modified smali for having names for the bytecode executions dex to see exactly how it was modified document intended change by luckypatcher

luckypatcher works by patching dex (patching based not call intercept)

most patching options target googles lvl, but also available for amazon and samsung

information if lvl is contained can be pulled from manifest because of com.android.vending.CHECK_LIC permission, only to show user and can circumvent anyway since solely for user to flag in market (ist das noch so?), trying to trick and not declare would break violate permissions and be stopped by andorid

luckypatcher extracts original classes.dex from apk and patches it patching is doen on binary level and done by using different patterns which are dependent on the modus (see patterns/modi) the result is either used to substitude the optimized classes.dex of attacked app with the patched .odex in dalvik cache (/data/dalvik-cache/), or can be output as an apk

works on most applications but has few problems on custom modified lvl libraries (liste der apps wo es funzt aus gdrive tabelle)

after applying patterns LP needs to update file header to reflect new checksum and hash values

[28]

wo arbeitet er?

warum dex und nicht odex anschauen?

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)

after modification the dex is signed again in order to work on the phone (see installation und signature)

WIE IST MEIN VORGEHEN? aufgrund dass odex datein device spezifisch sind und allgemeiner ansatz gesucht wird, wird die app playstore -> modified APK erstellen -> analysieren

3.3 Variants for Cracking License Verification

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

patterns und patching modes grob erklären (modi von luckypatcher die verschiedene operationen (pattern) auf app anwenden) => vorgehensweise zur

see figure **??** middle liuckypatcher offeres different sets of methods to remove the license verification Auto Mode - "The monomal number of patches. Suitable for most applications with simple protection" - uses patterns

Auto Mode (Inversed) - "There are a few differences from the ”Auto mode”. It may help you, if "Auto mode" was unsuccessful." - uses patterns

Other Patches (Extreme Mode!) - "Additional patches (mnay cause instability). Apply only if the other patterns were unsuccessful. Requires internet. Try to use together with ”Auto mode” or ”Auto mode (Inversed)”." - uses patterns

Auto Mode (Amazon Market) - "Removes License Verification for applciations from Amazon Market" - uses patterns

Auto Mode (SamsungApps) - "Removes License Verification for Apps from SamsungApps" - uses patterns (is now GalaxyApps)

in order to find out what patterns are doing, different apps had to be analysed after patching the apps chosen were already owned, in addition an app for each license verification model was created, uploaded and installed from the store so the license verification was working

to verify that license check is enabled, each app was extracted from the device using method described in 2.4 and installed on a device with a different google account then for each app a modified apk see figure **??** left, using one modus is created and copied to a computer for further inspection. so for each app there are 5 modified apks now

as example apps to show results Runtastic Pro[29], Version 6.3, the created LicenseTest and Teamspeak 3[40], Version 3.0.20.2, are chosen

the result after patching the different apps with each modus returned the patterns used by each modus

3.4 Patching Patterns

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

In order to identify the single patterns, the information from the output of cracking **??** right, of the apps was matched with the changes in the code. the changes in the code were inspected on dex, smali and java level with the tools explained in Section 2.4. in case of LVL, from the information where in the package the change was done,

Modus	Application LicenseTester	Runtastic Pro	Teamspeak 3
Purchased	yes	yes	yes
Pirated	no	no	no
Auto	yes	yes	no
Auto (Inversed)	no	yes	no
Extreme	no	yes	no
Auto+Extreme	yes	yes	no
Auto (Inversed)+Extreme	no	yes	no

Table 3.1: Functionality for the test apps before and after patching

conclusion to the original class from in the lvl could be done

diff for original app and modified app

example code taken from an app which was inspected, modification happens for all at the same spot/manner

dex == smali, smali better readable but dex to see how easy change since the translation from java to dex does some optimizations/logik, dex and java do not express the same, but it is how it is in the decompiled code, java is also an abstraction of the actual code, sometimes java also a little confusing since changes happened in dex code and cannot be decompiled to java in a good manner, very messy, it is included for better understanding anyways since humanreadable

Pattern N1

classes it attacks `com/google/android/vending/licensing/LicenseValidator` LicenseValidator, responsible for decrypting and verifying the response from the licensing server[16]

```
@@ Pattern N1 @@
- 03 01 00 00 0f 00 00 00 1a 00 00 00 0f 00 00 00 |................|
+ 03 01 00 00 0f 00 00 00 0f 00 00 00 1a 00 00 00 |................|
```

Code Snippet 3.1: Diff on Dex level for N1 pattern

values are swapped

```
@@ Pattern N1 @@
- 0x1 -> :sswitch_e0
- 0x2 -> :sswitch_d5
+ 0x1 -> :sswitch_d5
+ 0x2 -> :sswitch_e0
```

Code Snippet 3.2: Diff on Smali level for N1 pattern

switch case for input 0x01 (not licensed) and 0x02 (old license key) are swapped

```
@@ Pattern N1 @@
- case LICENSED_OLD_KEY: handleResponse();
- case NOT_LICENSED: handleError();
+ case NOT_LICENSED: handleResponse();
+ case LICENSED_OLD_KEY: handleError();
```

Code Snippet 3.3: Diff on Java level for N1 pattern (abstracted)

old code when license code not licensed return in case not licensed with error after patching when not licensed return as old license key

Pattern N2
classes it attacks `com/google/android/vending/licensing/LicenseValidator.java` LicenseValidator, responsible for decrypting and verifying the response from the licensing server[16] greift auch zB. google maps api (`com/google/android/gms/`) oder in app billing (`com/android/iab/v3/`) an, collateral schaden one Pattern

```
@@ Pattern N2 @@
- 0c 05 6e 20 9d 4a 53 00 0a 05 39 05 2d 00 1a 05 |..n .JS...9.-...|
+ 0c 05 6e 20 9d 4a 53 00 12 15 39 05 2d 00 1a 05 |..n .JS...9.-...|
```

Code Snippet 3.4: Diff on Dex level for N2 pattern

move-result is replaced by move const

```
@@ Pattern N2 @@
- move-result v5
+ const/4 v5, 0x1
```

Code Snippet 3.5: Diff on Smali level for n2 pattern

instead of moving the result from a function to v3, it is initiated with true/1

```
@@ Pattern N2 @@
- if (sig.verify(Base64.decode(signature))) {...;}
+ sig.verify(Base64.decode(signature); ...;
```

Code Snippet 3.6: Diff on Java level for N2 pattern (abstracted)

old code: signature was verified, if true it is continued after patching the verification is treated as always true and so it is continued

Pattern N3
classes it attacks `com/google/android/vending/licensing/APKExpansionPolicy.java` `com/google/android/vending/licensing/ServerManagedPolicy.java` Policy integration of License Verification Library, those are the two examples offered by Google[16]

```
@@ Pattern N3 @@
- 12 10 12 01 71 00 a6 89 00 00 0b 02 52 84 c1 1c |....q.......R...|
+ 12 10 12 11 71 00 a6 89 00 00 0b 02 52 84 c1 1c |....q.......R...|

@@ Pattern N3i @@
- 34 00 00 00 12 11 12 00 71 00 70 9d 00 00 0b 02 |4.......q.p.....|
+ 34 00 00 00 12 01 12 00 71 00 70 9d 00 00 0b 02 |4.......q.p.....|
```

Code Snippet 3.7: Diff on Dex level for N3 pattern

for forward value 0x0 is switched with 0x1 and for inverse...inversed

```
@@ Pattern N3 @@
- const/4 v1, 0x0
+ const/4 v1, 0x1

@@ Pattern N3i @@
- const/4 v1, 0x1
+ const/4 v1, 0x0
```

Code Snippet 3.8: Diff on Smali level for N3 pattern

variable is initiated with opposite of what they were initiated before

```
@@ Pattern N3 @@
- return false;
+ return true;

@@ Pattern N3i @@
- return true;
+ return false;
```

Code Snippet 3.9: Diff on Java level for N3 pattern (abstracted)

old code variable is initiated false and true for inversed as basic return value after patching the return is the opposite, meaning all true results are now false and all false are now true, meaning wrong input is declared as OK

Pattern N4
classes it attacks `com/google/android/vending/licensing/LicenseChecker.java` LicenseChecker, class that instatiates a license check[16]

```
@@ Pattern N4 @@
- d5 70 00 00 0a 00 38 00 0e 00 1a 00 5a 20 1a 01 |.p....8.....Z ..|
+ d5 70 00 00 0a 00 33 00 0e 00 1a 00 5a 20 1a 01 |.p....3.....Z ..|
```

Code Snippet 3.10: Diff on Dex level for N4 patch

if-eqz is repalces by if-ne

```
@@ Pattern N4 @@
- if-eqz v0, :cond_15
+ if-ne v0, v0, :cond_15
```

Code Snippet 3.11: Diff on Smali level for N4 patch

in the original code variable v0 is compared for not equality with zero after it is patched it is always compared with itself which returns always true and the condition is always called

```
*@@ Pattern N4 @@*
!!- if(licenseCached())!!
??+ b = licenseCached()??
??+ if(b == b)??
```

Code Snippet 3.12: Diff on Java level for N4 patch (abstracted)

in the original code it is checked whether the license is already cached, fi yes, condition is called after patching the result of the check is always compared to itself, and thus the condition is always called

Pattern N5
classes it attacks `com/google/android/vending/licensing/LicenseValidator.java`
works the same way as pattern N2
im gegensatz zu N2 wird jetzt die condition nie aufgeraufen anstatt sie immer aufzurufen wie in N5 result is that the check for the result code given to the function and extracted from the server response is disabled since the result of the check is set to always false

Pattern N6
classes it attacks `com/google/android/vending/licensing/LicenseValidator.java`

```
@@ Pattern N6 @@
- 38 0a 06 00 32 4a 04 00 33 5a 21 01 1a 00 ab 15 |8...2J..3Z!.....|
+ 12 0a 00 00 32 00 04 00 33 5a 21 01 1a 00 ab 15 |....2...3Z!.....|
```

Code Snippet 3.13: Diff on Dex level for N6 patch

if-eqz is replaced by move constant, variables for if-eq are changed

```
@@ Pattern N6 @@
- if-eqz p2, :cond_e
+ const/4 p2, 0x0

- if-eq p2, v4, :cond_e
+ nop
+
+ if-eq v0, v0, :cond_e
```

Code Snippet 3.14: Diff on Smali level for N6 patch

instead of testing for zero and then calling a condition, the to test variable is changed and the condition removed the second equal check is done by comparing a variable with itself thus always true and the conidition is called

```
@@ Pattern N6 @@
- if ( p2 == 0 || p2 == v8) cond_c
+ p2 = 0
+ if (v0 == v0) cond_c
```

Code Snippet 3.15: Diff on Java level for N6 patch (abstracted)

instead checking two variables for a case, the condition is just always called

Pattern N7

classes it attacks `com/google/android/vending/licensing/ILicenseResultListener.java` ILicenseResultListener, IPC callback implementation, receives async response from server[16] einfach auf alles was in `com/android/` ist, some kind of bruteforce

similar to N2, but Java result is more generic

```
@@ Pattern N7 @@
- x = foo();
+ x = false;
```

Code Snippet 3.16: Diff on Java level for N7 patch (abstracted)

instead of initializing variable with result from function, it is always initialized with false / 0

Amazon
also applies pattern N2

classes it attacks, inside kiwi logic `com/amazon/android/licensing/b.java com/amazon/android/o/d.java`

see, obfuscated

similar like pattern N4

```
@@ Pattern A @@
- 0a 00 38 00 0a 00 62 00 56 20 1a 01 4e 49 6e 20 |..8...b.V ..NIn |
+ 0a 00 33 00 0a 00 62 00 56 20 1a 01 4e 49 6e 20 |..3...b.V ..NIn |
```

Code Snippet 3.17: Diff on Dex level for Amazon patch

if-eqz is repalces by if-ne

```
@@ Pattern A @@
- if-eqz v0, :cond_1f
+ if-ne v0, v0, :cond_1f
```

Code Snippet 3.18: Diff on Smali level for Amazon patch

in the original code variable v0 is compared for not equality with zero after it is patched it is always compared with itself which returns always true and the condition is always called

```
@@ Pattern A @@
- if(v0.equals("LICENSED"))
+ b = v0.equals("LICENSED")
+ if(b == b)
```

Code Snippet 3.19: Diff on Java level for Amazon patch (abstracted)

in the original code the result from the server is tested whether it is "LICENSED" after patching the response is always evalauted and the result is compared with itself which is always true

result never the less what the check for "LICENSED" returns, the condition for "LICENSED" is always called

Samsung Pattern
also applies pattern N2

classes it attacks, inside zirconia logic com/samsung/zirconia/LicenseRetriever.java com/samsung/zirconia/Zirconia.java

not obfuscated

two patterns, lets call it S1 and S2, S1 used on both, S2 used twice on zirconia

```
@@ Pattern S1 @@
- 08 00 0c 08 6e 10 66 4a 08 00 0a 06 32 d6 0a 00 |....n.fJ....2...|
+ 08 00 0c 08 6e 10 66 4a 08 00 0a 06 32 00 0a 00 |....n.fJ....2...|

@@ Pattern S2 @@
- 10 02 0a 00 0f 00 00 00 03 00 01 00 02 00 00 00 |................|
+ 10 02 12 10 0f 00 00 00 03 00 01 00 02 00 00 00 |................|
```

Code Snippet 3.20: Diff on Dex level for Samsung patch

S1 input for if-eq is modified S2 move-result is replaced by move const

```
@@ Pattern S1 @@
- if-eq v6, v13, :cond_52
+ if-eq v0, v0, :cond_52

@@ Pattern S2 @@
- move-result v0
+ const/4 v0, 0x1
```

Code Snippet 3.21: Diff on Smali level for Samsung patch

S1 in the original code checks whether to different variables are equal after patching the check is done with the same variables and thus always returns true

S3 in the original code the result of a function is moved to v0 and returned after patching true/1 is always moved to v0 and returned

```
@@ Pattern S1 @@
- if (v6 == 12)
+ if (v0 == v0)

@@ Pattern S2 @@
- return foo();
+ return 1;
```

Code Snippet 3.22: Diff on Java level for Samsung patch (abstracted)

com/samsung/zirconia/LicenseRetriever.java always starts condition, even though input is not "12" as supposed to start com/samsung/zirconia/Zirconia.java S1 always

returns true for checkLicenseFile and checkLicenseFilePhase2, does not check anything which is done normally S2 always starts condition, even though input is not as supposed to start `com/samsung/zirconia/Zirconia.java`

	Patterns							
Modus	N1	n3	N3	N3i	N4	N5	N6	N7
Auto	X	X	X		X			
Auto (Inversed)	X	X		X	X			
Extreme						X	X	X
Auto+Extreme	X	X	X		X	X	X	X
Auto (Inversed)+Extreme	X	X		X	X	X	X	

Table 3.2: Overview of License Verification Library patching patterns applied by each modus

summarizing what patterns each modus applies Table 3.2

auto: just applies minimum patches, N1 swaps switch cases so not licensed is treated here as old license key in the LicenseValidator, N2 skips the signature verification in the LicenseValidator, N3 inverts the return boolean for the policy checks in the implemented Policy class by initializing with 0/false, and N4 skips, in the only case occured in the test set, the check whether download is allowed and allows it always auto inverse: does the same as auto but initializes the policy check with 1/true instead of false extreme: auto+extreme: applies auto and extreme patches auto inverse+extreme: applies auto and extreme patches

!!! kann man das excel sheet in die datein machen und nicht als appendix, da manche apps ihre ergebnisse nicht öffentlich sehen wollen !!!

3.5 Learnings from LuckyPatcher

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

first patching point could be the initial call, in case modified lvl patching initial call would be not enough since the on success block could contain important code (like ui creation) then it would be useless

since automated customizations have to be implemented to trick it make false checks to detect tampering -see- user patch

amazon/samsung not much to do since from company, beyond control of developer since injection after developer and a library provided by samsung which is only called, that is why the following not simple methods target lvl

known bytecode patterns, replace with custom, makes mechanism useless

following present ways of protecting against patching attempts, especially predefined recipes circumventing the LVL high motivation, the patterns/patching modes cover many apps, more than custom

should not use one but many methods solution for current version of lucky patcher, future might be different, arms race scenario [28]

4 Counter Measurements for Developers

Now that 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 aquired 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 developerś 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`

countermeasurements can be applied at different levels, when creating the software, when compiling the code to dex and on the dex file itself

goal is to

amazon/samsung not much to do since from company that is why the following not simple methods target lvl

patching application code is both most wide-spread and most powerful to interfer app logic ease is unfortunate for android developers, need better methods to protect vulnerable/precious code from attacks adding additional layer of security, making it a little ahrder for attackers

CHARAKTERIZED IN DIFFERENT TYPES, tampering protection to detect attack, modifications to enforce additional work in order to crack, methods directly targeting reengineering and additional external features, can be stacked [28]

4.1 Tampering Protection

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

applied when programming

Environment and Integrity Checks, wenn die umgebung falsch ist, kann die app verändert werden. deswegen von vornherein ausschließen, dass die bedingungen dafür gegeben sind. [28]

mechanisms should work for amazon/lvl/samsung –see- 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.

also works for samsung and amazon

in order to remove/disable lvl they have to modify the code unless done precisely can be detected by code [20]

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 funktionsweise 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.
            FLAG_DEBUGGABLE));
16
17      if (debuggable) {
18          android.os.Process.killProcess(android.os.Process.myPid());
19      }
20
21      return debuggable;
22  }
```

Code Snippet 4.1: asd[8]

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-licer`

```
16  public static boolean findBinary(Context context, final String binaryName) {
17      boolean result = false;
18      String[] places = {
19              "/sbin/",
20              "/system/bin/",
21              "/system/xbin/",
22              "/data/local/xbin/",
23              "/data/local/bin/",
24              "/system/sd/xbin/",
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.lackypatch",
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-fro`

```
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.
                getPackageName());
23
24          if (installer != null) {
25              if (installer.startsWith(PLAYSTORE_ID)) {
26                  result = true;
27              }
28              if (installer.startsWith(AMAZON_ID)) {
29                  result = true;
30              }
31              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

The unfortunate side effect of Lucky Patcher working with the Dalvik cache of an app is that the app developers cannot detect manipulations to their code through fingerprinting because the orig- inal code, located in “/data/app/<appName.apk>/classes.dex”, remains untouched. While it is allowed for an app to access its own optimized bytecode from the cache [32], computing a checksum or a hash for it doesn’t make sense because many optimizations to this bytecode are device-specific and cannot be known in advance. [28] !!!überprüfen!!!

Local Signature Check

This is my real text! Rest might be copied or not be checked!
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.
                getPackageName(), PackageManager.GET_SIGNATURES);
58
59          for (final Signature signature : packageInfo.signatures) {
60              final String currentSignature = signature.toCharsString();
61              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

—> was passiert wenn odex?

4.1.6 Flow Control

This is my real text! Rest might be copied or not be checked!
zweimal LVL und eins failed immer, wenn stumpf modifiziert wird werden beide immer strue und somit erkennt man ob gepatcht wurde
visuelle elemente block für block freischalten, weg der definiert ist, wenn lvl licensed, wenn irgendwo geskippt wird fehlt ein element activate/kill in defined blocks, e.g. if vor switch, noch radikaler

4.2 Library Modifications

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

applied when programming

way to challenge luckypatcher is to actively go against luckypatcher patterns, achieved by modifying the library, see patterns to fight in patterns chapter can be done in different ways, modify library or go native

many developers do not customize the library, easy to hack [28]

goal is to make lvl implementation unique, difficult to trace when decompiled counter intuitive from traditional software engineering viewpoint, removing functions, hiding license check routines in unrelated code

Google is aware of easy hacking and thus suggests modifcations to the lvl modify license verification library in way that it is difficult for attacker to modify the disassembled code and get a positive check as result advantages, harder to crack, cannot be used as blueprint and no blueprint can be used on it, unique [20] ERWÄHNEN DASS IM PROGRAMMIER PROZESS IMPLEMENTIERT

4.2.1 Modify the Library

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

beispiel für jeden patch

switch: replace switch statement with if

general move the lvl into own application folder replace functions with inline code when possible

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

4.2.2 Native Implementierung

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

impose strict native-to-native interaction not usable from java code, but only indirectly through native code library does need two things - users do not custimize library so a heavily obfuscated version could be needed - use encryption and dynamic code loading, updated and ecery-changing state that an app would not be stuck with a version until update dynamic code generation, automatically custimize itself for every app and ever time its loaded [28]

VORTEILE VON NATIVE?

Library native
native ist nicht in dex -see- besser?
so nur schnittstelle? dann einfach sozusagen die schnittstelle faken

luckypatcher tauscht so ganz aus bzw modifizeirt dex
ggf einfach .so library austauschen, aber großer aufwand zu kompilieren davor

4.3 Reverse Engineering Prevention

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

now that the environment is enforced and the lvl is modified, the next goal is to prevent pirates from even starting to analyze the applcation Reverse engineering and code protection are processes which are opposing each other, neither classified as good nor bad
"good" developer: malware detection and IP protection
"bad" developer: analysis for attack and analysis resistance

[23] it is not possible to 100 percent evade reengineering, but adding different methods to hide from plain sight of reengineering tools reengineering cannot be vermiede best is to apply technqiues to make it as hard a possible [28]

if they do not see what the app is doing, they cannot fix it

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 -see- 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 -see- 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-malwa
html

4.3.1 Break Common Reengineering Tools

applied on dex file

One way to prevent reengineering is to break the tools used to reengineer the software can be done by different ways APKfuscator[37] is an example which includes some variants of how to break these tools it was presented on Blackhat 2012 at the talk "dex education: practicing safe"[38] [39] it is a generic obfuscator and munger which works on dex fiels directly simple ideas the propotype has following features

Too long filenames
pirates want to have java to better understanding of code, try to fight there files inside jar have no character limit for names change name of class to alrge but valid name `https://youtu.be/Rv8DfXNYnOI?t=985` works except for the class
breaks only baksmali

Inject bad op code
viele schlagen vor: junkbyte injection well known technique in x86, confuse disassemblers in a way that they produce disassembly errors and disallow correct interpretations, inserting junkbytes in selected locations within the bytecode where a disassembler expects an instruction, junkbyte must take the disassembling strategy into account in order to reach a maximum of obfuscated code, break the two disassebly stragien from 2.4.0, condition for the location is that the junkbyte must not be executed, because an execution would result in an undesired behavior of the application, junkbyte must be located in a basic block which will never be executed [31]

use bad opcode in deadcode
e.g. reference not inited strings [39]

Abuse differences between Dalvik and Java
include code that is legal in dalvik world but not in java world e.g. recursive try/catch as described in [39], valid dex code but (might be) impossible in Java code, has to be implemented into the class which should not be recovered by the attacker

Increase header size
expected to be 112 bytes, just increase header size which might unexpected to some programms you have to edit every other offset as well

4.3.2 Obufscation

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

applied when compiling

(a) at source code and (b) bytecode level, Most existing open-source and commercial tools work on source code level

Java code is architecture-independent giving freedom to design generic code transformations. Lowering the obfuscation level to bytecode requires the algorithms applied to be tuned accordingly to the underlying architecture

[23]

a few dex obfuscators exist, with different approaches proguard or sdex, rename methods, field and calss names – break down string operations so as to chop hard coded strings or encrypt – can use dynamic class loading (dexloader classes to impede static analysis) can add dead code and dummy lopps (minor impact of performance) can also use goto into other onstructions

[26]

layout obfuscation most programmers name their variables, methods and calss in meaning ful way are preserved in generation of bytecode for dvm, hence still in dex, can be extracted by attacker, gain information and benefit when reengineering mangles names and ifentifiers that original meaning is lost while preserving correctness of syntax and semantics result is bytecode can be interpreted but dissable and decompiule provide meaningless name for identifiers etc, e.g single letters or short combinations, welcome for strings section make it smaller only complicates but does not stop

[28]

will not protect against autoamted attack, does not alter flow of program makes more difficult for attackers to write initial attack removing symbols that would quickly reveal original structure number of commercial and open-source obfuscators available for Java that will work with Android [20]

hilft nicht direkt, aber um reengineering besser zu machen

ERWÄHNEN WO IM PROZESS ANGEWENDET

Obfuscators/Optimizors definition

Obfuscation techniques are used to protect software and the implemented algorithms designed to make reverse engineering harder and more time consuming, hin und her zwischen obfuscation und reverse engineering techniken

obfuscation techniques must not alter the behavior of programs, often only target specific reverse engineering steps, few general protection schemes, possible slower execution, not topic here, just examples for obfuscation applications

remove dead/debug code

potentially encrypt/obfuscate/hide via reflection
https://youtu.be/6vFcEJ2jgOw?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

parallele zu disassembler ziehen

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!

A Java source code obfuscator. ProGuard performs variable identifiers name scrambling for packages, classes, methods and fields. It shrinks the code size by automatically removing unused classes, detects and highlights dead code, but leaves the developer to remove it manually [23]

open source tool shrinks, optimizes and obfuscates java .class files result - smaller apk files (use rprofits download and less space) - obfuscated code, especially layout obfuscation, harder to reverse engineer - small performance increase ddue to optimizations integrated into android build system, thus easy use default turned off minifyEnabled true proguardFiles getDefaultProguardFile('proguard-android.txt), 'proguard-rules.pro'

additional step in build process, right after java compiler compiled to class files, Proguard performs transformation on files removes unusaed classes, fields, methods and attributes which got past javac optimization step methods are inlined, unused parameters removed, classes and methods made private/static/final as possible obfuscation step name and identifiers mangled, data obfuscation is performed, packages flattened, methods renamed to same name and overloading differentiates them

after proguard is finished dx converts to classes.dex

BILD VORHER NACHER [28]

https://youtu.be/6vFcEJ2jgOw?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)

identifier mangling, ProGuard uses a similar approach. It uses minimal lexical-sorted strings like a, b, c, ..., aa, ab, original identifiers give information about interesting parts of a program, Reverse engineering methods can use these information to reduce the amount of program code that has to be manually analyzed -see- neutralizing these information in order to prevent this reduction, remove any meta information about the behavior, meaningless string representation holdin respect to consistence means identifiers for the same object must be replaced by the same string, advantage of minimizing the memory usage, e development process in step ”a” or step ”b”
string obfuscationa, string must be available at runtime because a user cannot understand an obfuscated or encrypted message dialog, information is context, other is information itself, e.g. key, url, injective function and deobfuscation stub which constructs original at runtime so no behaviour is changed, does not make understanding harder since only stub is added but reduces usable meta information
[31]

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? -see- 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? -see- 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 -see- how

http://developer.android.com/tools/help/proguard.html
optimizes, shrinks, (barely) obfuscates –see- free, reduces size, faster
gutes bild https://youtu.be/TNnccRimhsI?t=1360
removes unnecessary/unused code
merges identical code blocks
performs optimiztations
removes debug information
renames objects
restructures code

removes linenumbers –see- stacktrace annoying
https://youtu.be/6vFcEJ2jgOw?t=470
–see-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 -see- 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!

A commercial Android obfuscator [37] working both on bytecode and source code level (should not be mistaken with dexguard analysis tool). Performs various techniques including strings encryprion, encrypting app resources, tamper detection, removing logging code. [23]

ERWÄHNEN WO IM PROZESS ANGEWENDET

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)

OVERVIEW
son of proguard
the s̈tandardp̈rotection
optimizer
shrinekr
obfuscator/encrypter, does not stop reverse engineering
https://youtu.be/6vFcEJ2jgOw?t=643
WHAT DOES IT DO
everything that proguard does
automatic reflection
strign encryption
asset/library encryption
class encryption(packign)

applciation tamper protection
file-see-automatic reflection-see-string encryption-see-file
`https://youtu.be/6vFcEJ2jgOw?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

ESULT -see- UNTERSCHIED ZU DEN VORHERIGEN -see- 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!
ERWÄHNEN WO IM PROZESS ANGEWENDET

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
remvoes debug code
not much obfuscation
Proguard+string encryption
easily reversed
hacker protection factor 0.5
https://youtu.be/6vFcEJ2jgOw
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 -see- UNTERSCHIED ZU DEN VORHERIGEN -see- 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 Packers

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

ERWÄHNEN WO IM PROZESS ANGEWENDET

dynamic code loading best would be an application is transformed by obfuscator that it does not contain any meta information or directly interpretable bytecode, not possible because DVM would not be able to read -see- packing, often used in malware [18]
packer transforms code that a reverse engineer cannot directly extract information, e.g. by encrypting programm data no information can be extracted without decrypting,

would be bad for programm as well that is why packer uses loader stub to decrypt in runtime, soultion decrypt by hand or dynamic analysis
in general two components are created, loader stub and encrypted app, on android the encrypted dex file, easier to create as the loader stub
BILD WIE ER FUNKTIONIERT step 1 load encrypted app into memory (download from server, extract from data structure, plain file available) step 2 app file is decrypted -see- original dex, can be any encryption from simple to hard, speed may slow down step 3 load decrypted dex into DVM from a bytearray, see [31] step 4 execute

[31] stellt hier basic version vor, bessere versionen ist das im folgenden

result: protection makes it hard to analyze the target application, because its bytecode is only available encrypted, decrypted version the unpacking stub has to be analyzed, great slow down, other obfuscations can be applied on stub

program delivered to end user should be transformed, no direct link between it and original source code, attackers cannot reengineer code and find vulnerability

[28]

break static analysis tools, you ahve 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=M5GKDCcQB5dcwXR3hjtIv8pMlAA&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=6vFcEJ2jgOw
https://books.google.de/books?id=ACjUCgAAQBAJ&pg=PA372&lpg=PA372&dq=ijiami+integrity&source=bl&ots=NTf7YaqJiZ&sig=M5GKDCcQB5dcwXR3hjtIv8pMlAA&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/6vFcEJ2jgOw?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/6vFcEJ2jgOw?t=1982`

anti-debug
anti-tamper

appears to be defunct product
little usage/samples ITW
FUNCTION
https://youtu.be/6vFcEJ2jgOw?t=2040
encrypts dex file and bundles as asset in APK
very easy to find, logcat has to 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

BANGCLE
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)

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

APKprotect

bisschen anders als packer
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/6vFcEJ2jgOw?t=347`
`https://youtu.be/6vFcEJ2jgOw`
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 momory 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 knwo if still alive
hacker protection factor 3, no public documentation, but every app is the same

4.4 External Support

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!
ERWÄHNEN WO IM PROZESS ANGEWENDET

`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`

4.4.2 ART endlich durchsetzen

This is my real text! Rest might be copied or not be checked!
Evaluation Why is Android not all ART now? Your applications still compile into Dalvik (DEX) code, Final compilation to ART occurs on the device, during install, Even ART binaries have Dalvik embedded in them, Some methods may be left as DEX, to be interpreted, Dalvik is much easier to debug than ART
[26]

ERWÄHNEN WO IM PROZESS ANGEWENDET

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!
WAS IST ES? WAS MACHT ES? WIE IMPLEMENTIERT MAN?
ERWÄHNEN WO IM PROZESS ANGEWENDET

new section trusted execution environment trusttronic letzte conference samsung knox –see-gelten eher sicher
`https://usmile.at/sites/default/files/androidsecuritysymposium/presentations/Thomas_Holmes_AnInfestationOfDragons.pdf`
TEE!!!
was ist dann geschützt? content, servers, time constrained urls, obfuscation by using reflection combined with SE -see- 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`

DAP Verification .... normalerweise muss jede Applet, die auf so ein Secure Element/Smartcard etc. kommt mit ner Signatur unterschrieben sein ...
Waehrend ich Exploits finden konnte, die Dir erw. Zugriff geben, wenn du Applets installieren kannst, u.a.

4.4.4 Trusted Execution Environment

This is my real text! Rest might be copied or not be checked!
WAS IST ES? WAS MACHT ES? WIE IMPLEMENTIERT MAN?
nachdem du dich mit Secure Elements befasst, moechte ich dich auch auf TEEs hinweisen, die ebenfalls (und nach Aussage von Atredis) fuer DRM genutzt werden.

Speziell dortiges QSEE hatte jedoch schwerwiegende Luecken.

beispiele: new section trusted execution environment trusttronic letzte conference samsung knox

5 Evaluation of Counter Measurements

Now that the counter measurements are presented, it is time to evaluate their potential versus LuckyPatcher. But not only their capabilities are important for developers but their practicability as well, e.g. price or effort to implement. Each measurement will be looked at in the following.

Evaluation der vorgeschlagenen punkte mit pro cons und umsetzbarkeit

5.1 Tampering Protection

all tampering counter measurements have kind of the same pattern, boolean check, simple method == simple fix, can be nulled easily when code is known, just as easy to crack as LVL when you know the code, but attackr has to invest some time to understand code and to build counter measurement, in addition with Section 5.3 this can get annoying, evtl create native versions because harder to crack even though it is simple it adds a little bit extra work to attack and when cobined this grows exponential

but be careful because annoy people who want to use root annoy people who bought the app but have luckypatcher/root as well

!!!signature problem mit maps überprüfen!!!

5.2 Library Modifications

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

this should be the first solution anyone does

5.2.1 Modify the Library

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

jedes beispiel analysieren (gegen luckypatcher testen)

5.2.2 Native Implementierung

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

native diskutieren vor und nachteile bekannte exploits?

reengineering kann aushebeln

NATIVE Als ein eigenstaendiges Kapitel koenntest du auch noch untersuchen, wie sich Java-Code und Native-Code am Besten mit einander verflechten lassen, um optimalen Schutz gegen den Lucky Patcher zu gewaehrleisten.

Erste Ideen gab es dazu ja bereits - auch von anderen, wie etwa die Verschluesslung von Inhalten und Dekodierung im native Code unter Verwendung von Secure Elements oder Manipulation von Speicherwerten ueber native Libraries, sodass man die Aenderung im (Java) Smali-Code gar nicht mitbekommt. Letzteres hat Herr Hugenroth in einer Seminararbeit einmal grob skizziert (liegt Dir das vor?). Vielleicht fallen Dir weitere Optionen ein? Auch theoretische Ideen sind willkommen.

5.3 Reverse Engineering Prevention

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

now that the environment is enforced and the lvl is modified, the next goal is to prevent pirates from even starting to analyze the applcation Reverse engineering and code protection are processes which are opposing each other, neither classified as good nor bad

"good" developer: malware detection and IP protection

"bad" developer: analysis for attack and analysis resistance

[23] it is not possible to 100 percent evade reengineering, but adding different methods to hide from plain sight of reengineering tools reengineering cannot be vermiede best is to apply technqiues to make it as hard a possible [28]

if they do not see what the app is doing, they cannot fix it

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 -see- 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 -see- 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-malwa
html

5.3.1 Break Common Reengineering Tools

applied on dex file

One way to prevent reengineering is to break the tools used to reengineer the software can be done by different ways APKfuscator[37] is an example which includes some variants of how to break these tools it was presented on Blackhat 2012 at the talk "dex education: practicing safe"[38] [39] it is a generic obfuscator and munger which works on dex fiels directly simple ideas the propotype has following features

Too long filenames
pirates want to have java to better understanding of code, try to fight there files inside jar have no character limit for names change name of class to alrge but valid name https://youtu.be/Rv8DfXNYnOI?t=985 works except for the class
breaks only baksmali

Inject bad op code
viele schlagen vor: junkbyte injection well known technique in x86, confuse disassemblers in a way that they produce disassembly errors and disallow correct interpretations, inserting junkbytes in selected locations within the bytecode where a disassembler expects an instruction, junkbyte must take the disassembling strategy into account in order to reach a maximum of obfuscated code, break the two disassebly stragien from 2.4.0, condition for the location is that the junkbyte must not be executed, because an execution would result in an undesired behavior of the application, junkbyte must be located in a basic block which will never be executed [31]

use bad opcode in deadcode
e.g. reference not inited strings [39]

Abuse differences between Dalvik and Java
include code that is legal in dalvik world but not in java world e.g. recursive try/catch as described in [39], valid dex code but (might be) impossible in Java code, has to be implemented into the class which should not be recovered by the attacker

Increase header size

expected to be 112 bytes, just increase header size which might unexpected to some programms you have to edit every other offset as well

5.3.2 Obufscation

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

applied when compiling

(a) at source code and (b) bytecode level, Most existing open-source and commercial tools work on source code level

Java code is architecture-independent giving freedom to design generic code transformations. Lowering the obfuscation level to bytecode requires the algorithms applied to be tuned accordingly to the underlying architecture

[23]

a few dex obfuscators exist, with different approaches proguard or sdex, rename methods, field and calss names – break down string operations so as to chop hard coded strings or encrypt – can use dynamic class loading (dexloader classes to impede static analysis) can add dead code and dummy lopps (minor impact of performance) can also use goto into other onstructions

[26]

layout obfuscation most programmers name their variables, methods and calss in meaning ful way are preserved in generation of bytecode for dvm, hence still in dex, can be extracted by attacker, gain information and benefit when reengineering mangles names and ifentifiers that original meaning is lost while preserving correctness of syntax and semantics result is bytecode can be interpreted but dissable and decompiule provide meaningless name for identifiers etc, e.g single letters or short combinations, welcome for strings section make it smaller only complicates but does not stop

[28]

will not protect against autoamted attack, does not alter flow of program makes more difficult for attackers to write initial attack removing symbols that would quickly reveal original structure number of commercial and open-source obfuscators available for Java that will work with Android [20]

hilft nicht direkt, aber um reengineering besser zu machen

ERWÄHNEN WO IM PROZESS ANGEWENDET

Obfuscators/Optimizors definition

Obfuscation techniques are used to protect software and the implemented algorithms designed to make reverse engineering harder and more time consuming, hin und her zwischen obfuscation und reverse engineering techniken

obfuscation techniques must not alter the behavior of programs, often only target specific reverse engineering steps, few general protection schemes, possible slower execution, not topic here, just examples for obfuscation applications

remove dead/debug code
potentially encrypt/obfuscate/hide via reflection
`https://youtu.be/6vFcEJ2jgOw?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

parallele zu disassembler ziehen

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!

A Java source code obfuscator. ProGuard performs variable identifiers name scrambling for packages, classes, methods and fields. It shrinks the code size by automatically removing unused classes, detects and highlights dead code, but leaves the developer to remove it manually [23]

open source tool shrinks, optimizes and obfuscates java .class files result - smaller apk files (use rprofits download and less space) - obfuscated code, especially layout obfuscation, harder to reverse engineer - small performance increase ddue to optimizations integrated into android build system, thus easy use default turned off minifyEnabled true proguardFiles getDefaultProguardFile('proguard-android.txt), 'proguard-rules.pro'

additional step in build process, right after java compiler compiled to class files, Proguard performs transformation on files removes unusaed classes, fields, methods and attributes which got past javac optimization step methods are inlined, unused parameters removed, classes and methods made private/static/final as possible obfuscation step name and identifiers mangled, data obfuscation is performed, packages

flattened, methods renamed to same name and overloading differentiates them
after proguard is finished dx converts to classes.dex
BILD VORHER NACHER [28]
https://youtu.be/6vFcEJ2jgOw?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)

identifier mangling, ProGuard uses a similar approach. It uses minimal lexical-sorted strings like a, b, c, ..., aa, ab, original identifiers give information about interesting parts of a program, Reverse engineering methods can use these information to reduce the amount of program code that has to be manually analyzed -see- neutralizing these information in order to prevent this reduction, remove any meta information about the behavior, meaningless string representation holdin respect to consistence means identifiers for the same object must be replaced by the same string, advantage of minimizing the memory usage, e development process in step ”a” or step ”b”
string obfuscationa, string must be available at runtime because a user cannot understand an obfuscated or encrypted message dialog, information is context, other is information itself, e.g. key, url, injective function and deobfuscation stub which constructs original at runtime so no behaviour is changed, does not make understanding harder since only stub is added but reduces usable meta information
[31]
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? -see- 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? -see- 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 -see- how

http://developer.android.com/tools/help/proguard.html
optimizes, shrinks, (barely) obfuscates –see- free, reduces size, faster
gutes bild https://youtu.be/TNnccRimhsI?t=1360
removes unnecessary/unused code
merges identical code blocks
performs optimiztations

removes debug information
renames objects
restructures code
removes linenumbers –see- stacktrace annoying
https://youtu.be/6vFcEJ2jgOw?t=470
–see-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 -see- 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!

A commercial Android obfuscator [37] working both on bytecode and source code level (should not be mistaken with dexguard analysis tool). Performs various techniques including strings encryprion, encrypting app resources, tamper detection, removing logging code. [23]

ERWÄHNEN WO IM PROZESS ANGEWENDET

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)

OVERVIEW
son of proguard
the s̈tandardp̈rotection
optimizer
shrinekr
obfuscator/encrypter, does not stop reverse engineering
https://youtu.be/6vFcEJ2jgOw?t=643
WHAT DOES IT DO
everything that proguard does
automatic reflection

strign encryption
asset/library encryption
class encryption(packign)
applciation tamper protection
file-see-automatic reflection-see-string encryption-see-file
`https://youtu.be/6vFcEJ2jgOw?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

ESULT -see- UNTERSCHIED ZU DEN VORHERIGEN -see- 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!
ERWÄHNEN WO IM PROZESS ANGEWENDET

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
remvoes debug code
not much obfuscation
Proguard+string encryption
easily reversed
hacker protection factor 0.5
`https://youtu.be/6vFcEJ2jgOw`
`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 -see- UNTERSCHIED ZU DEN VORHERIGEN -see- 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.

5.3.3 Packers

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

ERWÄHNEN WO IM PROZESS ANGEWENDET

dynamic code loading best would be an application is transformed by obfuscator that it does not contain any meta information or directly interpretable bytecode, not possible because DVM would not be able to read -see- packing, often used in malware

[18]
packer transforms code that a reverse engineer cannot directly extract information, e.g. by encrypting programm data no information can be extracted without decrypting, would be bad for programm as well that is why packer uses loader stub to decrypt in runtime, soultion decrypt by hand or dynamic analysis
in general two components are created, loader stub and encrypted app, on android the encrypted dex file, easier to create as the loader stub
BILD WIE ER FUNKTIONIERT step 1 load encrypted app into memory (download from server, extract from data structure, plain file available) step 2 app file is decrypted -see- original dex, can be any encryption from simple to hard, speed may slow down step 3 load decrypted dex into DVM from a bytearray, see [31] step 4 execute

[31] stellt hier basic version vor, bessere versionen ist das im folgenden
result: protection makes it hard to analyze the target application, because its bytecode is only available encrypted, decrypted version the unpacking stub has to be analyzed, great slow down, other obfuscations can be applied on stub
program delivered to end user should be transformed, no direct link between it and original source code, attackers cannot reengineer code and find vulnerability
[28]
break static analysis tools, you ahve 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=M5GKDCcQB5dcwXR3hjtIv8pMlAA&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=6vFcEJ2jgOw
https://books.google.de/books?id=ACjUCgAAQBAJ&pg=PA372&lpg=PA372&dq=ijiami+integrity&source=bl&ots=NTf7YaqJiZ&sig=M5GKDCcQB5dcwXR3hjtIv8pMlAA&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/6vFcEJ2jgOw?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/6vFcEJ2jgOw?t=1982
anti-debug
anti-tamper
appears to be defunct product
little usage/samples ITW
FUNCTION
https://youtu.be/6vFcEJ2jgOw?t=2040
encrypts dex file and bundles as asset in APK
very easy to find, logcat has to 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

BANGCLE
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)

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

APKprotect

bisschen anders als packer
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/6vFcEJ2jgOw?t=347`
`https://youtu.be/6vFcEJ2jgOw`
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 momory 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 knwo if still alive
hacker protection factor 3, no public documentation, but every app is the same

5.3.4 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-malwa`
`html`

BEISPIELBILDER!!

5.4 External Support

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

5.4.1 Service-managed Accounts

This is my real text! Rest might be copied or not be checked!
ERWÄHNEN WO IM PROZESS ANGEWENDET

`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

5.4.2 ART endlich durchsetzen

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

Evaluation Why is Android not all ART now? Your applications still compile into Dalvik (DEX) code, Final compilation to ART occurs on the device, during install, Even ART binaries have Dalvik embedded in them, Some methods may be left as DEX, to be interpreted, Dalvik is much easier to debug than ART
[26]

ERWÄHNEN WO IM PROZESS ANGEWENDET

art hat masschinen coed
wenn reengineerbar dann nicht gut

warum jetzt noch keine art apps? https://en.wikipedia.org/wiki/Android_Runtime
dex2oat

5.4.3 Secure Elements

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

WAS IST ES? WAS MACHT ES? WIE IMPLEMENTIERT MAN?

ERWÄHNEN WO IM PROZESS ANGEWENDET

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

https://usmile.at/sites/default/files/androidsecuritysymposium/presentations/Thomas_Holmes_AnInfestationOfDragons.pdf

TEE!!!

was ist dann geschützt? content, servers, time constrained urls, obfuscation by using reflection combined with SE -see- 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

DAP Verification .... normalerweise muss jede Applet, die auf so ein Secure Element/Smartcard etc. kommt mit ner Signatur unterschrieben sein ...

Waehrend ich Exploits finden konnte, die Dir erw. Zugriff geben, wenn du Applets installieren kannst, u.a.

5.4.4 Trusted Execution Environment

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

WAS IST ES? WAS MACHT ES? WIE IMPLEMENTIERT MAN?

nachdem du dich mit Secure Elements befasst, moechte ich dich auch auf TEEs hinweisen, die ebenfalls (und nach Aussage von Atredis) fuer DRM genutzt werden. Speziell dortiges QSEE hatte jedoch schwerwiegende Luecken.

beispiele: new section trusted execution environment trusttronic letzte conference samsung knox

5.4.5 Service-managed Accounts

5.4.6 ART

5.4.7 Secure Elements

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

6 Conclusion

This is my real text! Rest might be copied or not be checked!
research and also a valuable market for companies
Because source code can be easier recovered from an application in comparison to x86, there is a strong need for code protection and adoption of existing reverse engineering methods. Main parts of Android application functionalities are realized in Dalvik bytecode. So Dalvik bytecode is of main interest for this topic
Also, the Android system does not prevent modification of this bytecode during runtime, This ability of modifying the code can be used to construct powerful code protection schemata and so make it hard to analyze a given application.
[31]
current state of license verification on Android reverse engineering far too easy due to OS, extract/install allowed gaining root easy, allows everyone especially pirates avoiding proteciton mechanisms java was chosen to support a lot of hardware, java has bad protection
lvl popular but broken, has not done much since beginning of known issues [28]
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!
jedes chapter beschreiben

6.2 Discussion

This is my real text! Rest might be copied or not be checked!
clear in beginnign that lvl not sufficiently safe with current technology unclear degree and fixavle

shortly after start insufficient reilience against reverse engineering, not explusivly to lvl thus shift from lvl protection to general protection against reverse engineering, decompilation and patching

eternal arms race no winning solution against all cases, jsut small pieces quantitative improvement no qualitatively improve resilience limited to quantitative resilience, matter of time until small steps generate more work for reengineering, ggf lower motivation for cracker only matter of time until patching tools catch up, completely new protection schemes need to be devised to counter those [28]

not a question of if but of when bytecode tool to generate the licens elibrary on the fly, using random permutations and injecting it everywhere into the bytecode with an open platform we have to accept a crack will happen [22]

alles hilft gegen lucky patcher auf den ersten blick, jedoch custom patches, welche LuckyPatcher anbietet[28], können es einfach umgehen, deswegen hilft nur reengineering schwerer zu machen viele piraten sind nicht mehr motiviert wenn es zu schwer ist every new layer of obfuscation/modifcation adds another level complexity

sis is text `http://www.digipom.com/how-the-android-license-verification-library-is-lulling-y`
What Google should have really done
`http://programmers.stackexchange.com/questions/267981/should-i-spend-time-preventing-pirac`
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!

lvl has room for improvement art promising but not root issue, dex is distributed and art compilation to native on device needs to become relevant so developers can release art only apps, native code and no issue with reverse engineering stop/less important

until lvl see major update custom improvements have to be done [28]

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

List of Figures

List of Tables

List of Code Snippets

Bibliography

[1] Amazon. *Amazon Send Developers a Welcome Package*. URL: http://www.androidheadlines.com/2010/10/amazon-send-developers-a-welcome-package.html (visited on 01/19/2016).

[2] Amazon. *Introducing Amazon Appstore for Android*. URL: http://phx.corporate-ir.net/phoenix.zhtml?c=176060&p=irol-newsArticle&ID=1541548 (visited on 01/19/2016).

[3] Apple. *Piracy Prevention*. URL: http://www.apple.com/legal/intellectual-property/piracy.html (visited on 01/18/2016).

[4] P. Bernhard. "A Security Analysis of Apps for Android Lollipop and Possible Countermeasures against Resulting Attacks." Master's Thesis. Technische Universität München, Fakultät für Informatik, Aug. 2015.

[5] Blackmart. *Blackmart Alpha*. URL: http://www.blackmart.us/ (visited on 01/20/2016).

[6] L. Botezatu. *Manipulation und Diebstahl im Google Play Store*. URL: http://www.bitdefender.de/hotforsecurity/manipulation-und-diebstahl-im-google-play-store-2673.html (visited on 01/16/2016).

[7] J. Callaham. *Smartphone OS Market Share*. URL: http://www.androidcentral.com/google-says-there-are-now-14-billion-active-android-devices-worldwide (visited on 01/16/2016).

[8] ChelpuS. *Lucky Patcher*. URL: http://lucky-patcher.netbew.com/ (visited on 01/09/2016).

[9] E. Chu. *Licensing Service For Android Applications*. URL: http://android-developers.blogspot.de/2010/07/licensing-service-for-android.html (visited on 01/18/2016).

[10] comScore. *comScore Reports November 2015 U.S. Smartphone Subscriber Market Share*. URL: https://www.comscore.com/ger/Insights/Market-Rankings/comScore-Reports-November-2015-US-Smartphone-Subscriber-Market-Share (visited on 01/19/2016).

[11] CrackAPK. *Android APK Cracked*. URL: http://www.crackapk.com/ (visited on 01/20/2016).

[12] A. Developers. *Adding Licensing to Your App*. URL: https://developer.android.com/google/play/licensing/adding-licensing.html (visited on 01/18/2016).

[13] A. Developers. *Application Fundamentals*. URL: http://developer.android.com/guide/components/fundamentals.html (visited on 01/18/2016).

[14] A. Developers. *DexFile*. URL: http://www.businessinsider.com/android-app-profitability-v-ios-2015-1?IR=T (visited on 01/16/2016).

[15] A. Developers. *Licensing Overview*. URL: https://developer.android.com/google/play/licensing/overview.html (visited on 01/18/2016).

[16] A. Developers. *Licensing Reference*. URL: https://developer.android.com/google/play/licensing/licensing-reference.html (visited on 01/21/2016).

[17] D. Ehringer. *The Dalvik Virtual Machine Architecture*. Mar. 2010.

[18] F. Guo, P. Ferrie, and T.-c. Chiueh. "A Study of the Packer Problem and Its Solutions." English. In: *Recent Advances in Intrusion Detection*. Ed. by R. Lippmann, E. Kirda, and A. Trachtenberg. Vol. 5230. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2008, pp. 98–115. ISBN: 978-3-540-87402-7. DOI: 10.1007/978-3-540-87403-4_6.

[19] IDC Research, Inc. *Smartphone OS Market Share*. URL: http://www.idc.com/prodserv/smartphone-os-market-share.jsp (visited on 01/16/2016).

[20] T. Johns. *Securing Android LVL Applications*. URL: http://android-developers.blogspot.de/2010/09/securing-android-lvl-applications.html (visited on 01/18/2016).

[21] E. Johnston. *Mobile Game Piracy Isn't All Bad, Says Monument Valley Producer (Q&A)*. URL: http://recode.net/2015/01/06/mobile-game-piracy-isnt-all-bad-says-monument-valley-producer-qa/ (visited on 01/18/2016).

[22] Kevin. *How the Android License Verification Library is Lulling You into a False Sense of Security*. URL: http://www.digipom.com/how-the-android-license-verification-library-is-lulling-you-into-a-false-sense-of-security/ (visited on 01/18/2016).

[23] A. Kovacheva. "Efficient Code Obfuscation for Android." Master's Thesis. Université de Luxembourg, Faculty of Science, Technology and Communication, Aug. 2013.

[24] M. Kroker. *App-Markt in Deutschland 2014: Umsätze im Google Play Store erstmals größer als bei Apple*. URL: http://blog.wiwo.de/look-at-it/2015/02/25/app-markt-in-deutschland-2014-umsatze-im-google-play-store-erstmals-groser-als-bei-apple/ (visited on 01/16/2016).

[25] J. Levin. *Android Security - New threats, New Capabilities*. URL: http://newandroidbook.com/files/Andevcon-Sec.pdfand (visited on 01/18/2016).

[26] J. Levin. *Dalvik and ART*. Dec. 2015.

[27] S. Morrow. *Rooting Explained + Top 5 Benefits Of Rooting Your Android Phone*. URL: http://www.androidpolice.com/2010/04/15/rooting-explained-top-5-benefits-of-rooting-your-android-phone/ (visited on 01/18/2016).

[28] M.-N. Muntean. "Improving License Verification in Android." Master's Thesis. Technische Universität München, Fakultät für Informatik, May 2014.

[29] Runtastic. *Runtastic PRO Laufen & Fitness*. URL: https://play.google.com/store/apps/details?id=com.runtastic.android.pro2&hl=de (visited on 01/20/2016).

[30] Samsung. *How to protect your app from illegal copy using Samsung Application License Management (Zirconia)*. URL: http://developer.samsung.com/technical-doc/view.do?v=T000000062L (visited on 01/19/2016).

[31] P. Schulz. "Code Protection in Android." Lab Course. Friedrich-Wilhelms-Universität Bonn, Institute of Computer Science, July 2012.

[32] M. T. Serrafero. *Piracy Testimonies, Causes and Prevention*. URL: http://www.xda-developers.com/piracy-testimonies-causes-and-prevention/ (visited on 01/16/2016).

[33] Y. Seznec. *Gentlemen! Or, how our most successful game is also our least profitable*. URL: http://www.gamasutra.com/blogs/YannSeznec/20130820/198453/Gentlemen_Or_how_our_most_successful_game_is_also_our_least_profitable.php (visited on 01/18/2016).

[34] statista. *Number of apps available in leading app stores as of July 2015*. URL: https://its.uncg.edu/Software/Licensing/ (visited on 01/16/2016).

[35] statista. *Umsatz im Apple App Store und Google Play Store im Jahr 2013*. URL: http://de.statista.com/statistik/daten/studie/180896/umfrage/apple-app-store-vs-google-playstore-umsatz/ (visited on 01/16/2016).

[36] Stericson. *Busybox - Android-Apps auf Google Play*. URL: http://www.androidheadlines.com/2010/10/amazon-send-developers-a-welcome-package.html (visited on 01/19/2016).

[37] T. Strazzere. *APKfuscator*. URL: https://github.com/strazzere/APKfuscator (visited on 01/21/2016).

[38] T. Strazzere. *APKfuscator*. URL: https://www.youtube.com/watch?v=Rv8DfXNYnOI (visited on 01/21/2016).

[39] T. Strazzere. *APKfuscator*. URL: http://www.strazzere.com/papers/DexEducation-PracticingSafeDex.pdf (visited on 01/21/2016).

[40] TeamSpeak Systems GmbH. *TeamSpeak 3*. URL: https://play.google.com/store/apps/details?id=com.teamspeak.ts3client&hl=de (visited on 01/20/2016).

[41] The University of North Caroline Greensboro. *Software Licensing*. URL: http://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/ (visited on 01/16/2016).

[42] J. Underwood. *Today Calendar's Piracy Rate*. URL: https://plus.google.com/+JackUnderwood/posts/jWs84EPNyNS (visited on 01/16/2016).