Messing with the Android Runtime

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specialized in mobile handset security

Current work
- Android security
- Android security

Past work
- Some Bluetooth security work
- A lot on SMS and MMS security
- Mobile web usage and privacy
- Some early work on NFC phone security
Introduction

- Android Application Security
  - Find vulnerabilities (audit)
  - Analyze malware
  - RE ... what is this application doing

- What does this thing do? How does this thing work?
  - Disassemble → look at smali code
  - Run in emulator/sandbox → look at traces / network
  - (Static) instrumentation → look at app while it runs
Introduction

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- This talk is about Dynamic Instrumentation
  - Instrumentation at the Dalvik level
    (not bytecode!)
Static Instrumentation on Android

- Unpack APK
  - Convert manifest back to plain text, ...

- Disassemble DEX classes
  - Get smali code

- Instrument smali code
  - Modify smali code, add own code

- Repackage application
  - Compile code, Sign, etc...

- Install and run
  - Hope it works... (bug in patch, self integrity check, ...)

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Dynamic Instrumentation

- **Change/modify application code at runtime**
  - Allows to add and remove code/hooks on-the-fly
  - Technique has been around for many years

- **Instrument library calls: quick overview what happens**
  - No disassembly needed

- Still need to disassemble for target specific stuff
  - Find the interesting stuff to instrument
Dynamic Instrumentation on Android

- No: unpacking, compile, repacking
  - Saves us time

- APK not modified
  - Defeat 'simple' integrity checks

- But Android Apps are written in Java and run in a VM...
Android

Picture: Google
Android Runtime

- Dalvik Virtual Machine (DVM) Core Libraries (java.x.y)
  - Executes: Framework and Applications

- Application
  - Process for “MainActivity”
  - Additional process(s) for “Service”

- Framework
  - system_server
  - ...

Android Process

Dalvik Classes

libdvm

libc, libz, libjpeg,...
Dalvik Instrumentation – The Basic Idea

- Convert Dalvik method to native (JNI) method
  - We get control of the execution

- Call original Dalvik method from native method
  - This creates an in-line hook of the Dalvik method

- Implement instrumentation code using JNI
  - Access to everything (private, protected doesn't exist)
Dalvik Instrumentation – Tech Overview

- Inject 'shared object' (.so) into running process
  - Provides the native code
  - My talk: Dynamic Binary Instrumentation on Android

- Native code 'talks to the DVM'
  - Resolve symbols from DVM
  - Call DVM functions to:
    - Lookup classes and methods
    - Hook method
    - Call original method
Messing with the Android Runtime

- The Runtime “runs”
  - Applications and their Services
  - The Android System/Framework

- What can we do with this
  - Aid reverse engineering
  - Attacks
  - Test stuff fast

- Examples...
Monitor / Reverse Applications

- How does the application work?
  - Maybe App is obfuscated, strings are “encrypted”

- Instrument interesting methods to see what App does
  - String operations
  - Reflection
  - ...

```java
String java.lang.StringBuffer.toString()
int java.lang.String.compareTo(..)
int java.lang.String.compareToIgnoreCase(..)
String java.lang.StringBuilder.toString()

Method java.lang.Class.getMethod(..)
```
Attack “stuff”

- Two Apps talk to each other via some IPC
  - Instrument one side to attack the other side

- Disable Signature Verification
  ```java
  boolean java.security.Signature.verify(byte[]) { ... }
  ```
  - Used for all kinds of things...
  - Patch to always “return true;”
    (used it to attack various things)
Rapid Prototyping of Framework Modifications

- Defense against SMS OTP stealing Trojans [1]
  - Change local SMS routing based on SMS content

- For the prototype we needed to change code in the framework
  
  ```java
  com/android/internal/telephony/SMSDispatcher.java
  protected void dispatchPdus(byte[] pdus) { ... }
  ```

- Instead of recompiling Android just replace the method
  → save a lot of time
  → test on many different devices without custom compile

  To appear In the Proceedings of the 10th Conference on Detection of Intrusions and Malware & Vulnerability Assessment (DIMVA 2013) Berlin, Germany, July 2013
Conclusions

- Dynamic Instrumentation via the Android Runtime allows
  - Modification of Apps and the Framework in memory
  - Doesn't break APK signatures
  - Portable across devices
  - Super stable (not a hack)
  - But can only replace whole functions
    - no bytecode modification

- Possible to stir up Android AppSec quite a bit
  - Obfuscation and use of reflection is kinda useless

- We have various ongoing projects based on this
  - Students doing interesting stuff
Thank you!

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