Dynamic Analysis of Android Apps

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About me

- Founder of AppSec Labs
- Application security expert
- Book author
  - Managed Code Rootkits (Syngress)
- Speaker & Trainer
  - Presented at BlackHat, Defcon, RSA, OWASP USA, OWASP IL, etc..
  - Secure Coding / Hacking trainer
- Speaking for the 8th time in a row at OWASP IL 😊
AppSec Labs
The leading Application Security Company

- A bunch of Application Security Experts
- Ninja Pentesters of Web & Mobile Apps
- Elite Trainers for Hacking & Secure coding courses
Welcome to the Software Security Training Center!

The Software Security Training Center (SSTC) was created with the intent to enhance your awareness in application security and secure coding.

By understanding the threat landscape and implementing the appropriate countermeasures we are improving the integrity of our products.

**Awareness is the name of the game!**

SSTC is now available for you to enhance your knowledge of software security and improve our products' security.

Check out your personal training program and download course materials and lab environment to practice what you’ve learned under Courses in the menu.

Check out our easy-to-use knowledgebase for application security issues you are confronting in real time.

We wish you good luck in revealing the fascinating world of software security

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HP SW IT Management Security & Trust Office
WTF ?!

A world without mobile technology ?
Agenda

- Why dynamic analysis?
- Memory dumps and analysis
- Smali debugging
- Setting breakpoints
- Native debugging with IDA (building signatures, types etc.)
- Runtime instrumentation and manipulation using ReFramewoker
Why dynamic analysis?

Pentesing the app “from the inside”
Some examples – real world scenarios encountered in the wild

- Requests to the server side are encrypted, signed, or just cannot be MiTMed for some reason
  - Your proxy is useless.

- Dynamic values stored in memory - created while the app runs, received from network, etc.
  - Decompiling is useless. The value is not in the code

- Strings are obfuscated
  - Decompiling is hard

- The app is using some hard coded values such as URLs, encryption keys
  - Patching is time consuming
Example – requests with signed data

Cannot manipulate with requests since they are signed

POST /GreatBank/TransferMoney.aspx HTTP/1.1
Host: GreatBank.com
Proxy-Connection: keep-alive
Content-Length: 274
Cache-Control: max-age=0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,*/*;q=0.8
Origin: http://GreatBank.com
Content-Type: application/x-www-form-urlencoded
Accept-Encoding: gzip, deflate, sdch
Accept-Language: he-IL,he;q=0.8,en-US;q=0.6,en;q=0.4
Cookie: SessionId=rqpyxteuQd4aSondzsfqfQR

SourceAcc=1111111111111&DestinationAcc=2222222222222&Amount=10000&Signature=MjNiYjMONXByM3BvajRpadQ=
Example – requests with encrypted data

Cannot view/manipulate with requests since they contain encrypted data

POST /GreatBank/SensitiveOperation.aspx HTTP/1.1
Host: GreatBank.com
Proxy-Connection: keep-alive
Content-Length: 274
Cache-Control: max-age=0
Accept: text/html, application/xhtml+xml, application/xml;q=0.9, image/webp, */*;q=0.8
Origin: http://GreatBank.com
Content-Type: application/x-www-form-urlencoded
Accept-Encoding: gzip, deflate, sdch
Accept-Language: he-IL,he;q=0.8,en-US;q=0.6,en;q=0.4
Cookie: SessionId=rqpyxteu0d4a00hdzsfqfrx

SuperSensitiveData=KChcNTy3ODk6Q0FQFrkdISUpTVFVWVlhZWNkZWZnaGlqc3R1bm4eXrp4uTg5efq6+jG9PYby+/n/ltzz+vHRqrq/EKYTAiRhY1ZVY1EsHAA8X19aVG1lWWhSU2tqGAtwKPDtcSmmKl12CAh90iwGbegFCARCCBGAxQDAREgAhEBAnEBAwGwDAMBIAIRAXEAgPyAgPWcccURWwVmm26WHgTLEgpbxWJ1nAxBLzNkVh/AsPGWjkhMQZqZdagjc3+Apk2E6H/whC9SYnJ0ixU7VKARRVKWXJy7xFPAGB1OSMA1ahS7wFLeEkA/3w9hPKwy9Czc5HBBkGQVZR+wbZmV3VpmyT1ToxouFPRVZSTqG2t5LBt3/QcZmqTeZB9ktxpBH5YiAtuCFjJbgEJ7pPvkTocUuwWcns19FJhTvxl2NS7cRTGVQgACsaGajIYITHnBGFcCPV8sPhSTk1BWS5CAgUGaVTG3V9o11M7gjJICQB+zgeqU+RIVgS9L9/xW3sdKzQ+pRVdj6CXcVdMKFVR7wUOEWJJKH9gd/nG0PMeCGR1XQlibS0hxQ==
Example – obfuscated code/values

Cannot read values from decompiled code since it is obfuscated

```java
import com.whatsapp.App;

public class e {
    public static boolean g;
    private static final String[] z;
    public String a = "";
    public String b = "";
    public List<String> c = new ArrayList();
    public byte[] d;
    public Set<String> e = new HashSet();
    public Set<String> f = new HashSet();

    static {
        String[] arrayOfString = new String[7];
        char[] arrayOfChar1 = "\k\/Lv\035mlVc\024nSwc8,\J\6".toCharArray();
        int i = arrayOfChar1.length;
        int j = 0;
        char[] arrayOfChar2;
    }
```
What to do?

- We must “work from the inside”
- Let’s start with direct memory analysis

- Exposure of
  - Code sections
  - Sensitive data – application data, passwords, encryption keys, network traffic, calculations, etc.
  - Interactions with OS – files, processes, etc.
Memory Analysis

- Eclipse’s MAT (Memory Analyzer Tool)
- Dump the application’s current memory to disk
- Go to the “DDMS” Perspective, select the app and click “Dump HPROF file”
Query

SELECT toString(pwd.mText.mText) FROM com.appsec.hackmepal.Main

toString(pwd.mText.mText)

<Regex>
22222222222
\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0000
Exposing obfuscated encryption key from memory
Debugging

- Debugging allows us to analyze the app in real time
  - Setting breakpoints
  - Bypassing restrictions
  - Jump into specific code sections
  - Expose secrets from memory
Debugging With Source

- Debugging with the source is easy
- Just load the project in eclipse
- Place your breakpoint
- And click debug
Debugging Without Source ("smali debugging")

- Most often you will not have the source
- Extracting the java code using dex2jar and creating an eclipse project is a bit tricky
  - Rebuilding the project dependencies
  - Decompiled code not always recompiles
- Alternatively, we can **remote debug smali code**
Major Steps

- Decode apk in debug (-d) mode:
  - apktool d -d app.apk out

- Make it debuggable at the AndroidManifest.xml <application> tag
  - <application .... android:debuggable="true“ ...>

- Build new apk in debug (-d) mode:
  - apktool b -d out

- Sign, install and run new apk
  - signapk input.apk
Major Steps - Continued

- create Netbeans project
  - add new Java Project with Existing Sources, select "out" directory as project root and "smali" subdirectory as sources dir.

- Find application port using DDMS
  - it should be something like "86xx / 8700".

- Attached debugger in Netbeans
  - Debug -> Attach Debugger -> select JPDA and set Port to 8700 (or whatever you saw in previous step).

- Set breakpoint.

- NOTE – Officially, not all versions works, you need to use: netbeans 6.8 and apktool 1.4.1
- Currently, you can also use NetBeans 7.2 with Apktool v2.0.0-Beta9
Smali debugging
Tip - Wait for Debugger

- Programmatically – by calling
  `android.os.Debug.waitForDebugger()`

  or

- `boolean debuggerAttached = false; while(!debuggerAttached ) { ; }`

- Another option – DEV tools
JNI Debugging

- Suppose our target code is inside native .so files.
- We can use IDA to analyze it, and GDB to remotely debug it
Using IDA

- You can use existing static binary analysis (such as IDA) to better understand the code.
- It will give you the idea where to start, where to set breakpoints, etc.
JNI Debugging - Main Steps

- Find the process id, attach to it and create a listener port inside the device. Then remotely debug the app.

```sh
gdbserver :5050 --attach 1234  //pid=1234, port=5050
```

- Use regular GDB commands such as break, continue, finish, etc.
DEMO (if time permits 😊)

- Analyzing .so files using IDA
- Remotely debugging native code using GDB
The ReFrameworker Platform
Changing App Behavior Without Patching Any Code

- Runtime manipulation framework by AppSec Labs
- Integrated as part of AppUse
- Released at BlackHat USA 2013
- Presented at OWASP IL 2013 – **look for the slides from last year for more info!!**
The Android runtime was compiled with many hooks placed into key placed inside its code.

The hooks look for a file called "Refrrameworker.xml", located inside /data/system.

So each time an application is executed, whenever a hooked runtime method is called, it loads the Reframeworker configuration along with the contained rules ("items") and acts accordingly.
Enabling / Disabling ReFrameworker

- Replacing the original device jars with our modified version
The ReFrameworker Dashboard

Modify Runtime Logic
- Trust all certs
- Disable hostname verification
- Disable APK signature
- disable permissions
- Use Strict mode

Notify Usage Of...
- OS Command Execution
- File Access
- Native JNI Function Calls
- NFC
- GPS
- SMS
- Dynamic Invoke (Reflection)

Forge Values (Tamper With...)
- Encryption keys
- IMEI
- Phone number
- Intent proxy
- URL
- DNS resolver
- HTTP/S
- TCP/IP
- SIP

Hide Stuff
- Hide Application Existence
- Hide File Existence

Info: Online device found!
List of devices attached
emulator-5554 device

Info: Loading configuration from device...
Info: Succeed loading config from device!
Defining Behavior

- User defines required behavior
  - can turn on sniffing of important information
  - bypass of certain logic
  - doing some string replacement
  - sending some data to the ReFrameworker dashboard
  - Etc.
Modify Mode

replace a particular content with another content

- The inspected value should match the value of the defined item
- The toValue contains the new value to be set
- You can use * as ANY (i.e. the hooked value will be sent always)
Send Mode

- send the hooked content to the ReFrameworker dashboard
- Requires the listener to be up
- The inspected value should match the value of the defined item
- You can use * as ANY (i.e. the hooked value will be sent always)
- The toValue is ignored (not in use)
Proxy Mode

Now each time the hooked method is called, the device will send this data to the proxy, and will replace the original value with modified received value.

Start the proxy

The proxy window
When a message will be received, the proxy will wake up and give the user the opportunity to observe the message AND modify it – while the android app is waiting for the response.
Item Example – Live Editing of the IMEI (Proxy Mode)

Explanation – mode is set to "proxy" since we want to modify this data at realtime. Other values stayed the same (compared to previous example).
Summary

- Runtime analysis provide us with the means to observe the behavior of an app during its execution.
- It allows us to inspect issues such as communication, memory, file access, etc.
- We can detect problems that are hard to see using just static methods.
- ReFремeworker is a great platform for that.
QUESTIONS ?
THANK YOU!

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...and last thing: we’re hiring !!!