HUNTING ANDROID MALWARE

A RUNTIME TECHNIQUE FOR IDENTIFYING MALICIOUS APPLICATIONS

WHOAMI

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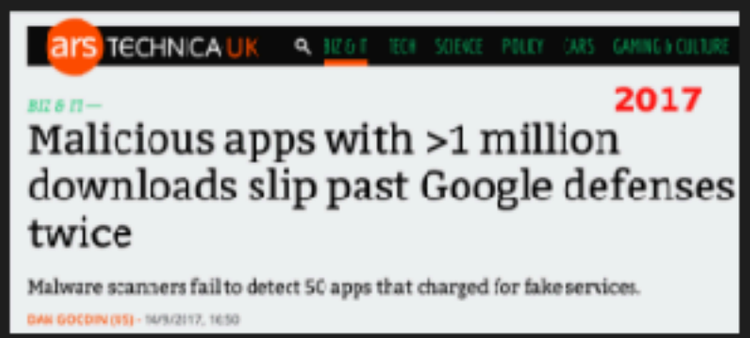
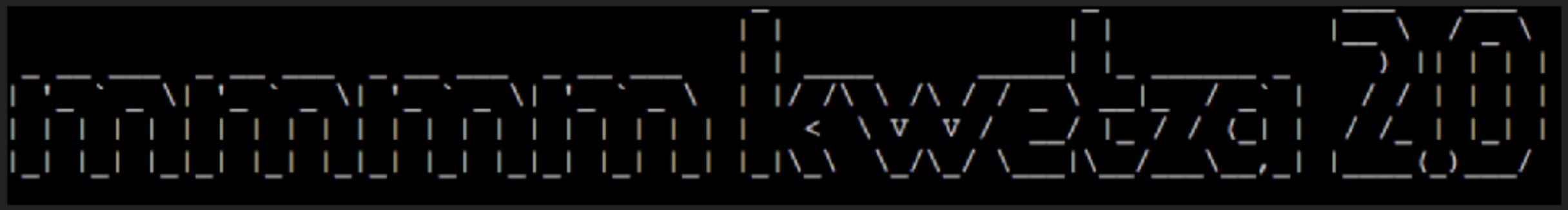
OUTLINE

- Problem
- Question
- Idea
- PoC
- Results
- Conclusion

MALWARE HAS AND IS A CONSTANT THREAT IN THE ANDROID ECOSYSTEM



PREVIOUS RESEARCH LED ME TO THIS RESEARCH



HOW DO I PROTECT MYSELF FROM THESE KIND OF ATTACKS?

- We have to look at the APK
  - Statically
  - In a sandbox of sorts

WE LOOK AT MALWARE IN A FEW WAYS

- Hashes
- Code Signatures
- Permissions Reputation
- Behaviour

HOW ARE WE PROTECTED BY MALWARE?

- Google Play Protect
- Google Playstore
- Third-Party Software
  - Anti-Virus
  - OS Support
  - MDM’s, MAM’s

WHAT'S THE SHORTCOMINGS OF EXISTING TECHNIQUES

- Static Analysis is hard
- Can't run Cuckoo on my phone
- Scalability
- What if the app is not on an official Store?
- Bypassing AV is too easy
- Forensics is cool but how do you do it at realtime?
- Static analysis can only reveal a subset of the app's functionality

NO RELIABLE WAY TO DETECT MALWARE ON DEVICES

BUT THERE IS HEAPS OF DATA TO BE LOOKED AT!

- Android apps make use of objects
- Import statements are useful BUT
- You can import but not instantiate
- If it’s instantiated, something is using the object
- Instantiated objects have data (some)

ALL THIS DATA HAS TO BE SOMEWHERE TO BE LOOKED AT

- /PROC/{PID}/MAPS?
  - Analyse the heap regions?
- Analyse Heap Dumps? (HPROFs)
- Memory Forensics?
  - LiME ~ Linux Memory Extractor
  - Volatility
- (gdb) x /20xg 0x7fbd6208?
  - myObject.hashCode()
  - Not too bad with the DVM (dlmalloc)

INSTRUMENTATION

- Objects exist on the heap so they are accessible
- Trace calls and monitor/engage with behaviour
- Its relatively easy
- Great way to gain insight into applications
- Object carving functionality is AWESOME

FRIDA

WOULDN'T IT BE COOL IF AT RUNTIME I COULD SEE

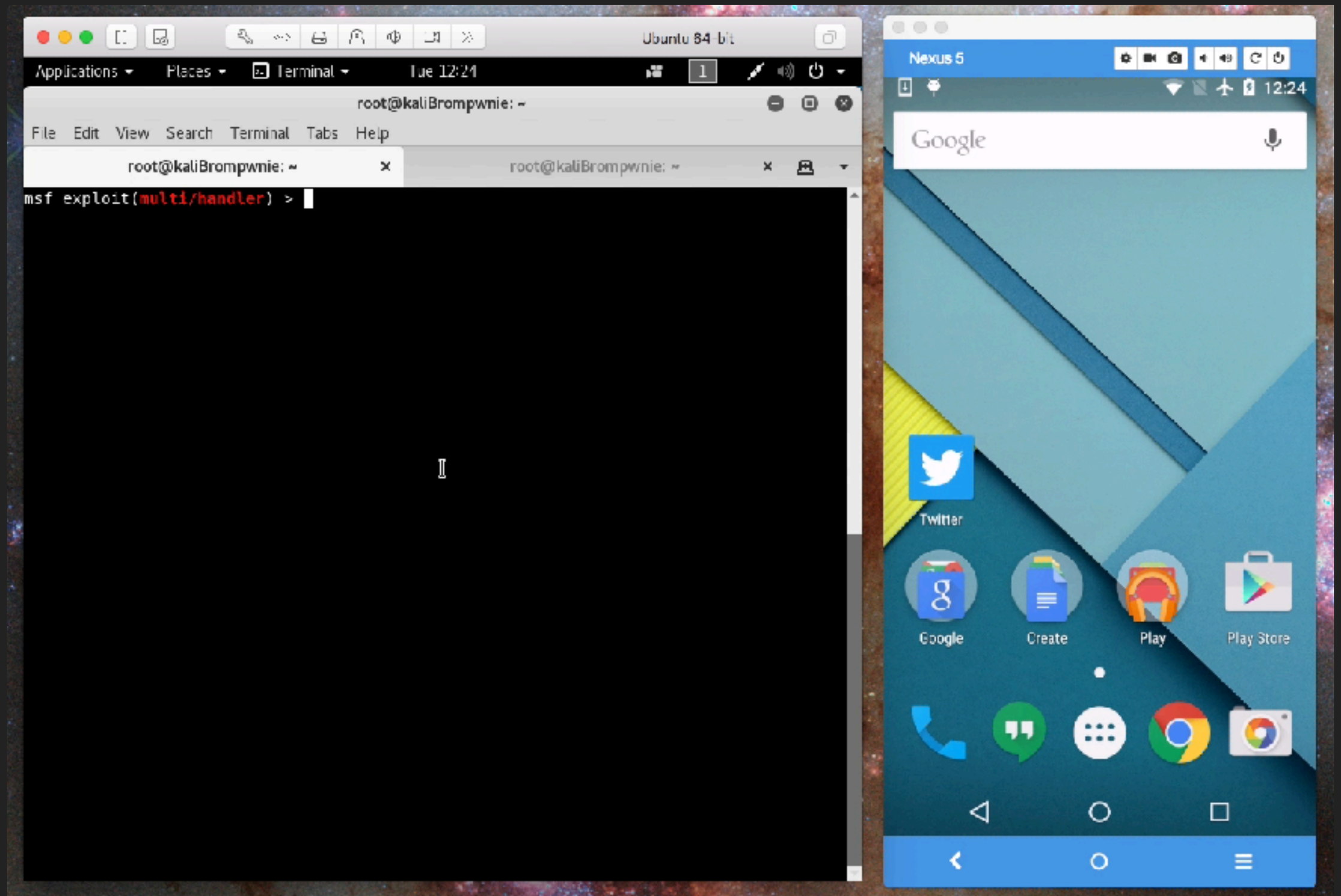
- Which objects an app is using
- Which objects are instantiated
- What are the values for these objects

THIS WOULD GIVE ME AN IDEA AS TO WHAT AN APP IS DOING AND HOW

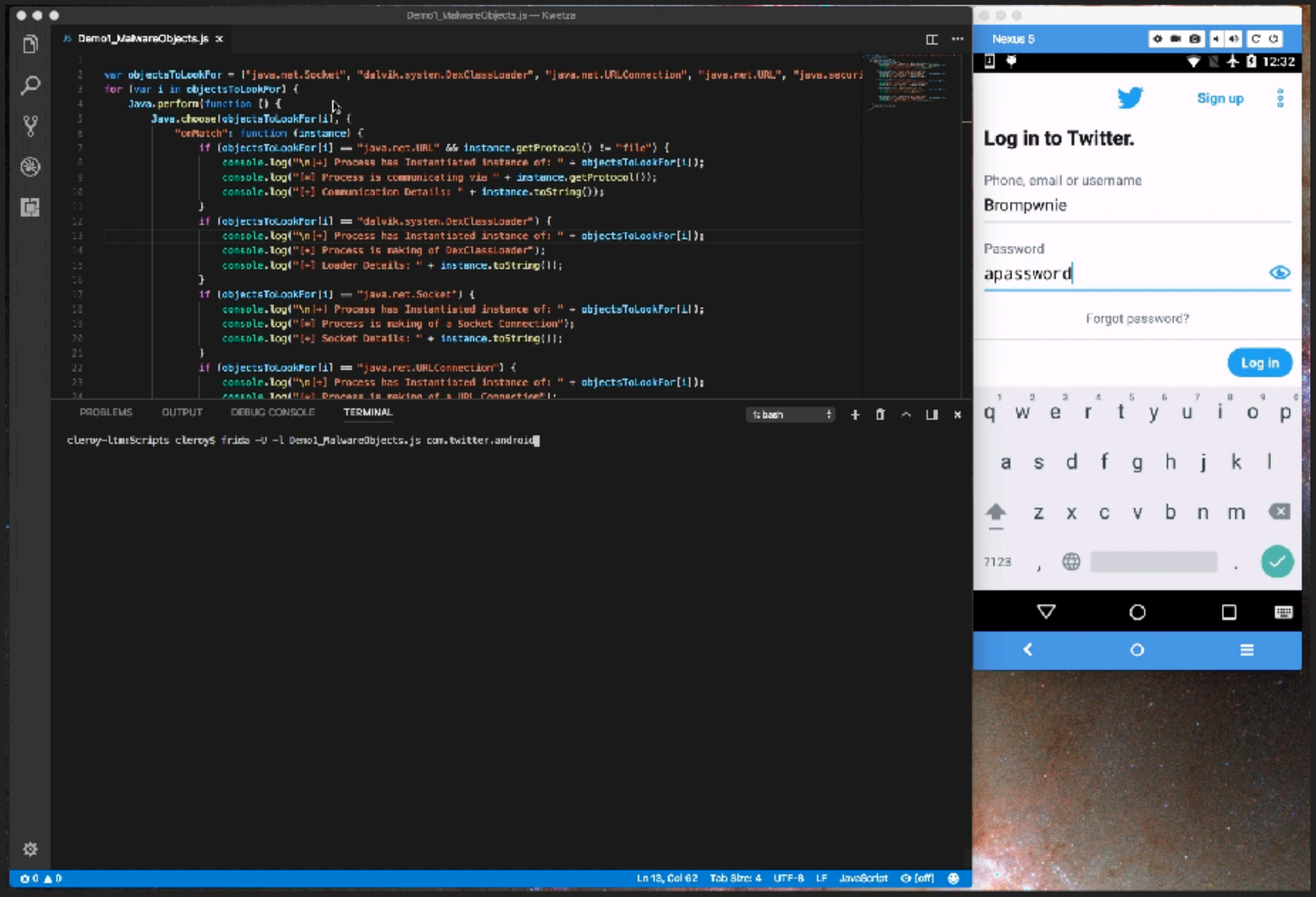
FOR EXAMPLE, ANALYSING AN APP WITH A METERPRETER BACKDOOR:

- Experience tells me to look for:
  - DexClassLoader
    - And what this injected code does
  - TCP Connection
- Which tells me that this app is
  - Injecting code at runtime
    - For example, encryption/decryption routines
  - Communicating remotely

DEMO: BASIC MALWARE INFECTION



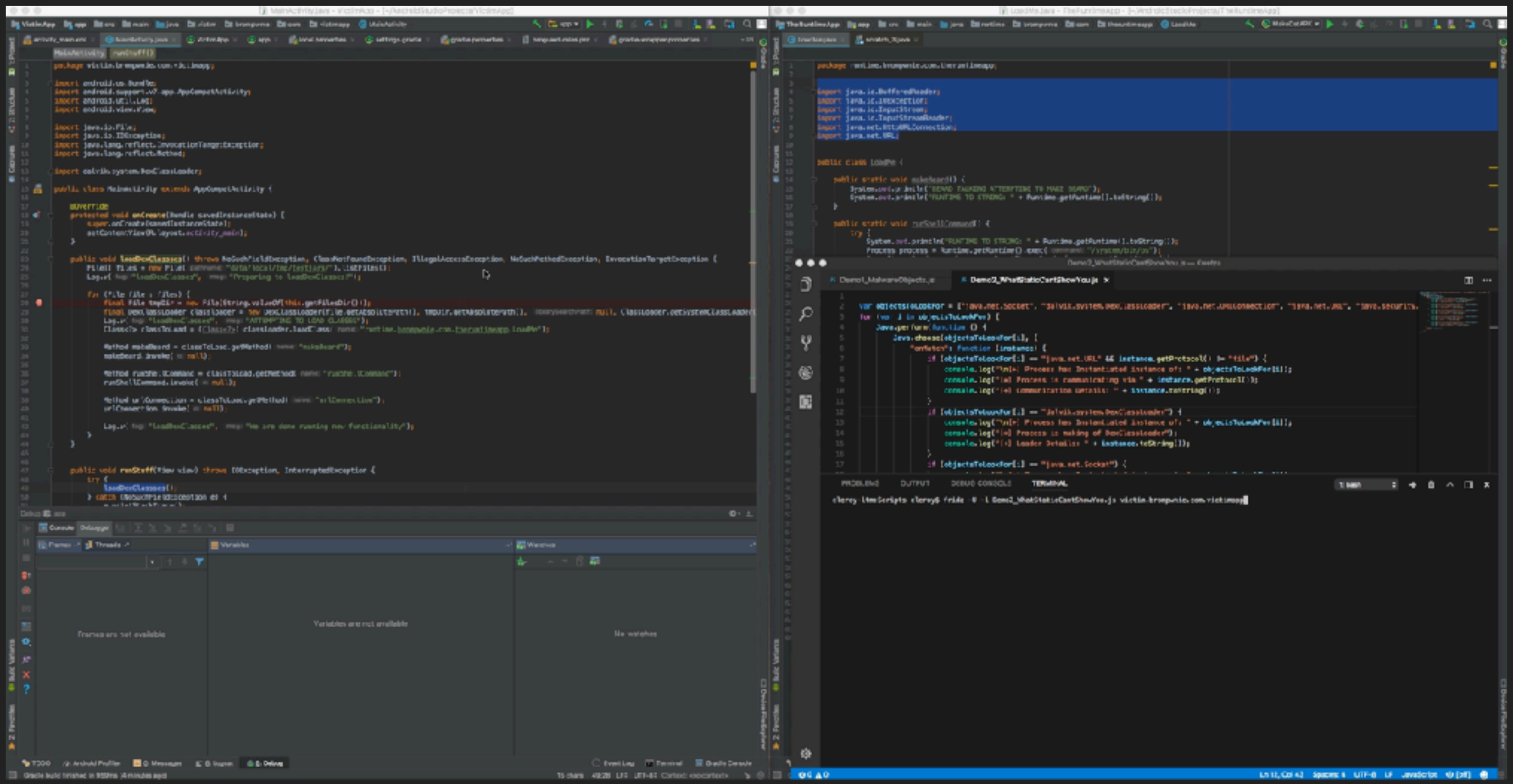
DEMO: BASIC RUNTIME MALWARE ANALYSIS USING FRIDA



STATIC ANALYSIS WONT SHOW YOU EVERYTHING

- Runtime Injection
  - Class Loaders
    - Very powerful to inject your functionality at runtime, requires analyst to acquire the jar/apk/dex
  - What if you don't have the injected JAR/APK?
    - /data/data/com.app.sandbox
- Java.Lang
  - Runtime.exec("/bin/sh")
  - No Import Statements
  - Instantiated but kinda immutable

DEMO: WHAT STATIC ANALYSIS CAN'T SHOW YOU

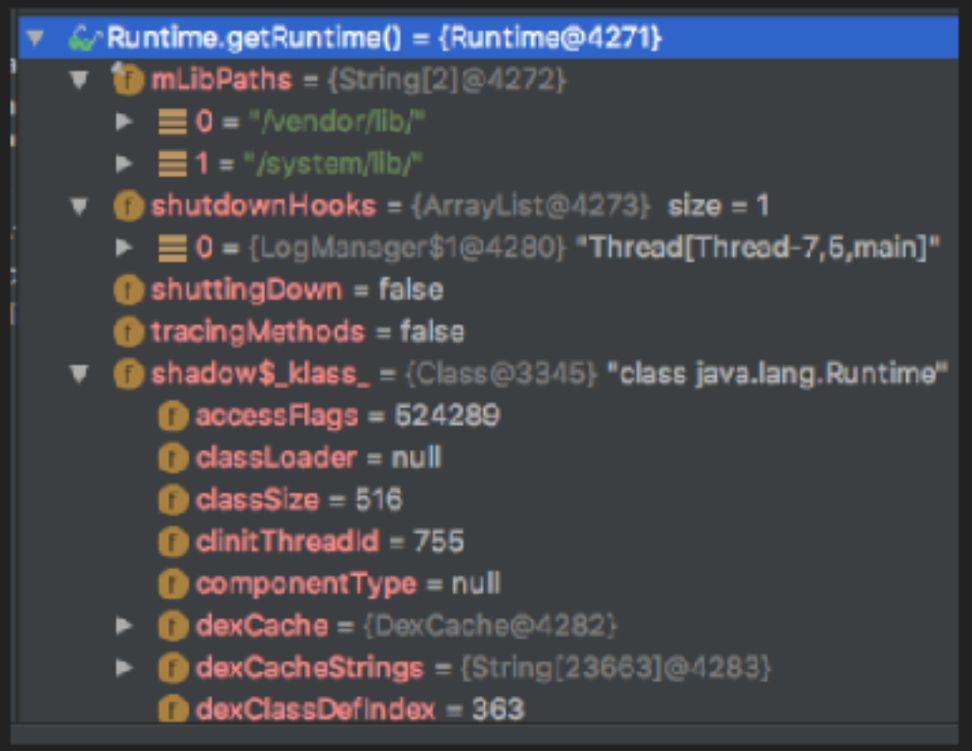


HEAPS OF LOVE

- Don’t have to trawl code
- Identify specific anomalies

THERE IS ALSO HEAPS OF FRUSTRATION

- java.lang.Runtime
- Kind of immutable?
- exec("/system/bin/ps")
- Does not have much of a footprint



WHATS THE PLAN?

exec(String command)
Executes the specified string command in a separate process.

exec(String[] cmdarray)
Executes the specified command and arguments in a separate process.

exec(String[] cmdarray, String[] envp)
Executes the specified command and arguments in a separate process with the specified environment.

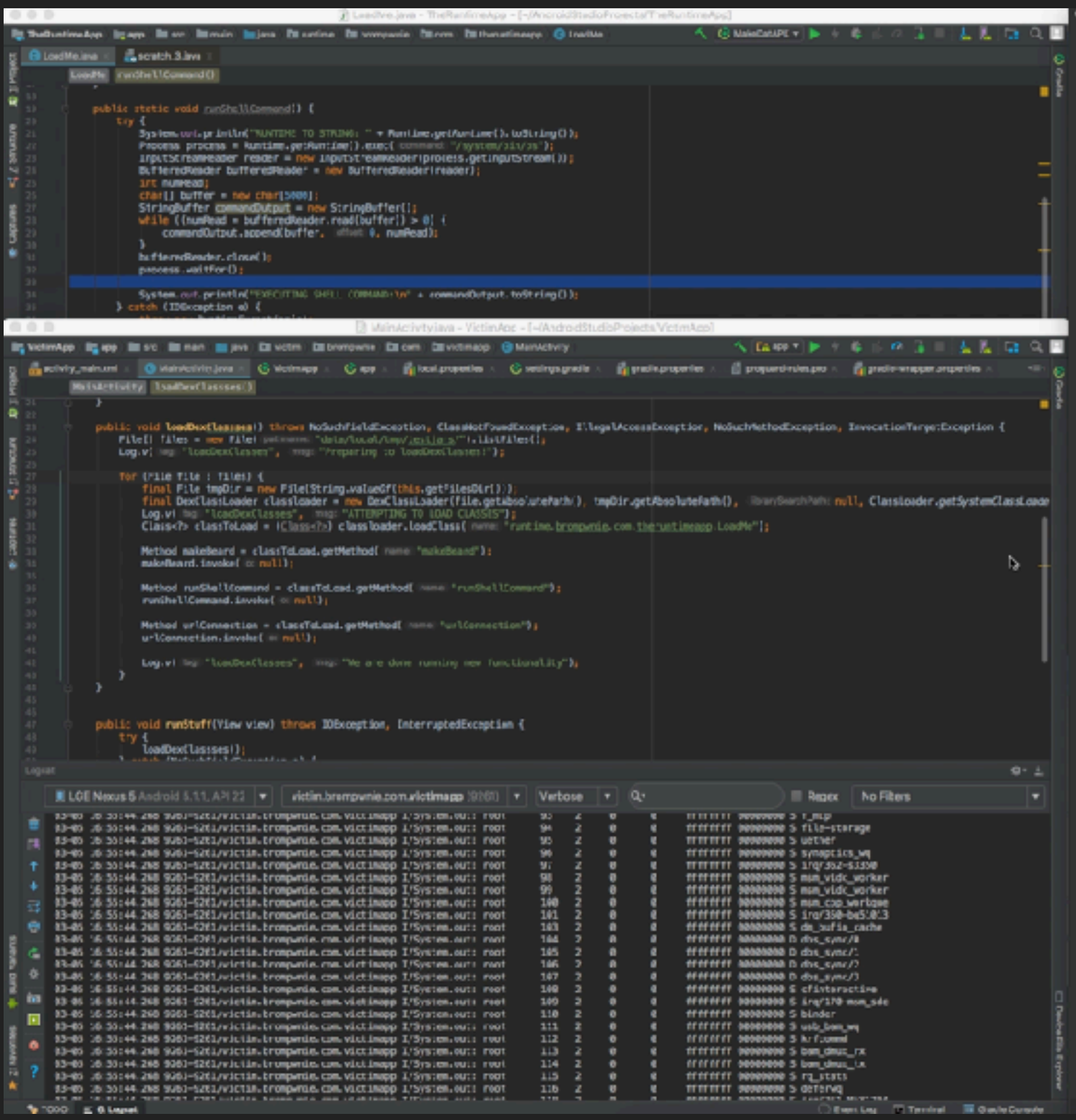
exec(String[] cmdarray, String[] envp, File dir)
Executes the specified command and arguments in a separate process with the specified environment and working directory.

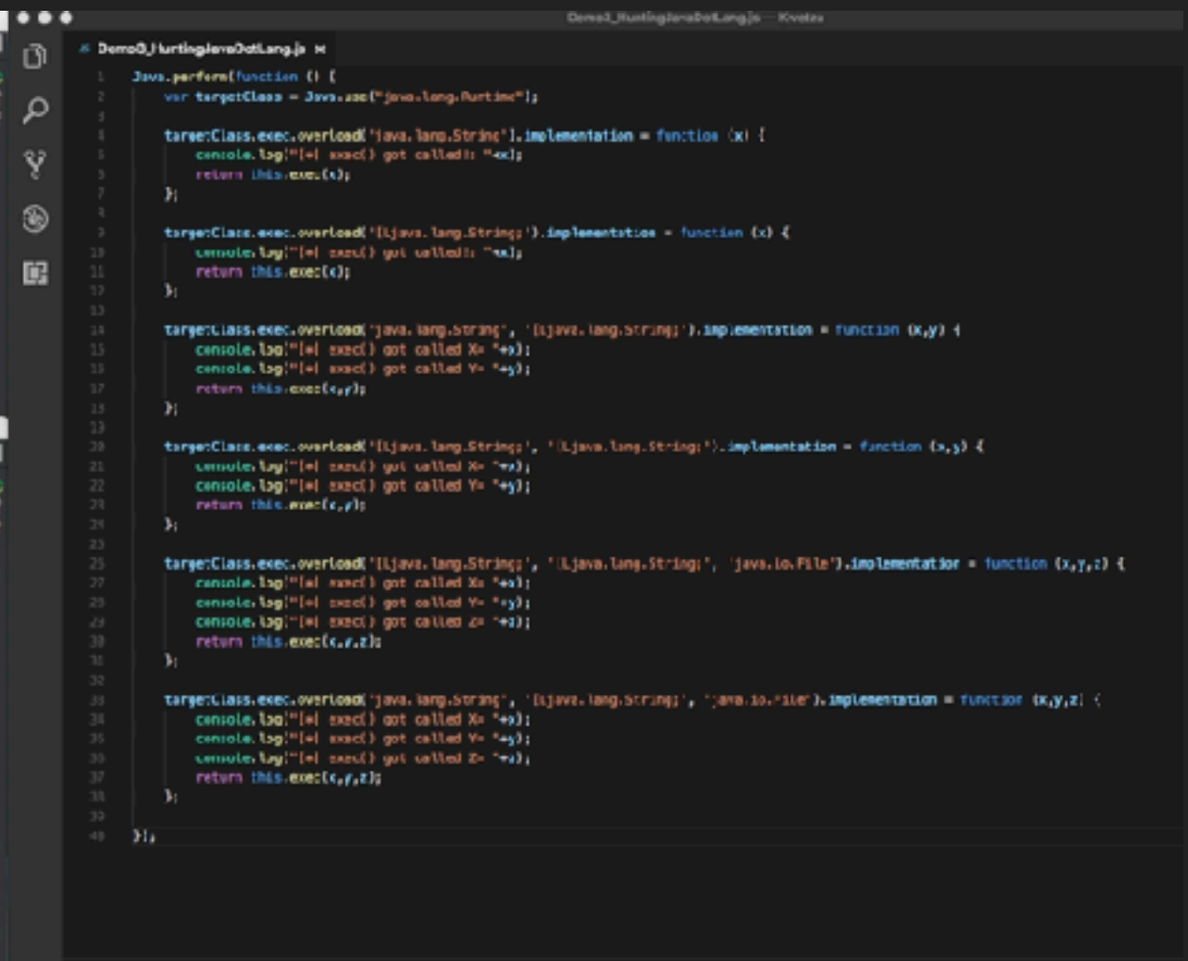
exec(String command, String[] envp)
Executes the specified string command in a separate process with the specified environment.

exec(String command, String[] envp, File dir)
Executes the specified string command in a separate process with the specified environment and working directory.

```
Java.perform(function () {
    var targetClass = Java.use("java.lang.Runtime");

    targetClass.exec.overload('java.lang.String').implementation = function (x) {
        console.log("[*] exec() got called!: "+x);
        return this.exec(x);
    };

    targetClass.exec.overload('[Ljava.lang.String;').implementation = function (x) {
        console.log("[*] exec() got called!: "+x);
        return this.exec(x);
    };

    targetClass.exec.overload('java.lang.String', '[Ljava.lang.String;').implementation = function (x,y) {
        console.log("[*] exec() got called X= "+x);
        console.log("[*] exec() got called Y= "+y);
        return this.exec(x,y);
    };
```

DEMO: OVERLOAD METHOD CALLS TO OBSERVE OTHERWISE HARD TO OBSERVE ANOMALIES





WE HAVE THE ABILITY TO:

- Analyse objects on the heap
- Hook methods for certain objects
- Do all this at runtime on a device
- See more than static analysis
- Perform the above from a workstation

A SOLUTION: SAFETY NET ATTESTATION API

The SafetyNet Attestation API helps you assess the security and compatibility of the Android environments in which your apps run. You can use this API to analyze devices that have installed your app.

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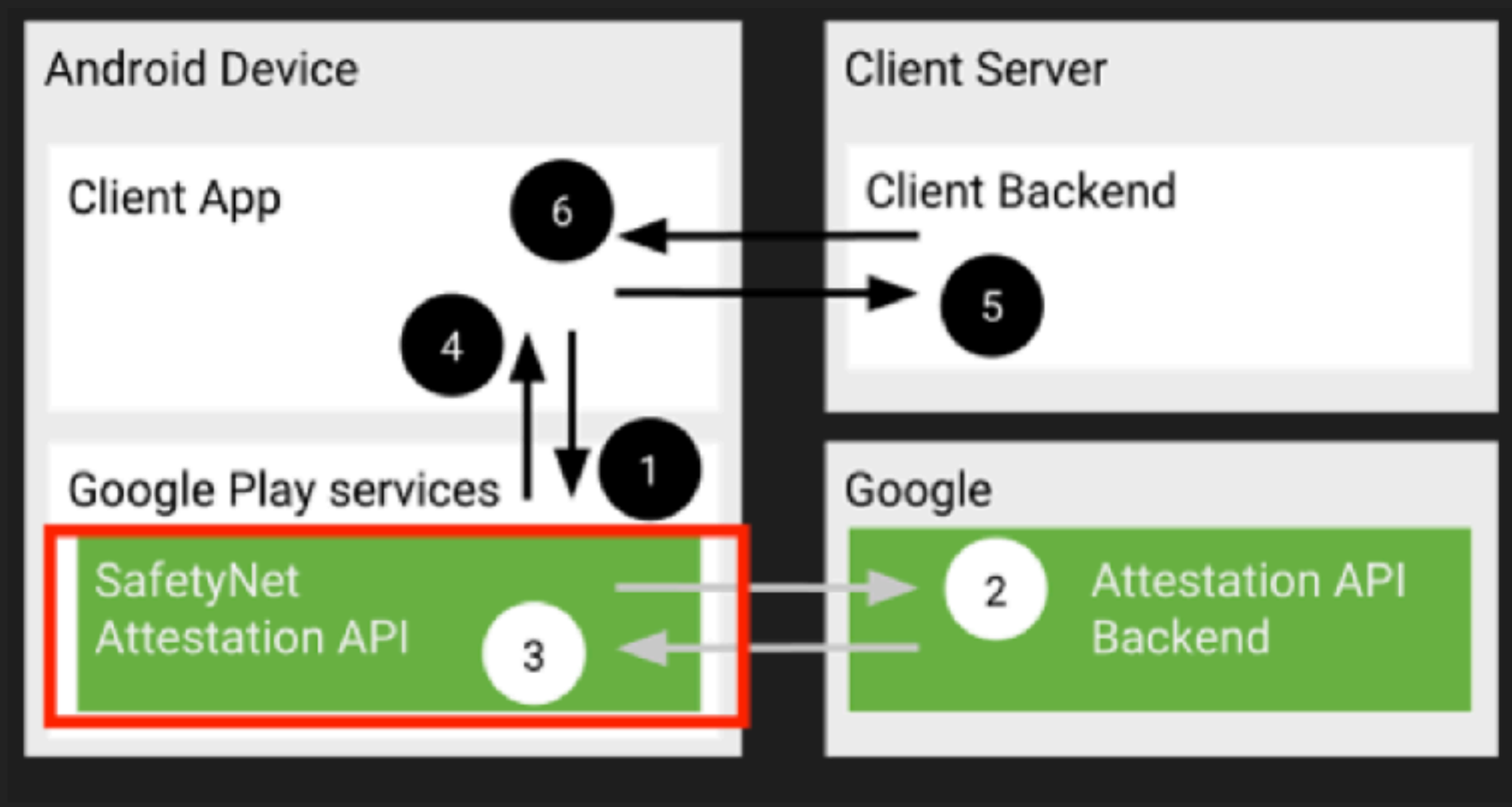


UITKYK

- You can use this API to analyze applications that are installed on a Android device
- Custom Android Frida Library
- DBUS over TCP
- Frida Server Integration
- Can run all the previously demo'd tests
- And more!

HEY FRIDA, GIVE ME RUNNING PROCESSES

```
$ frida-ps -U
  PID  Name
-----  ------------------------------------------------------------
  207  adbd
27599  android.process.acore
 1566  android.process.media
16850  app_process
16894  app_process
17005  app_process
17145  app_process
17163  app_process
17190  app_process
17327  app_process
17384  app_process
17430  app_process
26767  app_process32
  194  bridgemgrd
27556  com.android.defcontainer
27799  com.android.keychain
27622  com.android.musicfx
 1799  com.android.nfc
 1855  com.android.phone
 1544  com.android.systemui
27643  com.android.vending
27882  com.google.android.apps.cloudprint
```

HEY ANDROID, GIVE ME RUNNING PROCESSES

```
@Override
protected String doInBackground(String... params) {
    UitkykUtils uitkykUtils= new UitkykUtils();
    return uitkykUtils.fridaPS(fridaHost,fridaPort);
}
```

HEY FRIDA TELL ME IF THIS APPLICATION LOOKS MALICIOUS

```
var objectsToLookFor = ["java.net.Socket", "dalvik.system.DexClassLoader", "java.net.URLConnection", "java.net.URL", "java.security.cert.X509Certificate"];
for (var i in objectsToLookFor) {
    Java.perform(function () {
        Java.choose(objectsToLookFor[i], {
            "onMatch": function (instance) {
                if (objectsToLookFor[i] == "java.net.URL" && instance.getProtocol() != "file") {
                    console.log("\n[+] Process has Instantiated instance of: " + objectsToLookFor[i]);
                    console.log("[*] Process is communicating via " + instance.getProtocol());
                    console.log("[+] Communication Details: " + instance.toString());
                }
                if (objectsToLookFor[i] == "dalvik.system.DexClassLoader") {
                    console.log("\n[+] Process has Instantiated instance of: " + objectsToLookFor[i]);
                    console.log("[*] Process is making of DexClassLoader");
                    console.log("[+] Loader Details: " + instance.toString());
                }
```

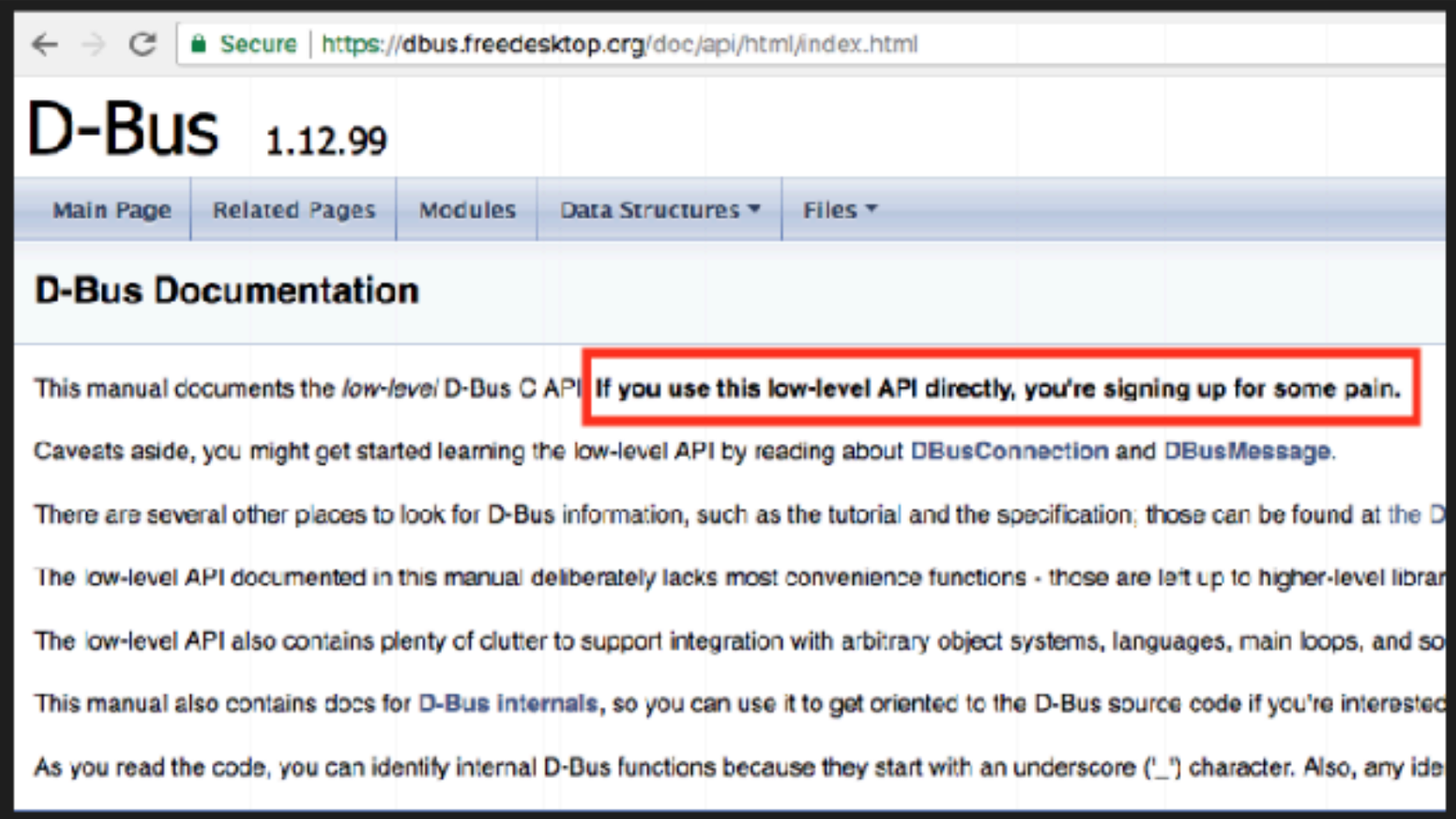
```
$ frida -U -l Demo1_MalwareObjects.js com.twitter.android
     ____
    / _  |   Frida 10.6.51 - A world-class dynamic instrumentation toolkit
   | (_| |
    > _  |   Commands:
   /_/ |_|       help      -> Displays the help system
   . . . .     object?   -> Display information about 'object'
   . . . .     exit/quit -> Exit
   . . . .
   . . . .   More info at http://www.frida.re/docs/home/
Attaching...

[+] Process has Instantiated instance of: java.net.Socket
[*] Process is making of a Socket Connection
[+] Socket Details: Socket[address=/192.168.0.16,port=4444,localPort=60695]

[+] Process has Instantiated instance of: java.net.Socket
[*] Process is making of a Socket Connection
[+] Socket Details: Socket[address=settings.crashlytics.com/50.19.106.12,port=443,localPort=42306]
```

HEY ANDROID TELL ME IF THIS APPLICATION LOOKS MALICIOUS

```
protected String doInBackground(Object... objects) {
    UitkykUtils uitkykUtils = new UitkykUtils(fridaHost, fridaPort);
    return uitkykUtils.analyzeProcess(this.pid);
}
```

WHY UITKYK API?

- No Android Frida Library
- Wanted to use Frida
- Wanted a Client Server Model
- Didn't want pain



HOW DOES UITKYK UITKYK?

- TCP Socket to Daemon
- Push and Pull Bytes
- Sniffed Frida sessions
- Outlined TCP Flags
- Identified key bytes (trial and error)
- Stared at my monitor
- Wash,rinse,repeat

```
byte[] AUTH_Message2 = {
        (byte) 0x41, (byte) 0x55, (byte) 0x54, (byte) 0x48,
        (byte) 0x20, (byte) 0x41, (byte) 0x4e, (byte) 0x4f,
        (byte) 0x4e, (byte) 0x59, (byte) 0x4d, (byte) 0x4f,
        (byte) 0x55, (byte) 0x53, (byte) 0x20, (byte) 0x34,
        (byte) 0x37, (byte) 0x34, (byte) 0x34, (byte) 0x34,
        (byte) 0x32, (byte) 0x37, (byte) 0x35, (byte) 0x37,
        (byte) 0x33, (byte) 0x32, (byte) 0x30, (byte) 0x33,
        (byte) 0x30, (byte) 0x32, (byte) 0x65, (byte) 0x33,
        (byte) 0x31, (byte) 0x0d, (byte) 0x0a};
```

SOMETHING ABOUT A POC

```
import socket

TCP_IP = '10.42.0.15'
TCP_PORT = 1337
BUFFER_SIZE = 100
# .AUTH
MESSAGE = '\x2e\x41\x55\x54\x48\x0d\x0a'
# MESSAGE = '\x41\x55\x54\x48\x0d\x0a'

s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
print "Sending-> .AUTH"
s.connect((TCP_IP, TCP_PORT))
s.send(MESSAGE)
data = s.recv(BUFFER_SIZE)
print "received data:", data
# s.close()

# AUTH ANONYMOUS 4744427573203832e31
MESSAGE2="\x41\x55\x54\x48\x20\x41\x4e\x4f\x4e\x59\x4d\x4f\x55\x53\x20\x34\x37\x34\x34\x34\x32\x37\x35\x37\x33\x32\x30\x33\x30\x32\
BUFFER_SIZE2 = 100
# s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
print "Sending-> AUTH ANONYMOUS 4744427573203832e31"
# s.connect((TCP_IP, TCP_PORT))
s.send(MESSAGE2)
data2 = s.recv(BUFFER_SIZE2)
print "received data:", data2
# s.close()

# #
# #BEGIN
MESSAGE3="\x42\x45\x47\x49\x4e\x0d\x0a"
BUFFER_SIZE3 = 100
# s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
print "Sending-> BEGIN"
# s.connect((TCP_IP, TCP_PORT))
s.send(MESSAGE3)
# data3 = s.recv(BUFFER_SIZE3)
# print "received data:", data3
# # s.close()

# 6c 01 00 01 1b 00 00 00 01 02 00 02 60 08 00 02 08 01 67 00 01 73 20 20 01 81 6f 20 15 00 20 00 2f 72 65 2f 66 72 69 64 61 2f 48 6
# HostSession.....s.....GetAll....s.....org.freedesktop.DBus.Properties.....re.frida.HostSession28.
MESSAGE4="\x6c\x01\x00\x01\x1b\x00\x20\x00\x01\x20\x00\x02\x60\x00\x20\x00\x08\x01\x67\x00\x01\x73\x00\x00\x01\x01\x6f\x00\x15\x00\
BUFFER_SIZE4 = 100
print "Sending-> HostSession"
s.send(MESSAGE4)
data4 = s.recv(BUFFER_SIZE4)
print "received data:", data4
```

WHERE TO GET IT ALL

- Library
  - github.com/brompwnie/uitkyk
- Frida Scripts
  - github.com/brompwnie/uitkyk
- Videos
  - https://goo.gl/k6BNBq

SHORTCOMINGS

- Increased Attack Surface
- Abuse, it is process running as root
- We are still struggling to get basic security right

CONCLUSION & QUESTIONS

- It's a journey
- Uitkyk is a step in the right direction
- No Silver Bullet
- Defence In Depth
- Android OS is key to protecting itself
- Questions?