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San Francisco | February 29 – March 4 | Moscone Center

Connect to Protect

SESSION ID: MBS-R02

How to Analyze an Android Bot

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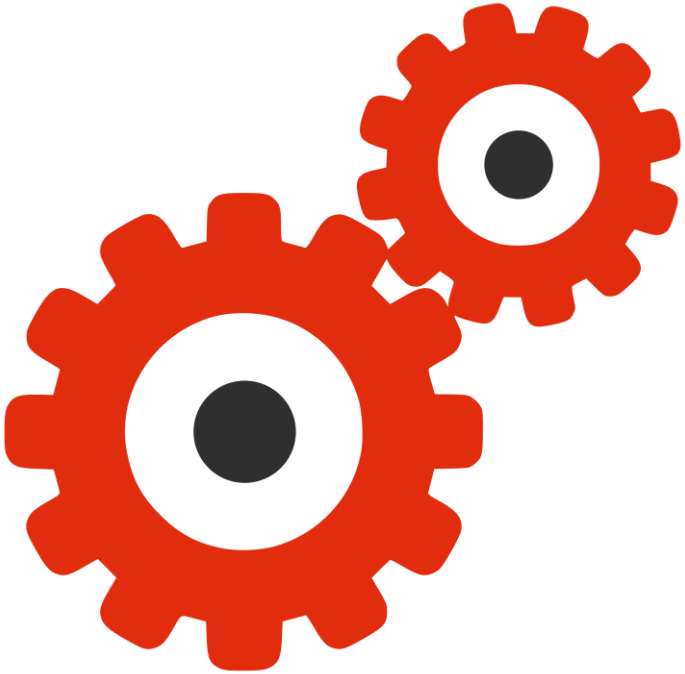
#RSAC

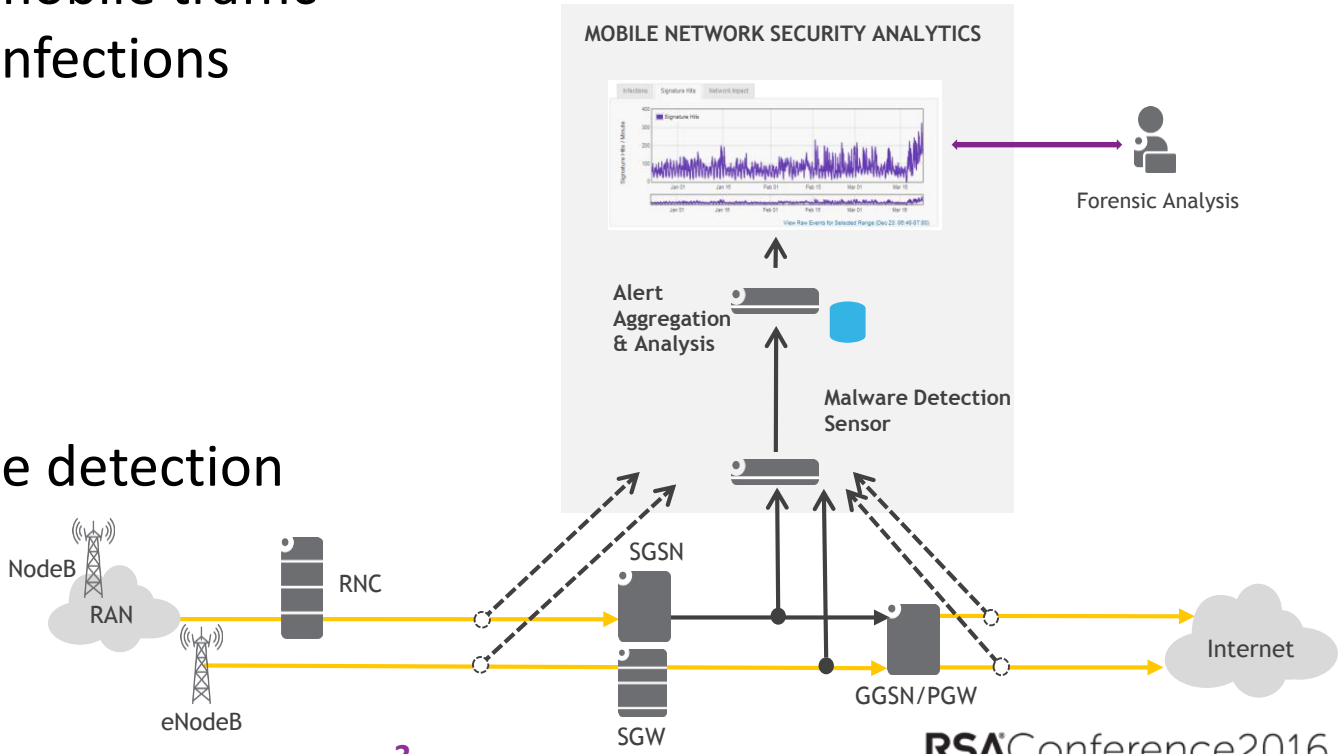
Agenda

- Introduction
- Tools
- The Lab
- Demo
- Q&A

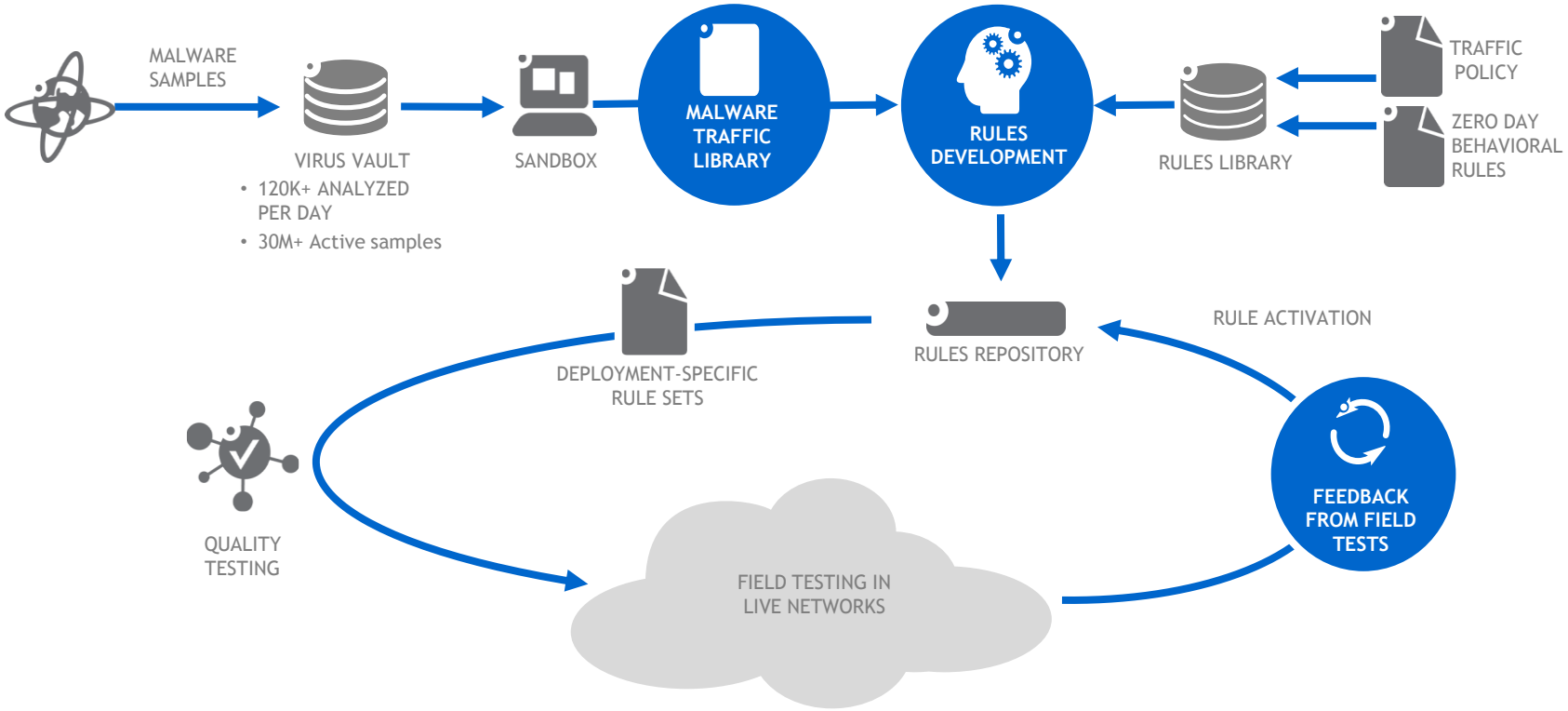


Why Analyze Android Malware

- We monitor mobile traffic for malware infections
  - Malware C&C
  - Exploits
  - DDOS
  - Hacking
- Need accurate detection rules



Developing Malware Detection Rules



Android Malware Analysis

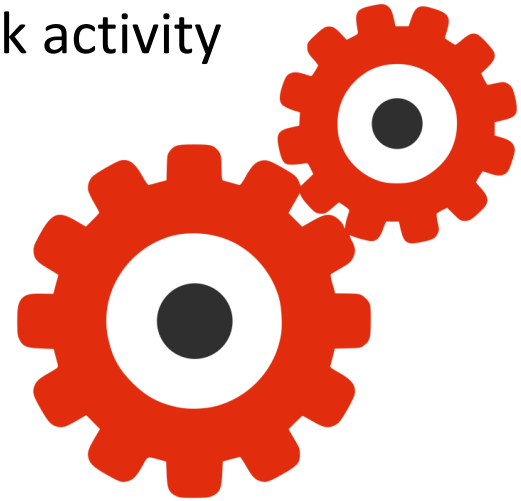
- So, we built our own Android malware analysis lab
- You will learn
  - What tools are required
  - How to set up the network environment
  - How they are used
- Analysis allows you to:
  - Know what the malware does
  - Understand its threat level
  - Detect and remediate the infection

Android App

- Contained in APK file (zip format)
- Main components include:
  - Manifest
  - Dalvik byte code (classes.dex file)
  - Resources
  - Assets
  - Libraries

Basic Analysis Process

- Explore what's in APK file
- Decompile DEX and review source
- Run app on phone or AVD & capture network activity



Tools – Android Studio

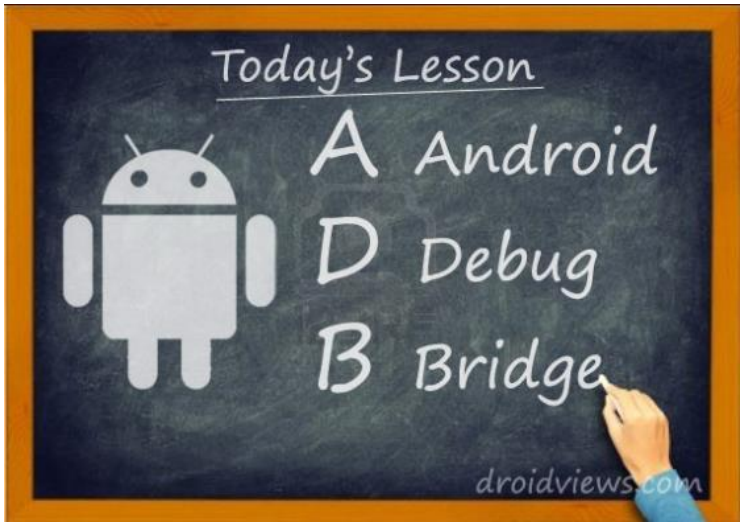
- If you are going to analyze apps you have to know a bit about how they are made…
- Also provides many of the tools needed for analysis…
  - ADB (debugging)
  - AVD (simulated phones)

Tools – Apktool

- Tool for reverse engineering Android packages (apk files)
- Extract components
  - Manifest, Resources, Libraries, Assets, Byte-code (Smali)
- Can edit and modify components
- Rebuild modified app

Tools – ADB

- Android Debug Bridge
- Comes with Android Studio
- Provides:
  - Shell access
  - Access to file system
  - Scripted remote control
  - Application Install/Uninstall



Tools – dex2jar

- Converts Dalvik byte code to Java byte code
- First step in de-compiling an Android app.

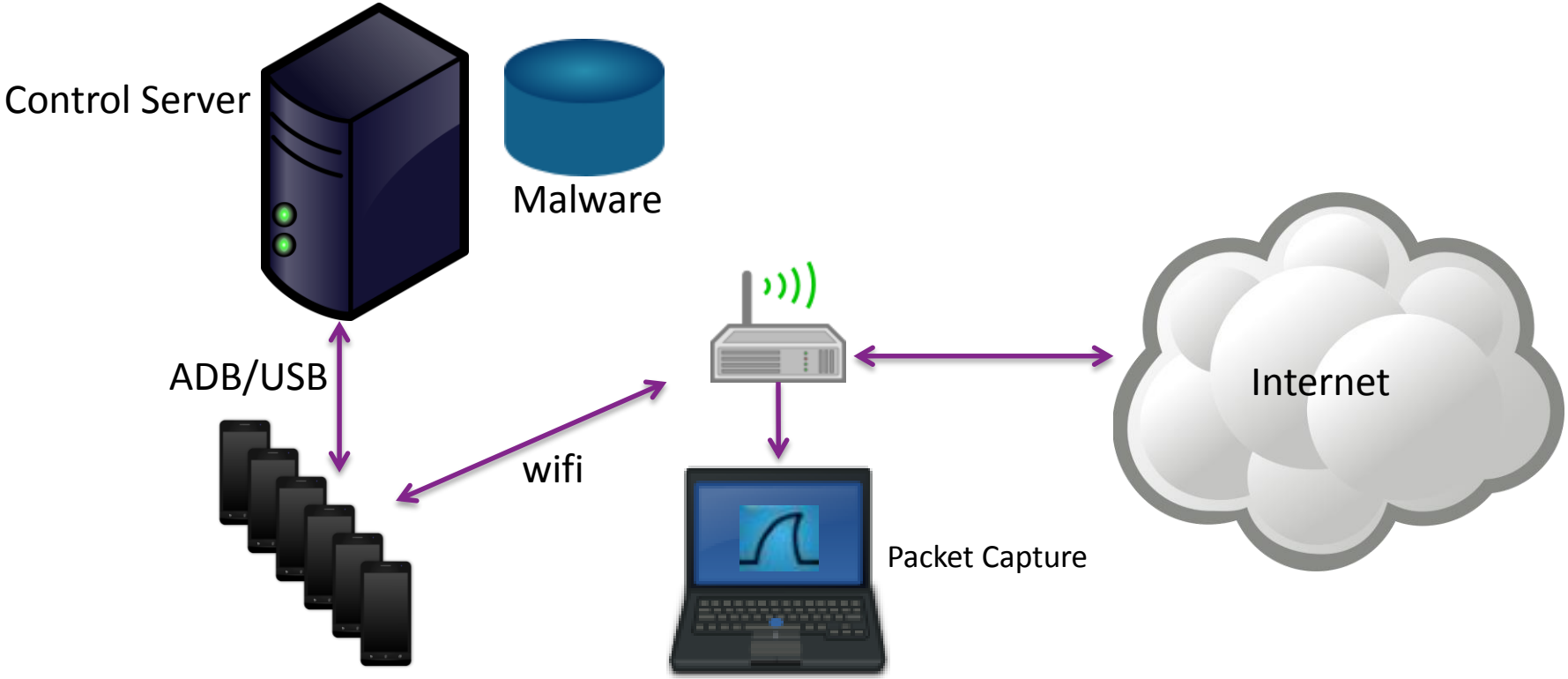
Tools – Java Decompiler

- Converts Java byte code to source code.
- Doesn't always work ☹
- Options include:
  - JD-GUI
  - Luyten (Procyon)

Tools – WireShark

- Capture and network traffic
- Analyze network traffic
- Help develop detection rules

The Lab


Control Server
Malware
ADB/USB
wifi
Internet
Packet Capture

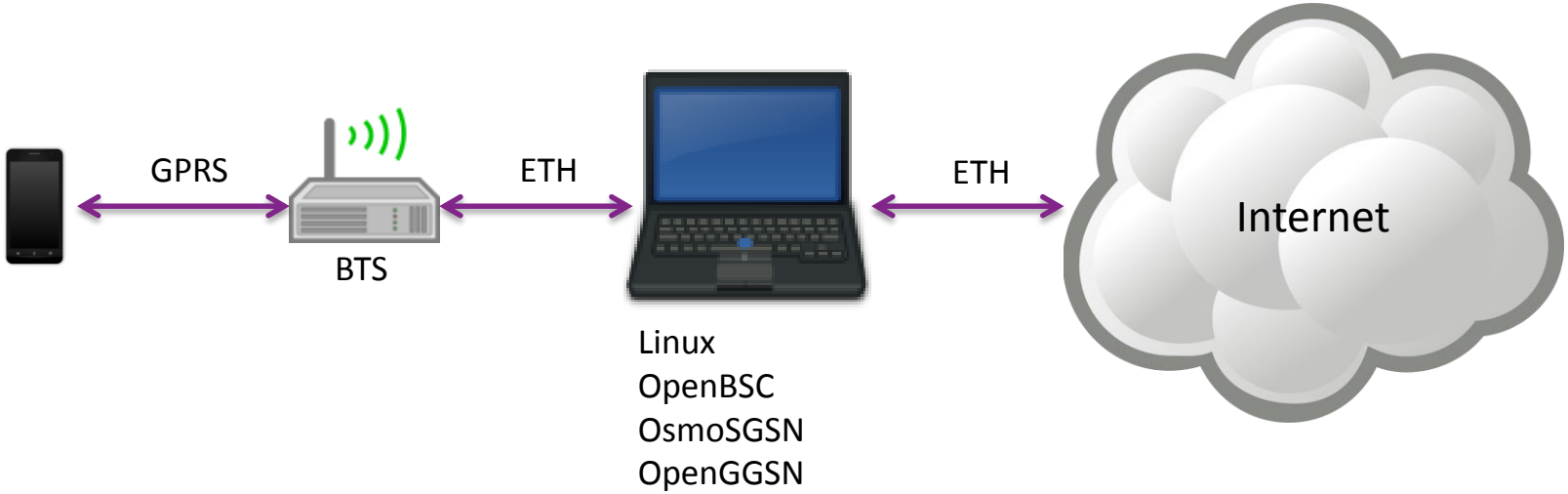

J
ZOE
D2
D1
Caution:
Malware


DELL
NETGEAR
2 52


IVY
JOE
EVA
FAY
BUS
HAL
B4
OREO
DANGER – Malware Sandboxes
SOPHOS

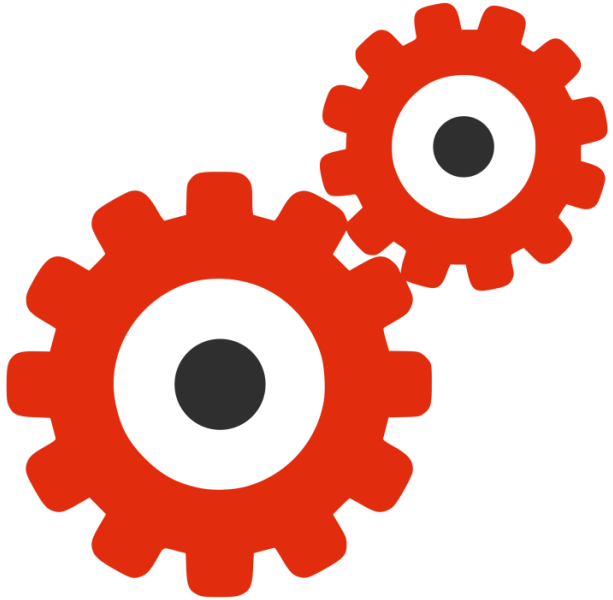
Using a Real Mobile Network

- Some malware may only function on a real mobile network
- You can build your own mobile network.



Automation

- We have automated the analysis process using:
  - Web based user interface
  - Real phones and AVDs
  - Malware database
  - APKtool/Dex2Jar/GD-GUI
  - ADB scripting
  - Monkey Script
  - WireShark
  - Interface to Virus Total



VirusTotal | SoakTest | PCAPs | Signature hits | NViso | Sandbox | APK | Download

Data provided by VirusTotal ® on 2013-11-28.

Comodo	UnclassifiedMalware	**Sophos**	Andr/Notcom-A
Symantec	Android.Notcompatible	**Avast**	Android:NotCom-A [Trj]
DrWeb	Android.Proxy.1.origin	**VIPRE**	Trojan.AndroidOS.Generic.A
TrendMicro-HouseCall	TROJ_GEN.F47V0319	**AntiVir**	Android/Proxy.A
Kingsoft	Android.Troj.at_Nisev.a.(kcloud)	**NANO-Antivirus**	Trojan.Nisev.bkqvoh
F-Prot	AndroidOS/NotCom.A	**GData**	Android.Trojan.NioServ.A
ESET-NOD32	a variant of Android/NoComA.B	**BitDefender**	Android.Trojan.NioServ.A
Ikarus	Trojan.AndroidOS.NotCom	**Emsisoft**	Android.Trojan.NioServ.A (B)
Kaspersky	HEUR:Backdoor.AndroidOS.Nisev.b	**MicroWorld-eScan**	Android.Trojan.NioServ.A
F-Secure	Trojan:Android/NioServ.A	**CAT-QuickHeal**	Android.Nisev.B2983
ClamAV	Andr.Trojan.NotCompatible	**AVG**	Android/Nise
Baidu-International	Backdoor.AndroidOS.Nisev.AO	**McAfee-GW-Edition**	Artemis!0E8525862F9C
TrendMicro	ANDROIDOS_NISEV.VTD	**Fortinet**	Android/Compatible.A!tr.bdr
McAfee	Artemis!0E8525862F9C	**Commtouch**	AndroidOS/GenBl.0E852586!Olympus
Ad-Aware	Android.Trojan.NioServ.A	**Bkav**	MW.Clod0e8.Trojan.5258
K7AntiVirus	Trojan (0040f2631)	**K7GW**	Trojan (0040f2631)

Update

The detailed VirusTotal report can be viewed Here

Provides a name

VirusTotal | SoakTest | PCAPs | Signature hits | NViso | Sandbox | APK | Download

Android APK Analysis

Application: com.android.fixed.update

Version: 1.0

Requested Permissions:

- android.permission.ACCESS_NETWORK_STATE
- android.permission.INTERNET
- android.permission.RECEIVE_BOOT_COMPLETED

Intent Filters (receiver):

- android.intent.action.BOOT_COMPLETED
- android.intent.action.USER_PRESENT

Visual UI Activities:

Application Services:

- FixedUpdate

Broadcast Receivers:

- OnBootReceiver

Content Providers:

Information from Manifest

VirusTotal | SoakTest | PCAPs | Signature hits | NViso | Sandbox | APK | Download

A malware soak test involves passively running a malware sample on a virtual machine and capturing any resulting network traffic.

Initiate Malware Soak test:

Duration: 5 minutes

VM Host: Android-1: Android 4.0 (Jelly Bean)

Malware Launch: (•) Automatic ( ) Manual

DNS: (•) Actual
( ) Failover to FakeDNS
( ) FakeDNS Only

Listener Ports: [ ] (comma seperated list of TCP ports >1024 or IPaddress:Port)

Retain PCAP: [x]

Start

Run Sample in AVD

VirusTotal | SoakTest | PCAPs | Signature hits | NViso | Sandbox | APK | Download

Existing Packet Capture Files:

Date	Source	Details	Grade	Packets	Delete
2013-04-01 06:49:18		By Arvind from Anubis		40	
2013-10-28 13:18:34	AndroidSandbox	Automated Android Sandbox execution (,DNS)		3449	
2013-10-28 16:19:25	Soak	Automated 10 minute soak test ()		553	
2013-10-28 16:30:06	Soak	Automated 15 minute soak test ()		919	
2013-11-28 11:19:08	Soak	Automated 5 minute soak test ()		201	
2013-11-28 15:19:42	AndroidSandbox	Automated Android Sandbox execution (,DNS)		229	
2013-12-16 16:56:19	AndroidSandbox	Automated Android Sandbox execution (,DNS)		699	
2015-12-04 11:26:48	AndroidSandbox	Interactive Android Sandbox 042b8abd13b6f9f9 execution (,DNS)	A	105	

Upload PCAP File:

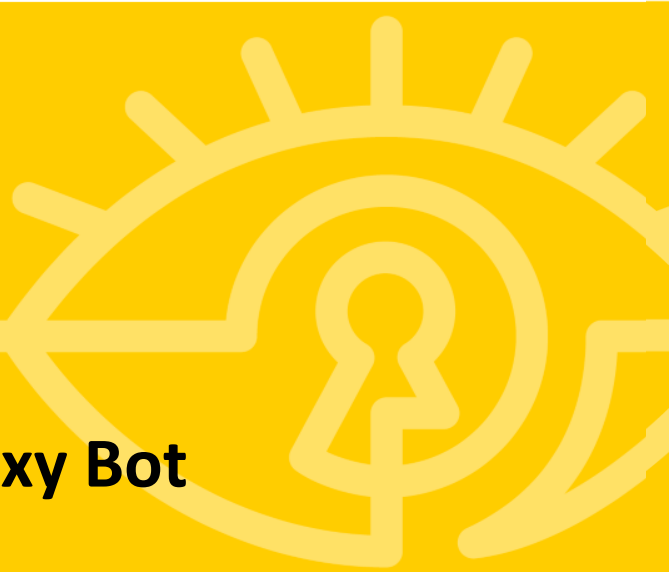
Select File: Browse...

Source: upload

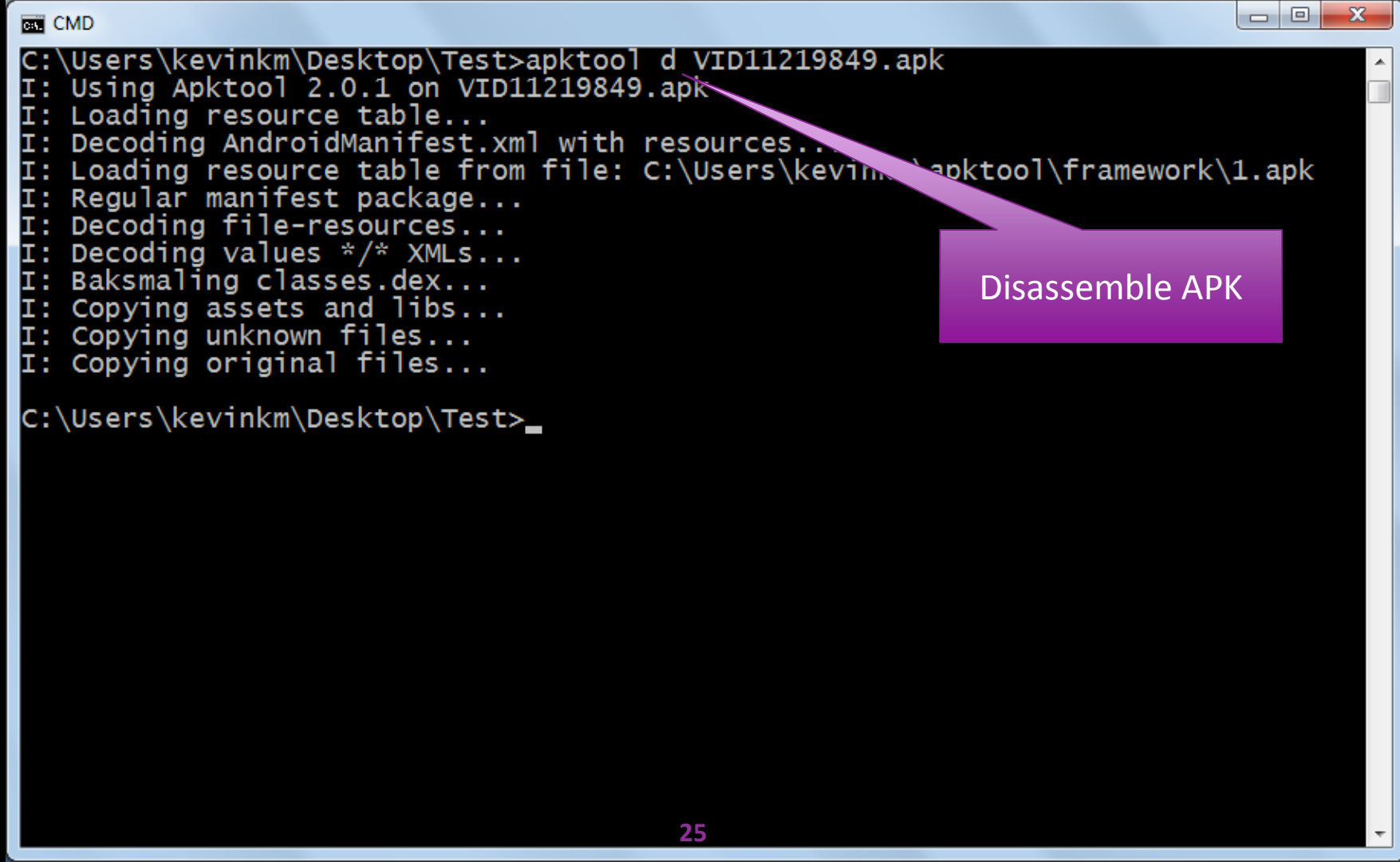
Details:

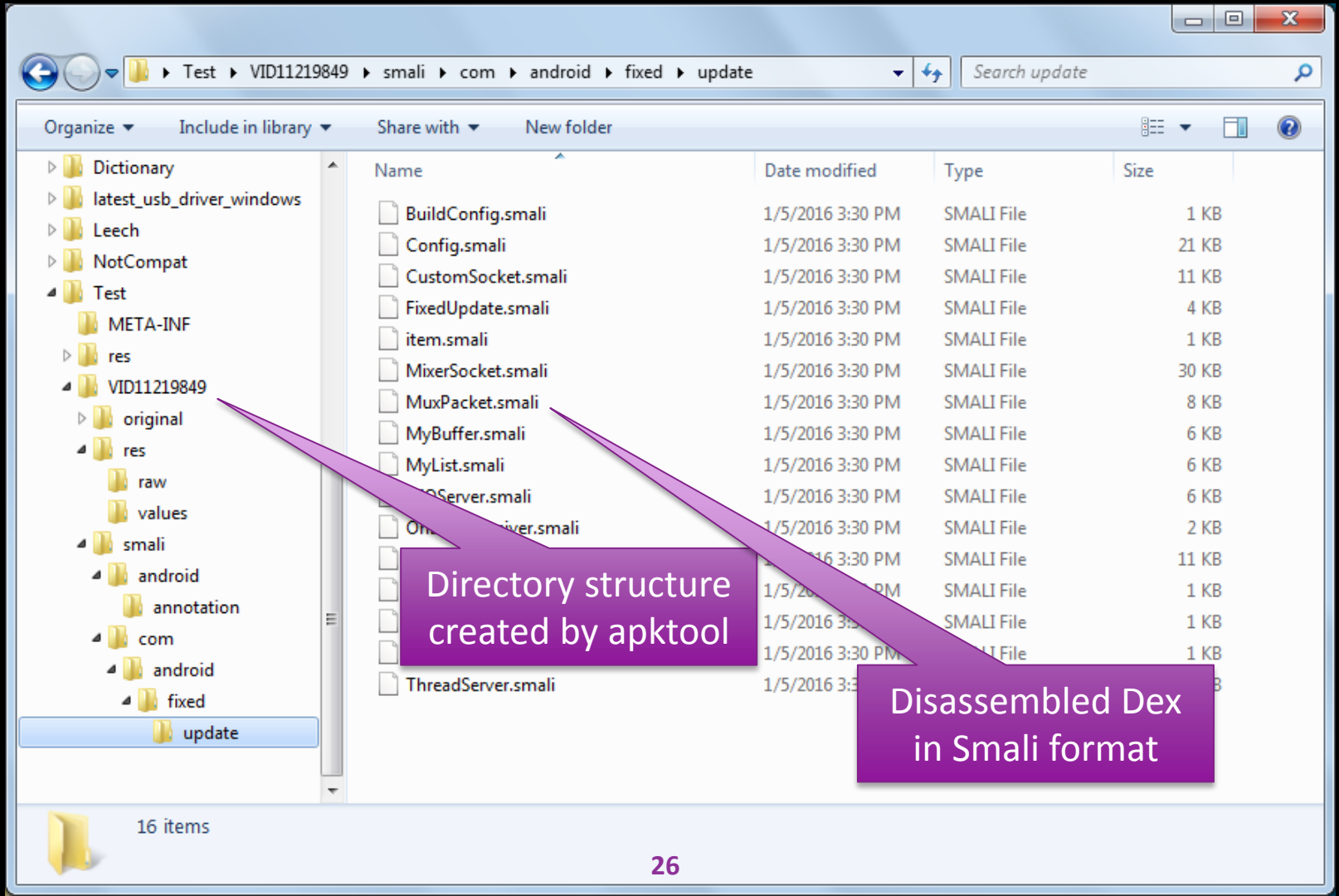
Upload PCAP

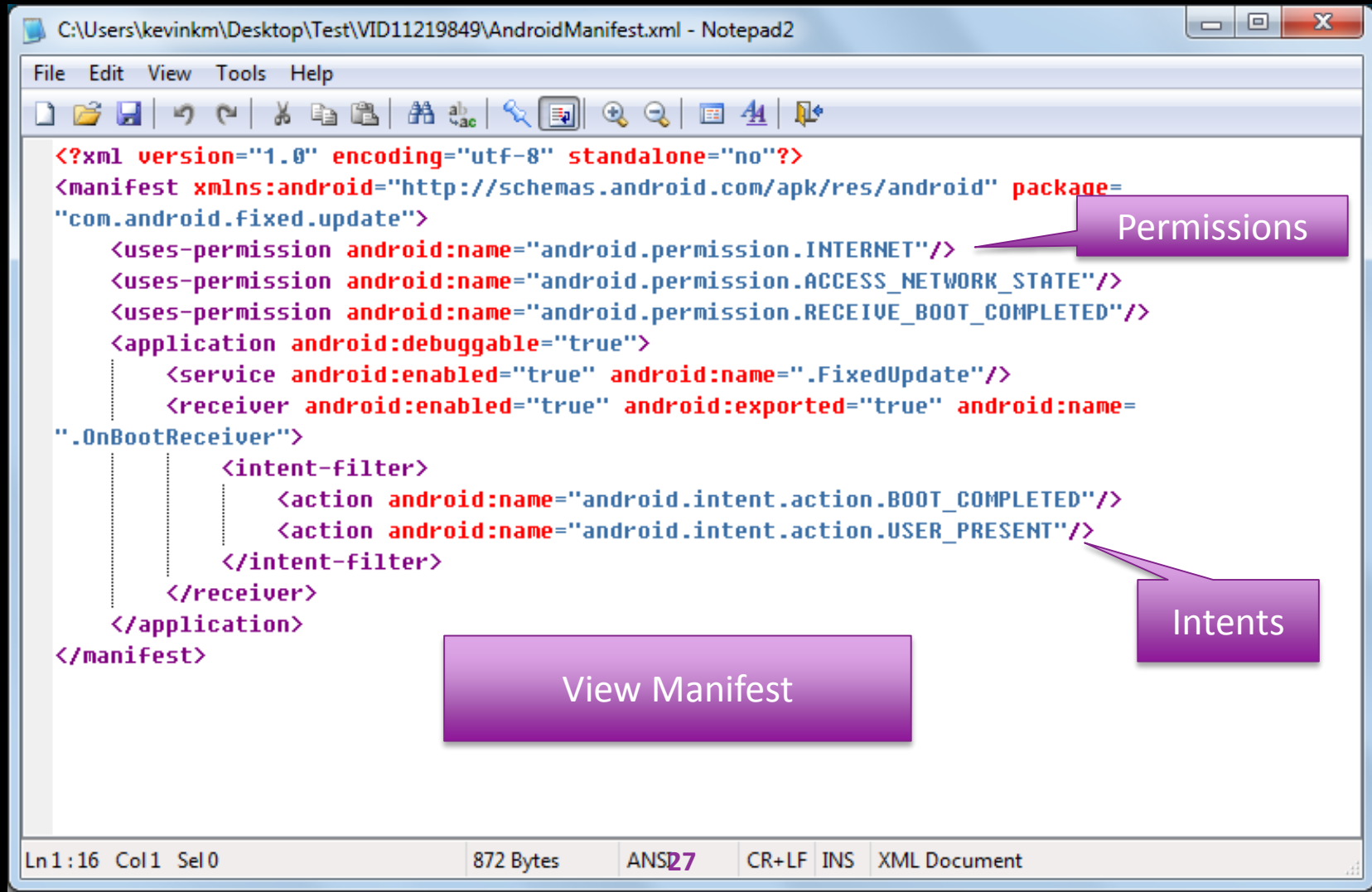
Analyze Network Traffic

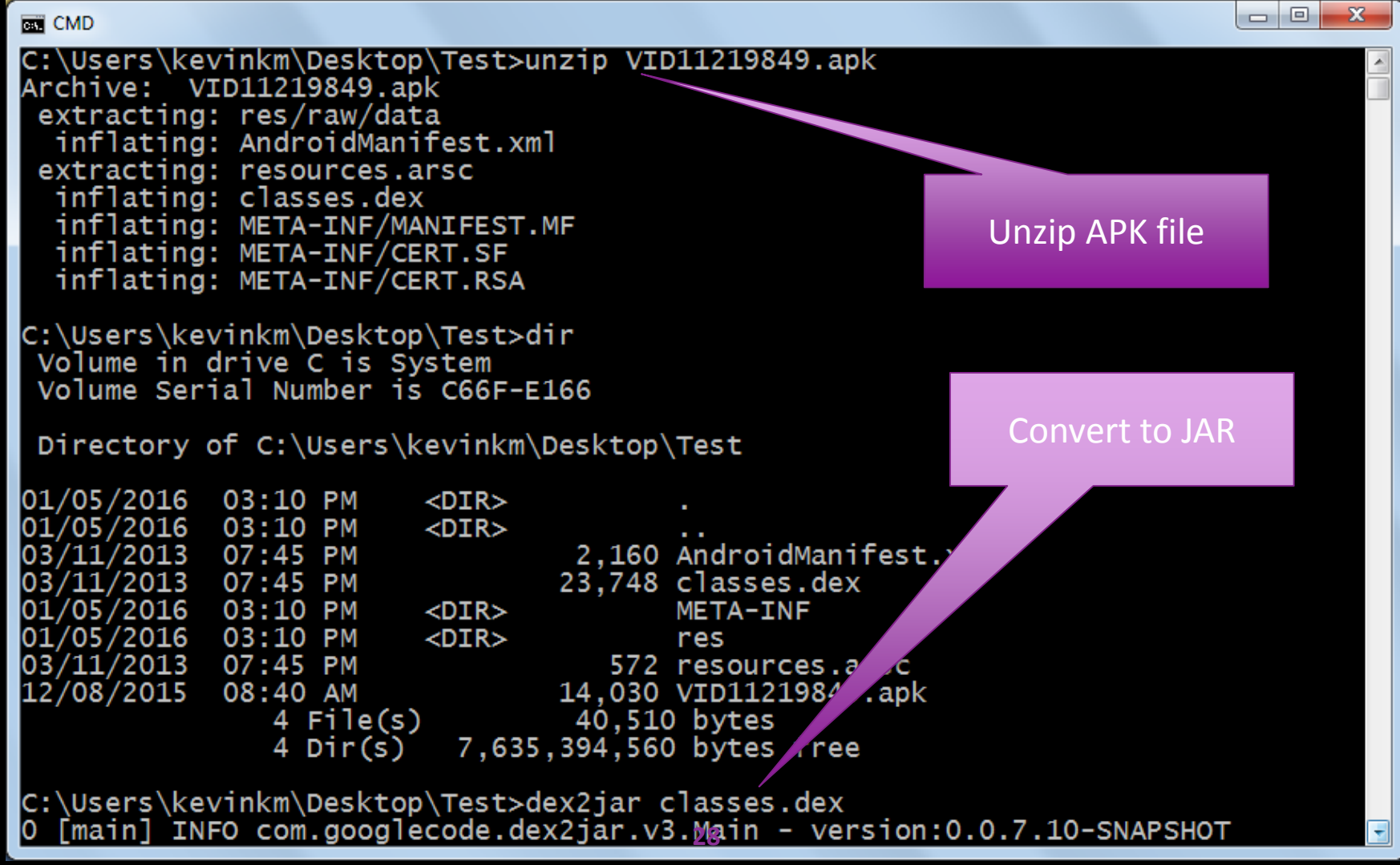


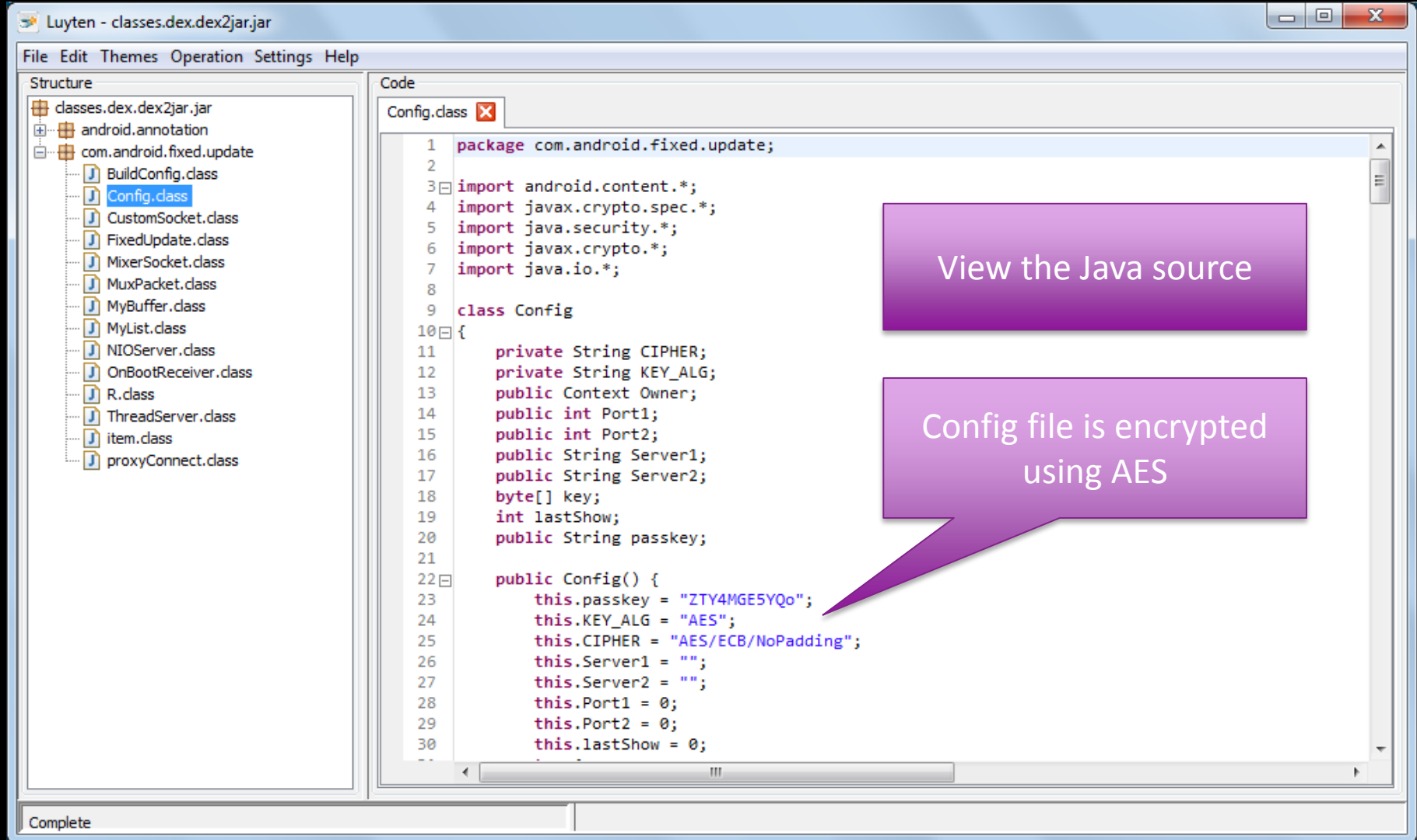
Manual Demo – NotCompatible Proxy Bot

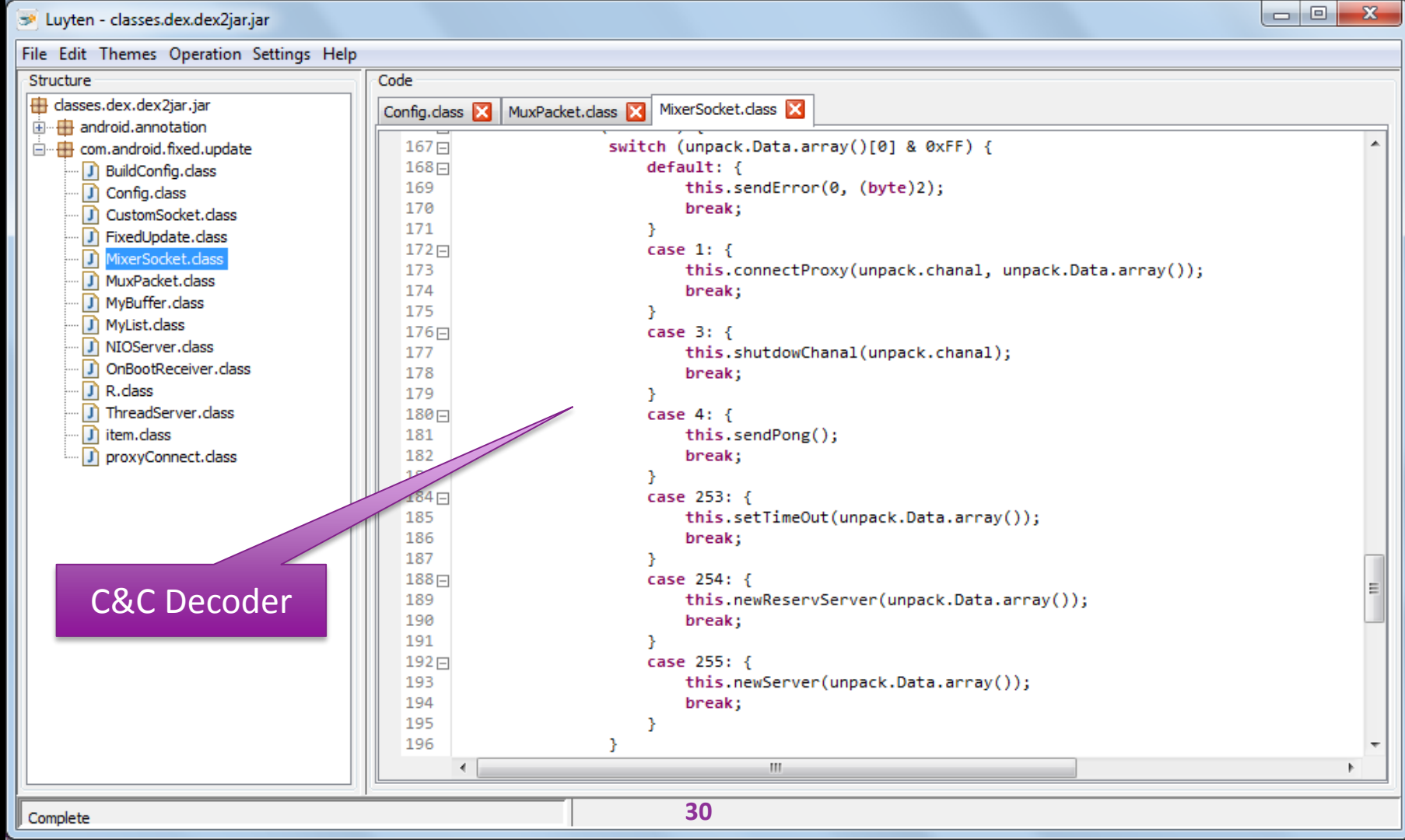

CMD
C:\Users\kevinkm\Desktop\Test>apktool d VID11219849.apk
I: Using Apktool 2.0.1 on VID11219849.apk
I: Loading resource table...
I: Decoding AndroidManifest.xml with resources...
I: Loading resource table from file: C:\Users\kevinkm\apktool\framework\1.apk
I: Regular manifest package...
I: Decoding file-resources...
I: Decoding values */* XMLs...
I: Baksmaling classes.dex...
I: Copying assets and libs...
I: Copying unknown files...
I: Copying original files...
C:\Users\kevinkm\Desktop\Test>
Disassemble APK


Test ▸ VID11219849 ▸ smali ▸ com ▸ android ▸ fixed ▸ update
Search update
Organize
Include in library
Share with
New folder
Dictionary
latest_usb_driver_windows
Leech
NotCompat
Test
META-INF
res
VID11219849
original
res
raw
values
smali
android
annotation
com
android
fixed
update
Name
Date modified
Type
Size
BuildConfig.smali 1/5/2016 3:30 PM SMALI File 1 KB
Config.smali 1/5/2016 3:30 PM SMALI File 21 KB
CustomSocket.smali 1/5/2016 3:30 PM SMALI File 11 KB
FixedUpdate.smali 1/5/2016 3:30 PM SMALI File 4 KB
item.smali 1/5/2016 3:30 PM SMALI File 1 KB
MixerSocket.smali 1/5/2016 3:30 PM SMALI File 30 KB
MuxPacket.smali 1/5/2016 3:30 PM SMALI File 8 KB
MyBuffer.smali 1/5/2016 3:30 PM SMALI File 6 KB
MyList.smali 1/5/2016 3:30 PM SMALI File 6 KB
ThreadServer.smali
Directory structure created by apktool
Disassembled Dex in Smali format
16 items


C:\Users\kevinkm\Desktop\Test\VID11219849\AndroidManifest.xml - Notepad2
File Edit View Tools Help
<?xml version="1.0" encoding="utf-8" standalone="no"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android" package=
"com.android.fixed.update">
<uses-permission android:name="android.permission.INTERNET"/>
<uses-permission android:name="android.permission.ACCESS_NETWORK_STATE"/>
<uses-permission android:name="android.permission.RECEIVE_BOOT_COMPLETED"/>
<application android:debuggable="true">
<service android:enabled="true" android:name=".FixedUpdate"/>
<receiver android:enabled="true" android:exported="true" android:name=
".OnBootReceiver">
<intent-filter>
<action android:name="android.intent.action.BOOT_COMPLETED"/>
<action android:name="android.intent.action.USER_PRESENT"/>
</intent-filter>
</receiver>
</application>
</manifest>
Permissions
Intents
View Manifest
Ln 1 : 16 Col 1 Sel 0
872 Bytes
ANSI
CR+LF
INS
XML Document


CMD
C:\Users\kevinkm\Desktop\Test>unzip VID11219849.apk
Archive: VID11219849.apk
 extracting: res/raw/data
  inflating: AndroidManifest.xml
 extracting: resources.arsc
  inflating: classes.dex
  inflating: META-INF/MANIFEST.MF
  inflating: META-INF/CERT.SF
  inflating: META-INF/CERT.RSA
C:\Users\kevinkm\Desktop\Test>dir
 Volume in drive C is System
 Volume Serial Number is C66F-E166
 Directory of C:\Users\kevinkm\Desktop\Test
01/05/2016 03:10 PM   <DIR>   .
01/05/2016 03:10 PM   <DIR>   ..
03/11/2013 07:45 PM   2,160 AndroidManifest.x
03/11/2013 07:45 PM   23,748 classes.dex
01/05/2016 03:10 PM   <DIR>   META-INF
01/05/2016 03:10 PM   <DIR>   res
03/11/2013 07:45 PM   572 resources.a c
12/08/2015 08:40 AM   14,030 VID1121984 .apk
               4 File(s)   40,510 bytes
               4 Dir(s)   7,635,394,560 bytes free
C:\Users\kevinkm\Desktop\Test>dex2jar classes.dex
0 [main] INFO com.googlecode.dex2jar.v3.Main - version:0.0.7.10-SNAPSHOT
Unzip APK file
Convert to JAR


Luyten - classes.dex.dex2jar.jar
File Edit Themes Operation Settings Help
Structure
classes.dex.dex2jar.jar
android.annotation
com.android.fixed.update
BuildConfig.class
Config.class
CustomSocket.class
FixedUpdate.class
MixerSocket.class
MuxPacket.class
MyBuffer.class
MyList.class
NIOServer.class
OnBootReceiver.class
R.class
ThreadServer.class
item.class
proxyConnect.class
Code
Config.class
1 package com.android.fixed.update;
2
3 import android.content.*;
4 import javax.crypto.spec.*;
5 import java.security.*;
6 import javax.crypto.*;
7 import java.io.*;
8
9 class Config
10 {
11 private String CIPHER;
12 private String KEY_ALG;
13 public Context Owner;
14 public int Port1;
15 public int Port2;
16 public String Server1;
17 public String Server2;
18 byte[] key;
19 int lastShow;
20 public String passkey;
21
22 public Config() {
23 this.passkey = "ZTY4MGE5YQo";
24 this.KEY_ALG = "AES";
25 this.CIPHER = "AES/ECB/NoPadding";
26 this.Server1 = "";
27 this.Server2 = "";
28 this.Port1 = 0;
29 this.Port2 = 0;
30 this.lastShow = 0;
View the Java source
Config file is encrypted using AES
Complete


Luyten - classes.dex.dex2jar.jar
File Edit Themes Operation Settings Help
Structure
classes.dex.dex2jar.jar
android.annotation
com.android.fixed.update
BuildConfig.class
Config.class
CustomSocket.class
FixedUpdate.class
MixerSocket.class
MuxPacket.class
MyBuffer.class
MyList.class
NIOServer.class
OnBootReceiver.class
R.class
ThreadServer.class
item.class
proxyConnect.class
Code
Config.class
MuxPacket.class
MixerSocket.class
167 switch (unpack.Data.array()[0] & 0xFF) {
168 default: {
169 this.sendError(0, (byte)2);
170 break;
171 }
172 case 1: {
173 this.connectProxy(unpack.chanal, unpack.Data.array());
174 break;
175 }
176 case 3: {
177 this.shutdowChanal(unpack.chanal);
178 break;
179 }
180 case 4: {
181 this.sendPong();
182 break;
184 }
184 case 253: {
185 this.setTimeOut(unpack.Data.array());
186 break;
187 }
188 case 254: {
189 this.newReservServer(unpack.Data.array());
190 break;
191 }
192 case 255: {
193 this.newServer(unpack.Data.array());
194 break;
195 }
196 }
C&C Decoder
Complete
30

C:\Users\kevinkm\Desktop\Test\VID11219849\smali\com\android\fixed\update\MixerSocket.smali - Notepad2

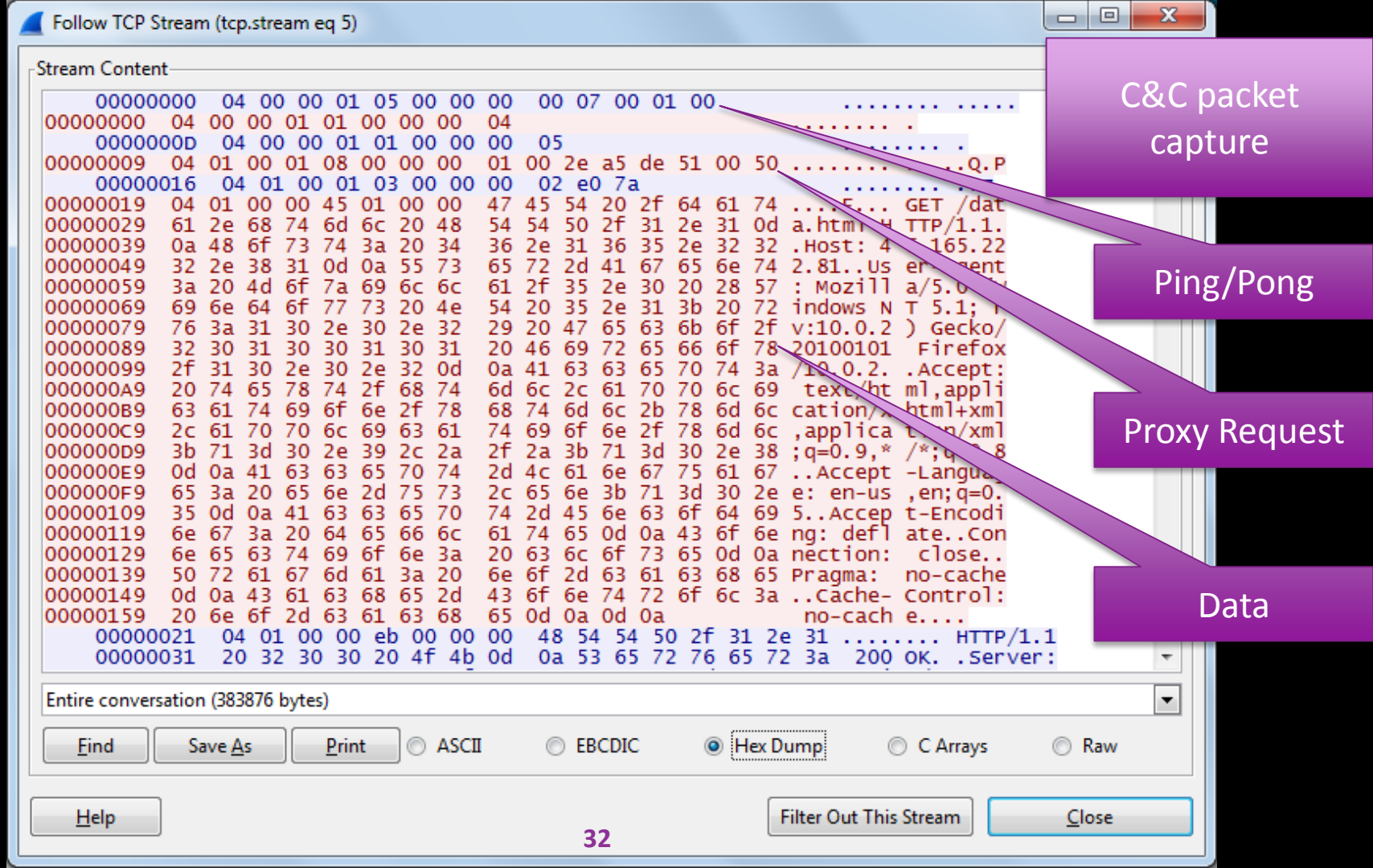
File Edit View Tools Help

```
    :sswitch_1
    iget v3, v1, Lcom/android/fixed/update/MuxPacket;->chanal:I

    invoke-virtual {p0, v3}, Lcom/android/fixed/update/MixerSocket;->shutd

    goto :goto_6

    .line 491
    :sswitch_2
    invoke-virtual {p0}, Lcom/android/fixed/update/MixerSocket;->sendPong()V

    goto :goto_6

    .line 495
    :sswitch_3
    iget-object v3, v1,
Lcom/android/fixed/update/MuxPacket;->Data:Lcom/android/fixed/update/MyBuffer;

    invoke-virtual {v3}, Lcom/android/fixed/update/MyBuffer;->ar()[B

    move-result-object v3

    invoke-virtual {p0, v3}, Lcom/android/fixed/update/MixerSocket;->setTimeOut(

    goto :goto_6

    .line 498
```

Ln 1 : 1,194 Col 1 Sel 0 | 29.32 KB | ANSI | CR+LF | INS | Default Text

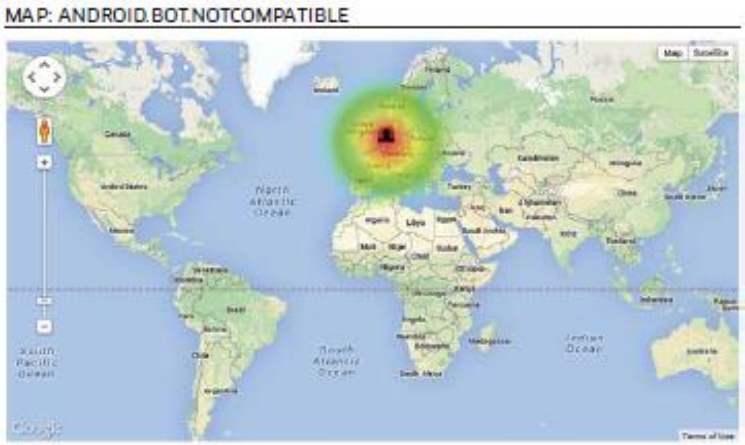
It can be modified and the APK can be rebuilt using apktool

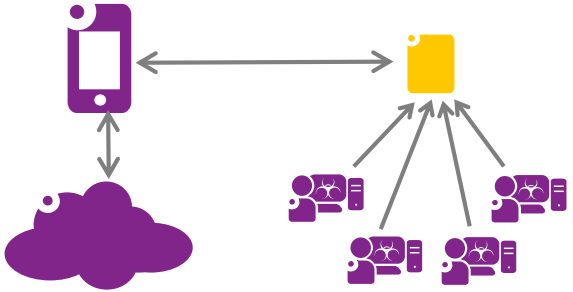
C&C Decoder


Follow TCP Stream (tcp.stream eq 5)
Stream Content
00000000 04 00 00 01 05 00 00 00 00 07 00 01 00 ....
00000000 04 00 00 01 01 00 00 00 04 ..... .
0000000D 04 00 00 01 01 00 00 00 05 ..... .
00000009 04 01 00 01 08 00 00 00 01 00 2e a5 de 51 00 50 ....Q.P
00000016 04 01 00 01 03 00 00 00 02 e0 7a ....
00000019 04 01 00 00 45 01 00 00 47 45 54 20 2f 64 61 74 ....E... GET /dat
00000029 61 2e 68 74 6d 6c 20 48 54 54 50 2f 31 2e 31 0d a.html H TTP/1.1.
00000039 0a 48 6f 73 74 3a 20 34 36 2e 31 36 35 2e 32 32 .Host: 4 6.165.22
00000049 32 2e 38 31 0d 0a 55 73 65 72 2d 41 67 65 6e 74 2.81..Us er-Agent
00000059 3a 20 4d 6f 7a 69 6c 6c 61 2f 35 2e 30 20 28 57 : Mozill a/5.0 (W
00000069 69 6e 64 6f 77 73 20 4e 54 20 35 2e 31 3b 20 72 indows N T 5.1; r
00000079 76 3a 31 30 2e 30 2e 32 29 20 47 65 63 6b 6f 2f v:10.0.2) Gecko/
00000089 32 30 31 30 30 31 30 31 20 46 69 72 65 66 6f 78 20100101 Firefox
00000099 2f 31 30 2e 30 2e 32 0d 0a 41 63 63 65 70 74 3a /10.0.2. .Accept:
000000A9 20 74 65 78 74 2f 68 74 6d 6c 2c 61 70 70 6c 69 text/ht ml,appli
000000B9 63 61 74 69 6f 6e 2f 78 68 74 6d 6c 2b 78 6d 6c cation/x html+xml
000000C9 2c 61 70 70 6c 69 63 61 74 69 6f 6e 2f 78 6d 6c ,applica tion/xml
000000D9 3b 71 3d 30 2e 39 2c 2a 2f 2a 3b 71 3d 30 2e 38 ;q=0.9,* /*;q=0.8
000000E9 0d 0a 41 63 63 65 70 74 2d 4c 61 6e 67 75 61 67 ..Accept -Langua
000000F9 65 3a 20 65 6e 2d 75 73 2c 65 6e 3b 71 3d 30 2e e: en-us ,en;q=0.
00000109 35 0d 0a 41 63 63 65 70 74 2d 45 6e 63 6f 64 69 5..Accep t-Encodi
00000119 6e 67 3a 20 64 65 66 6c 61 74 65 0d 0a 43 6f 6e ng: defl ate..Con
00000129 6e 65 63 74 69 6f 6e 3a 20 63 6c 6f 73 65 0d 0a nection: close..
00000139 50 72 61 67 6d 61 3a 20 6e 6f 2d 63 61 63 68 65 Pragma: no-cache
00000149 0d 0a 43 61 63 68 65 2d 43 6f 6e 74 72 6f 6c 3a ..Cache- Control:
00000159 20 6e 6f 2d 63 61 63 68 65 0d 0a 0d 0a no-cach e....
00000021 04 01 00 00 eb 00 00 00 48 54 54 50 2f 31 2e 31 ..... HTTP/1.1
00000031 20 32 30 30 20 4f 4b 0d 0a 53 65 72 76 65 72 3a 200 OK. .Server:
Entire conversation (383876 bytes)
Find
Save As
Print
ASCII
EBCDIC
Hex Dump
C Arrays
Raw
Help
Filter Out This Stream
Close
C&C packet capture
Ping/Pong
Proxy Request
Data

NotCompatible - Overview

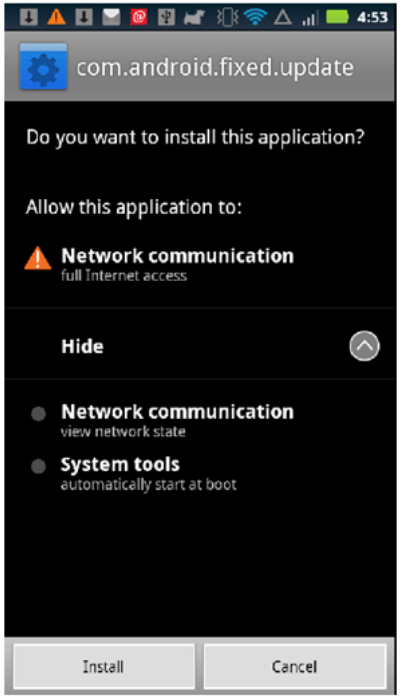
- Web Proxy Bot ported from Windows to Android environment.
- Allows remote miscreants to anonymously browse the web through the victim's phone.
- Consumes lots of bandwidth, for example 165MB in two hours over 300K TCP sessions





NotCompatible – Infection

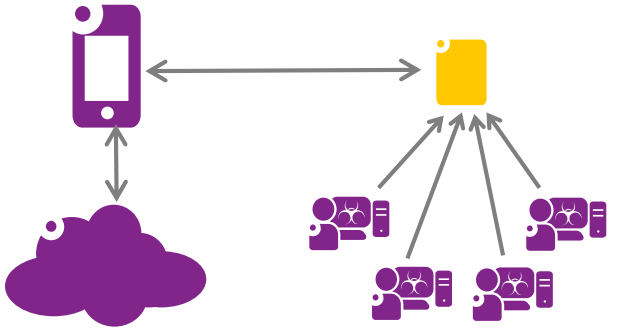
- Phishing spam is used to lure the victim to an infected web site.
- Web site tells you the browser is “not compatible” and provides an update.
- The user downloads and installs update.apk
- Malware has no icon or user interface. It is automatically started on BOOT.
- You can get rid of the infection by uninstalling the application.



NotCompatible – Operation

- Opens an encrypted configuration file containing the address and port number of the server.
- The bot connects to the server via TCP.
- Sophisticated command and control protocol is then used to multiplex Web proxy services over that connection.
- This provides an anonymous web browsing services to clients.

```
class Config
{
  private String CIPHER = "AES/ECB/NoPadding";
  private String KEY_ALG = "AES";
  public Context Owner;
  public int Port1 = 0;
  public int Port2 = 0;
  public String Server1 = "";
  public String Server2 = "";
  byte[] key;
  int lastShow = 0;
  public String passkey = "ZTY4MGE5YQo";
```



NotCompatible – Command & Control

- Simple command/response packet format contains both commands and data.
- Channel number can multiplex many connection at once.
- The ping and pong are used as a heartbeat when there is no proxy work to be done.
- Once a proxy request is issued the “raw data” commands are used to transfer the data in either direction.

Packet format:

0x04	chan	type	length	…data…

0x04	- Protocol Version (1 byte)
chan	- Multiplexor Channel number (2 bytes)
type	- 0x00:Proxy Data, 0x01:Command (1 byte)
len	- Length of the data field (4 bytes)
data	- Is either proxy packet data or a command

Commands:

Initial handshake:	| 00 | 07000v00 |
Proxy to IP:	| 01 | 00 |IP & port|
Proxy to domain name:	| 01 | 01 |len|domain name|
Response to proxy:	| 02 | nnnn |
End of proxy session:	| 03 |
Ping:	| 04 |
Pong:	| 05 |
Unknown (from victim):	| FC | 01 |
Set Timeout:	| FD | timeout |
Set Reserve Server:	| FE | server IP and port |
Set Primary Server:	| FF | server IP and port |

NotCompatible – Uses & Impact

- Uses
  - Anonymous Web Browsing Service
  - Providing Access to Restricted Foreign Content
  - Ad-Click Fraud
  - Web Site Optimization Fraud
  - APT Probing and Exfiltration

- Impact
  - One user from Finland, roaming in the US, used over 165MBytes in less than two hours of airtime.
  - In the lab it averages 100MBytes per hour.
  - Causes huge data bills
  - Caused the battery to run down quickly
  - Who knows what sites your phone in visiting!!!

Summary

- Android malware analysis enables you to:
  - Know what the malware does
  - Understand the threat level
  - Detect and remediate the infection
- You should now know:
  - What tools are required
  - How to set up the network environment
  - How to use the tools

Questions?

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