

# CRAB-Droid

AJ Arnold, Matthew Berthoud, Justin Crescent, Ada Rigsby

May 12, 2024

## Abstract

Analyzing Android applications for correct security practices such as using permissions, using the SSL API, and potential interface vulnerabilities is a challenging task. This paper presents our tool CRAB-Droid, a python script that builds upon Androguard to carry out a static analysis to identify potential security vulnerabilities in Android applications. We analyzed 100 apps from the Google Play Store with the objective of identifying potential security vulnerabilities. We created 5 experiments to test on our 7 research questions we had outlined in the planning stage of our analysis. Our findings ... #TODO This project shows the significance of developers following best practices when creating Android apps, and the abilities to develop tools to help guide and educate engineers to them. Implementing tools like Androguard and CRAB-Droid to be used in the development process can help to identify potential security vulnerabilities before putting apps into deployment onto the app stores. This can help to save time, money, and most of all, user privacy.

## 1 Introduction

Currently, Android is the most used smartphone operating system in the world, with a market share of 48% and over 400,000 applications (apps) available in the Google Play Market [4]. The Google Play Market is also mostly open and unrestricted, allotting developers more freedom, but many times at the cost of security. The ability to identify vulnerabilities within Android applications is vital to the safety of users and their information. Showcasing these vulnerabilities then helps to educate developers to carry-out best security practices when creating an app and to take vulnerable apps off the app store to be secured. This project investigates a variety of Android applications and vulnerabilities that potentially exist within them.

With technological enhancements to smartphone devices over the past two decades, user have been downloading more and more apps to their phones. This rise of phone apps results in a greater chance for users to download malicious ones that may contain malware, such as trojans [3]. This spike has also lead to many new devel-

opers to enter the ever expanding market, with many potential bad security practices in apps along with them. For reasons mentioned previously, it is important to identify these vulnerabilities in order to educate developers and protect users.

For this project, we analyzed a set of 100 Android apps from the Google Play Store. We then established 7 research questions to hypothesize about pontential vulnerabilities we believed we would find in the apps. We organized them into three domains: permission misuse, SSL API misuse, and interface vulnerabilities. These domains were chosen to cover a broad attack vector of the android applications such as the use of permissions that may violate user privacy, the use of SSL APIs that may not be secure, and the use of interfaces that may be vulnerable to attacks. Five experiments were then developed and tested on our set of apps.

The five experiments were tested on each app as follows: test apps for whether they use all the permissions they request and if they use any dangerous combinations of them, examine for an override on trust managers or error handlers, test for implementation of the AllowAllHostnameVerifier class, see if apps contain mixed use of HTTP and HTTPS (mixed SSL), and finally test apps for incorrect use of the addJavascriptInterface method.

Using the Androguard library [1] and referencing Malodroid [4], we completed a thorough analysis of the apps. The results showed ...

Overall, the significance of this project is seen in its use of static analysis and its applications into the discipline of Android mobile app security. This practice has the potential to be utilized in real-world applications to help secure the Google Play Store and protect users from malicious apps.

## 2 Methodology

This section outlines the methodology we will use for our experiments. We will use a set of ninety-seven apps applications during testing, using automated experiments to analyze each and every one. Finally, the results of these experiments will be analyzed for any true and/or false vulnerabilities present within each app.

## 2.1 Set of Apps

We have been given a set of ninety-seven .apk applications to test, many of which contain different purposes, uses, features, and developers. There are applications ranging from "Live Earth Map" to "Universal TV Remote Control". This variety and quantity of applications gives us a broad scope to test and is more representative of the population of all applications you can find on Google Play.

## 2.2 Experiment Design

Our experiments use lightweight static analysis to parse through each application and find vulnerabilities. We utilize Androguard libraries within our CRAB-droid script to help with the decompilation and searching of the 97 applications.

Androguard is a python-based tool used for the reverse engineering of Android applications. It takes raw Android Packages (.apk) files and breaks them down, making them easier to analyze. The capabilities of the library make it a great tool for testing the existence of vulnerabilities within applications.

After our script finishes, we then manually reviewed our results to identify trends with the applications.

## 2.3 Results Generation

Our script outputs results into a text file for us to analyze. It gives us data and statistics related to vulnerabilities within the apps.

Often, false positives can be found within our tests; our script identifies potential vulnerable patterns, but it does not guarantee that each individual finding is a true positive. In this way, our script also generates many false positives.

# 3 Experiments

## 3.1 Permissions Misuse

Many android applications misuse permissions that they allow their application to possess. Often, certain permissions are granted to an app that doesn't use them in the first place. This practice is dangerous: it can leave vulnerabilities within the application that should not be possible based on the actual functionality of the application. For example, it would be easy for a developer to add functionality to an app that requires a certain permission, and then leave the permission in after reverting their previous changes.

Another common theme seen within applications is the combination of two permissions that can create a dangerous combination. For example, a malicious applica-

tion with the permission combination of CAMERA and RECORD\_AUDIO would allow the application to have access to a device's camera and microphone, tools that would be able to perform serious invasions of privacy. Another example could be seen with INTERNET and ACCESS\_FINE\_LOCATION, which would grant an application the ability to track a device's physical location (and subsequently serve as a tool for stalking).

The ability of permissions to allow an application within reach of sensitive data means that users should be prompted whether they wish to allow certain permissions to be enabled. However, many applications do not give users the chance to make this decision; this choice is a significant breach of trust between an application and its users.

All of these developer mistakes constitute permission vulnerabilities within android applications. For our first experiment, we will be testing these common misuses of permissions. First, the experiment will test whether apps utilize all of the permissions that they request. Second, the experiment will search for the use of dangerous permission combinations implemented in the app. Finally, the experiment will test whether users are prompted to explicitly give their consent to every permission used.

Setup:

For this experiment, we will scrape the MediaStore documentation for permissions and their associations to specific constants (such as the CAMERA permission with ACTION\_IMAGE\_CAPTURE). After populating a dictionary with these associations, we will check whether every permission has a corresponding API call found within the code. If there are no matches, we can assume a permission is being used unnecessarily.

We will also use simple string searches within the Manifest file to look for potentially dangerous permission combinations.

Finally, we will check for lines of code with ".requestPermissions" and then the name of each permission. This will verify that the correct requests are being made for each permission.

## 3.2 Trust Managers and Error Handlers

Trust Managers are put in place to verify the authenticity of a remote server. To do this, many android built-in trust managers are implemented to securely verify a server's certificate. However, the built-in X509TrustManager class allows the complete override of the server verification process, potentially endangering an application if implemented incorrectly.

Many times, developers will avoid the built-in trust manager in an effort to take shortcuts around the correct implementation (whether this be for convenience or lack of experience). This practice is often carried out by im-

plementing the `checkServerTrusted()` and `getAcceptedIssuers()` functions in a way that configures the hostname verifier to trust all X.509 certificates. By doing this, developers expose their application to danger; third parties may attempt a Man-in-the-Middle attack on network traffic from the application, compromising a user's network data if successful.

#### TALK ABOUT ERROR HANDLING HERE

This experiment will be testing whether or not an app overrides a built-in trust manager or error handler to forgo either method's intended purpose of correctly verifying certificates.

#### Setup:

We will use simple string searches (through the parsing of class files) in order to see if built-in trust manager and/or error handler methods are being overridden. If they are, we will use more string matching to confirm whether or not the override uses potentially dangerous techniques within.

### 3.3 AllowAllHostnameVerifier

The `HostnameVerifier` interface within Android Studio is responsible for the verification of the hostname within the server being connected to, making sure the hostname within the server's certificate matches the one seen in the server the client is attempting to connect to.

A vulnerability arises when the developer attempts to shortcut the hostname verification process (similar to Experiment 2), resulting in an ineffective verification process. Specifically, many developers use the `AllowAllHostnameVerifier` class; this class essentially turns hostname verification off (by allowing all hostnames) and instructs the process to never throw an `SSLException`.

This vulnerability, similar to avoiding trust managers, creates the opportunity for a Man-in-the-Middle attack. If the host cannot be verified, a third-party has the opportunity to impersonate a legitimate server and trick the application into sending sensitive data to it.

This experiment will test whether or not an application implements the `AllowAllHostnameVerifier` class, which allows all hostnames to be accepted for a certificate.

#### Setup:

For this experiment, we will parse class files and perform a string search for `"AllowAllHostnameVerifier"`. This will confirm whether or not a developer is using unsafe coding practices by overriding proper hostname verification.

### 3.4 Mixed use SSL

When an application is connected to the internet, it is not good practice to use both HTTPS and HTTP. HTTPS connections are more secure since they use SSL (Secure

Sockets Layer) to encrypt normal HTTP requests and responses, which consist of only plaintext messages. When HTTP content is loaded by an HTTPS page, attackers have the opportunity to read and/or modify HTTP traffic. This results in a mixed SSL vulnerability.

Developers create this vulnerability when they do not ensure that every resource on their page is loaded over HTTPS, and this can prove tricky; modern websites often load several different resources from various places, making it hard to keep track of where HTTPS and HTTP is used. Many times, the solution (for a developer) is to simply place an "s" within `"http://"` to apply SSL to it. The consequence of this vulnerability is the potential for an attacker to perform a Man-in-the-Middle attack.

In this experiment, we will test whether or not an application is using a mixture of HTTP and HTTPS protocol when loading content.

#### Setup:

For this experiment, we will parse through class files to locate instances where the developer is using certain libraries (such as `"URLConnection"`), and whether or not said libraries are configured to use HTTPS consistently. This will involve string searches for `"http://"` and `"https://"` to see whether an app is only using HTTP (or if it is mixed use).

### 3.5 addJavascriptInterface Method

Many applications use `WebViews` as a way to display web pages as a part of their activity layout. The `addJavascriptInterface` method is subsequently used to inject a supplied Java object into a `WebView`. This process allows JavaScript to control the host application, but presents a significant security threat if a developer is not using the interface only where necessary.

The vulnerability arises when a malicious 3rd-party seeks to use the webview as a bridge into the users system. If a webview were to contain untrusted content, an attacker could use it to manipulate the host application in unintended ways. This is done by injecting JavaScript into a user's system and running the malicious code.

By using the `@JavascriptInterface` annotation, developers can use the interface only where necessary and avoid allowing untrusted content within webviews.

This experiment will test whether or not the application is being exposed to potentially dangerous outside sources, depending on if the application is using a webview.

#### Setup

For this experiment, we will use keyword searches to locate instances of the `addJavascriptInterface()` method. If it is successfully found, we will subsequently search for the use of the `@JavascriptInterface` annotation, confirming whether or not the developer is using the method responsibly.

## 4 Evaluation

This section comprehensively evaluates the performance of our proposed and tested experiments. It determines which experiments performed the best on criteria of most true positive matches and least false positive matches.

## 5 Results

## 6 Findings and Future Work

### 6.1 Analysis of Results

### 6.2 Future Work

## 7 Conclusion

This project explored developing and evaluating experiments that sought out to find potential vulnerabilities within a set of Android apps. After downloading the apps, we then developed a set of five experiments to cover three domains: permission misuse, SSL API misuse, and interface vulnerabilities.

Our work

Why eve and mallory love android: an analysis of android ssl (in)security. In *Proceedings of the 2012 ACM Conference on Computer and Communications Security*, CCS '12, page 50–61, New York, NY, USA, 2012. Association for Computing Machinery. ISBN 9781450316514. doi: 10.1145/2382196.2382205. URL <https://doi.org/10.1145/2382196.2382205>.

[4] [1] [2] [3]

## References

- [1] Sebastian Bachmann, Anthony Desnos, Geoffroy Gueguen. Androguard. <https://github.com/androguard/androguard>, 2018.
- [2] Erika Chin, Adrienne Porter Felt, Kate Greenwood, and David Wagner. Analyzing inter-application communication in android. In *Proceedings of the 9th International Conference on Mobile Systems, Applications, and Services*, MobiSys '11, page 239–252, New York, NY, USA, 2011. Association for Computing Machinery. ISBN 9781450306430. doi: 10.1145/1999995.2000018. URL <https://doi.org/10.1145/1999995.2000018>.
- [3] William Enck, Machigar Ongtang, and Patrick McDaniel. On lightweight mobile phone application certification. In *Proceedings of the 16th ACM Conference on Computer and Communications Security*, CCS '09, page 235–245, New York, NY, USA, 2009. Association for Computing Machinery. ISBN 9781605588940. doi: 10.1145/1653662.1653691. URL <https://doi.org/10.1145/1653662.1653691>.
- [4] Sascha Fahl, Marian Harbach, Thomas Muders, Lars Baumgärtner, Bernd Freisleben, and Matthew Smith.