IMPROVING SECURITY BY ENHANCING CLOUD ASSISTED VIRTUALIZED ANDROID APPLICATION SPECIFIC FIREWALL

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ABSTRACT

The no of users using Smartphone has increased enormously. so security is the major challenge here to protect user from malicious software accessing the user's privacy information. Since users may not be clearly aware of the malicious Apps existing in Android market so its important provide security for users Data. This paper proposes and evaluates an enhanced security model and architecture, By enhancing virtualized application specific firewalls managed by the cloud. The Proposed solution can be considered as an Android Firewall Application but enhanced with some extra functionality. Key components used by the solution include VPN technologies like the Point to Point Tunnelling Protocol (PPTP) and the Android Cloud to Device Messaging Framework (C2DM). Our solution is based on the cloud keeping track of millions of applications and their reputation (good, bad, or unknown) and comparing traffic flows of applications with a list of known malicious IP servers. We describe a prototype implementation and evaluate our solution.
Keywords: Android Market; Security; Mobility; Cloud Computing.

I . INTRODUCTION

The number of smart mobile devices has increased rapidly, due to users desire to have Internet access anywhere and at any time. Another driving force has been the steep decrease in cost, for smart model devices. There has also been a steep decrease in cost, of mobile device Internet access. Millions of users are using Android applications, on a daily basis. There have been over ten billion application downloads, from the Android market in 2010 [2]. More than 250 000 applications have been downloaded with malware [3][4]. There is a steep increase in the number of Android users who have been infected with malware. This increase in malware trend is expected to continue. This paper is an attempt to reverse this increase in malware trend.

The Android application market has not been designed to properly reject newly uploaded applications, which contain malware. Google removed 17 applications containing malware in March 2011 [5]. However these malware applications were not removed until long after the malware applications had been downloaded thousands or millions of times. So the removing of malware applications from the Android market after they are downloaded will, in general,

always be too late. Another problem is that even if the Android market had been designed to reject uploaded malware applications, this is simply not possible. It is impossible to always identify a malware application, after analyzing only the application. Sometimes, the application can't be identified as malware until after it is run on users' Android devices, in a real world scenario. This paper is an attempt to allow potential malware applications to run, in a real world scenario, but in a tightly controlled environment. In this paper, the tight controls are only based on the potential malware application's IP traffic. In addition to having these tight IP controls, this paper provides a solution, where anti-malware providers can also obtain detailed IP traffic statistics, on any and all potential malware applications. This paper also addresses the following issue. There are many applications which are not malware. However, if these non-malware applications are ot designed with the proper security in mind, malware applications can use these non-malware applications in improper ways, to give malware applications additional access. For example, a malware application which is not granted Internet access, can obtain Internet access via a non-malware application (which has not been implemented properly). This paper also addresses this latter issue.

Nowadays, anyone can implement Android applications

without having strong programming skills. So the cost of developing Android applications is very low. Most companies and developers do not have the proper security skills, to create secure Android applications. Therefore, the developers sometimes do not consider all security issues or more often, they are simply not skilled enough to be aware of all vulnerabilities.

It is the developer who specifies which permissions the application requires. Then, when the user installs the application, the user is presented with a list of the developer's requested permissions. The user must grant all permissions, otherwise, the application will not install. The allowed permissions cannot be changed at run time. Once the application is installed, it may obtain or give other applications sensitive data. Applications can also obtain sensitive data, by interacting with the user. The sensitive data might be shared between a normal application and a malware application. Then the malware application may transmit that sensitive data via the Internet directly. Again, if the malware application does not have direct access to the Internet, if may access the Internet indirectly, via a normal application. Malware applications and even normal applications may communicate sensitive information via Internet servers or via SMS/MMS without notifying the user.

Facebook, Twitter, and Google Apps (Calendar, Contacts, and Picasa) are a few examples, of non-malware applications which transmit private data as clear text [6], without the knowledge of most users.

Sending sensitive data without encryption over networks triggers a number of critical issues. When a smartphone establishes an Internet connection via WLAN, it is often possible to capture all traffic, including user IDs and passwords. Even if the WLAN is encrypted, with the most recent WLAN IEEE 802.11i WPA2 security, there is a serious vulnerability (Hole196). Our solution also addresses this issue.

Existing work is, to prevent leaking personal data and react fast, it suggest a framework, which aims to provide secure connections by normal and even malicious applications. The proposed paper to control these malicious software without even entering the users device either by deleting the application with high vulnerability or block the app to prevent user's device by block the app on a private server(control group) who actively monitoring the cloud server to detect the malware application which may transmit that sensitive data via the internet directly.

Without notifying the user.

The rest of the paper is organized the following way: Section II surveys related work, while Section III gives further background, while Section IV presents the proposed solution. Section V describes evaluations and experiments performed, while results, conclusions and future are indicated in Section VI.

II . RELATED WORK

There are lots of research projects going on to prevent leaking of personal data and malicious apps solutions for Android OS. One of the most commonly used approaches is a security-based permission model.

Tang et al. [7] highlights that Android Security System and treatment are too weak and proposed ASESD to prevent malware. Ongtang et al. [8] proposes the Saint framework, which grants permissions policies to overcome Android security weaknesses. Rassameeroj et al. [8] demonstrated detecting malware by distinguishing APKs' permission request from others, based on their functionality. Barrera et al. [10] overviewed iOS, Android, BlackBerry, and Symbian security frameworks and classified third-party-application installation models.

However, obviously the best and easiest solution is to prevent spreading the malicious applications from the Google Android Market rather than restricting permissions and defining new different permission levels for all applications on the phone. According to [10], the Google Android Market should be able to check security vulnerabilities and those authors even want Google to have that responsibility. Google have removed dangerous applications from their markets and even remotely from phones. Remote app uninstallation, also called a kill switch [12]. Kill switches let the vendor remotely uninstall (or deactivate) an application on a user's smartphone. Kill Switch and removing applications from market are solutions but these solutions often performed too late. Our solution is designed to take action much earlier than these solutions.

III BACKGROUND

A. Android OS

Android is a software stack (see fig. 1), which includes an operating system, middle-ware and core applications.
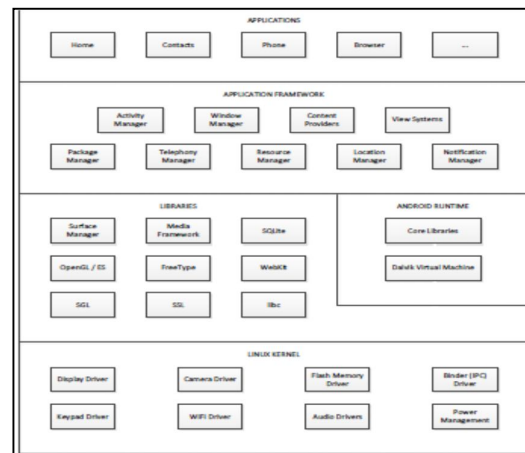

Figure 1. Overview of the Android OS

Android architecture consists of four different layers. The first layer is the Linux Kernel, the second layer is composed of Libraries and the Run Time Environment,

the third layer is the Application Framework, and finally the Application layer has been placed on the top.

Android applications are developed with the java programming language. All applications must be digitally signed with a certificate. A vendor can sign their application updates with the same certificate. A vendor can also sign multiple applications with the same certificate. All applications and updates with the same certificate are considered as the same application and assigned the same locally unique User-ID. Applications with different certificates are assigned different and unique User-IDs. Each application also runs in its own Dalvik VM which is in a separate process and by default, can access only its own application files. Therefore applications with different User-IDs are isolated from each other and this structure is called a kernel-level Application Sandbox. With the default settings, just a few core applications can run with root level permissions. Each application consists of four components; Activities, Services Broadcast receives and Content Providers. All components except Content Provider provide communications between applications. Access to these communication features are allowed, based on the application's requested and granted permissions by the Intent Message Passing System [13][14][15]. Most Android built-in services have been implemented as components, for example; Phone Book and device-based functions. Inter-Process Communication (IPC) mechanisms provide interactions between these components. Therefore an installed malicious application can use built-in services and expose private data easily [16].

The developer requests various permissions, by including tags in the application's Manifest.xml file. This file contains all critical information such as unique ID, protected parts, and access permissions. For example, if an application has the READ_PHONE_STATE and INTERNET permissions, that app can be used to get phone numbers, IMEI, user location etc. from the phone and can transmit the information to any Internet server [7]. Any application can also download and/or upload any kind of file in the background with appropriate permissions.

To protect an application from other applications, the permission label policy model is also defined in the applications manifest file.

The Android Security Policy is divided into groups; "Permission Granting Policy" and "Interaction Policy". Protection Level-based Policy, Signature–based Policy and Application Configuration-based Policy are found during installation in the "Permission Granting Policy". Interaction Policy covers four different policies as well, which includes the following: 1) Permission based Access Control Policy, 2) Signature based Policy, 3) Application Configuration based Policy, and 4) Context-based Policy, see fig. 2.

Interaction Policies are defined at runtime, for example Signature-based Policy can be used to restrict the component applications. The implementation is based on the applications' signatures, which includes default-allow and default-deny modes [13].

B. Android Cloud to Device Messaging Framework

The Android Cloud to Device Messaging Framework (C2DM) is a lightweight communication mechanism [17], which is used between application servers and their mobile Android applications, via the Google Cloud. The requirements follow: The Android OS must be at least version 2.2. The Android application must be installed via the Android market and the Android device must be logged into at least one Google account.

Pervasive and mobile computing consists of a few major challenges. One of the major challenges is battery life. C2DM is an elegant solution to reduce battery usage. Even if there are several different applications which wish to maintain communication with their own application servers, C2DM allows all applications to initially communicate over the same single shared TCP connection.

The application servers can initiate communication (push method instead of pull) with their own mobile applications. Then data can be exchanged, updated and/or queued for installation. The C2DM handles queuing of messages and delivery to its client Android mobile application. Therefore, C2DM is the most efficient way for the application server and its client Android mobile application to communicate. This is also the most efficient way to notify the user of new application updates. It is still the user who must approve or grant the application update Figure 2 illustrates the C2DM service mechanism. The structure consists of three components, which are Google C2DM servers, Application Server and Android applications. The Application Server sends messages to the Google C2DM servers with an HTTP POST, whenever the server wants to communicate with its Android application.
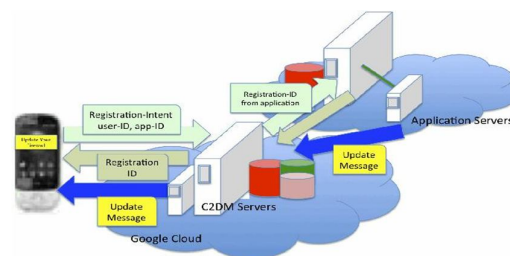

Figure 2. The Android Cloud To Device Messaging *Framework (C2DM)Overview*

The application must register with the C2DM servers before this C2DM service becomes active. Registration is performed by sending an Intent-register (com.google. android.c2dm.intent.REGISTER) with two parameters:

• Sender ID which is the role-based account authorized to identify an Android application before sending message. Developers set up the sender ID e.g.

myApp@gmail.com
• Application ID which is used for assuring that the messages are targeted to the correct application. Application ID is defined by the package name, which is found in the manifest.xml file.

After a successful registration, the C2DM server sends a registration ID to the Android application by broadcasting a REGISTRATION Intent message. The application stores this ID for later use. Finally, the application sends the registration ID to its own application server. This is also the most efficient way to notify the user of new application updates. It is still the user who must approve or grant the application update. The third -party application server is authorized to send messages to its Android application after it receives the registration ID. The application server issues an HTTP POST request https://android.apis.google.com/c2dm/send

in order to send messages to its client application. The server sends the following parameters: registration_id, collapse_key, data.<key>, delay_ while_ idle ,and Authorization:GoogleLoginauth=[AUTH_TOKEN]

When a user has installed an application that supports C2DM, they will be informed by the Android Market that the application supports C2DM. The user will then be requested to grant the application, including the C2DM rights Since the Control monitoring the information about ht malicious App that exist in Market as unknown, may also communicate via C2DM servers. Its secured protocol that's been working by Point to Point tunnelling protocol to transfer the message between the user's Device and Application server.

EXAMPLE OF THE ENHANCED WALLDORID APPLICATION SERVER TABLE CONTENT

Certificate ID	Vendor	Application	Number of Installs	Reputation	Status
67e2…	Skype	**Skype**	1,667,224	Known-Good	Direct Internet Ok
78a2…	Unknown	**Game_X**	672	Unknown	See Below
78a2…	Unknown	Game_Y	52	Unknown	See Below
8c22..	SocialNet	The SocialNet	8,767	Known-Bad	Block Internet
729b..	Games4Y	Angry	578,913	Known-	Direct

ou	Birds		Good	Internet Ok

Table :1
Control group server monitoring table content

Cert6ificate id	Vulnerability	status	Action	Reputation
67e2…	High risky	Possiblity to affect system	Delte App	Not recommended

Table :2

IV. SOLUTION ARCHITECTURE

This section presents the architecture of our application-based security model, which is called WallDroid which is an existing model and the proposed solution is concerned with enhancing this walldroid by adding additional server to existing architecture to strictly block the higly malicious content to not entering the user's device at least once. This section presents the architecture of our application-based security model, which is called WallDroid. The aim of WallDroid is to detect malicious activity at a very early stage and then to quickly prevent any future malicious activity.

The WallDroid architecture consists of three main components:

1) VPN Server,
2) WallDroid Application Server, and
3) Control group(to reduce malicious software)
4) WallDroid app (running on the device).

The WallDroid app can be considered as an Android Firewall Application but with some extra functionality.
Before presenting more details concerning our solution, we will prevent various anti-malware strategies, which we believe are inferior, to our solution. Note that the following are general strategies, which are used on various clients (e.g. Microsoft, Linux, and Mac OS).
Some anti-malware solutions require the user to decide what to do, for applications which are not clearly safe and not clearly malware. However, the user is often not in the best position to make a decision. We therefore propose that the user choose a security policy. There could be a large number of different security policies, which the user could subscribe to. However, we will greatly simplify the security policy discussion and just mention a few examples. The user, for example, could choose one of the

following security policies:
- High Security
- Medium Security
- Low Security

One anti-malware strategy is to grant permission to all Unknown applications. Another anti-malware strategy is to deny permission to all Unknown applications. The problem with these strategies is that these are far too general for decision making to choose the action which may not clearly known whether it could it affect or not.

Our solution's first component is, as mentioned, an ordinary VPN server and include secured communication system to efficiently communicate with the server. The second component is, also as mentioned above, the WallDroid Application Server maintaining a table of applications, including their status and other statistics. A simplified version of the WallDroid Application Server table is available in table 1. Since vendors can use the same certificate for multiple applications and updates, we must first find a way to create our own unique application ID. Our strategy is to run the application or update through a hash function (ex: MD5). Then our unique identifier is a combination of the certificate and hash value. The second column (Hash Result) contains the results of running the application install file through a cryptographic hash function (ex: MD5). We are not specifying which hash function should be used. Therefore we are using very simply hash results, in order to simplify the table.

In the above, we have three classifications of Android applications.

1) "The Good" - We have applications which are known to be good. For these applications, we grant permission for these good applications to have direct Internet access.

2) "The Bad" - We have applications which are known to be malicious (bad). For these applications, we deny permission for these bad applications to have direct Internet access. We also attempt to have these uninstalled.

3) "The Unknown" - The very interesting case is for applications which are not known to be good and not known to be bad. These unknown applications are the focus of our solution.

The third component of our proposed solution is the WallDroid application. Part of the WallDroid application is a cloud based database service. It is this database service which contains the list of all applications and their reputations (good, bad and unknown) which WallDroid has ever encountered, on any user's Android. When WallDroid is installed, it sends the list of installed application hash values to the cloud (based on a subset of the applications' extracted files). It is then the cloud that returns the reputation of each installed application. If WallDroid detects any application-ID, which is not in the cloud's database service, it tags that application as Unknown. According to the reputation tab, WallDroid treats each application based on the given label as

illustrated in the following table. Table 2 shows an example. WallDroid allows the Known-Good App to access Internet and connect its server directly without any limitation. It blocks the Known-Bad Apps' Internet-traffic, by restricting permissions of that malicious app. When WallDroid determines Enhanced walldroid application improve connection is established via VPN server, WallDroid System are also able to observe the Unknown app's data traffic to determine whether it is malicious app or the app is sending any personal data as a clear text. Once if WallDroid System figures out that the Unknown app is malicious or it does not care about network security, VPN server blocks the data traffic and informs the WallDroidAppl n server.
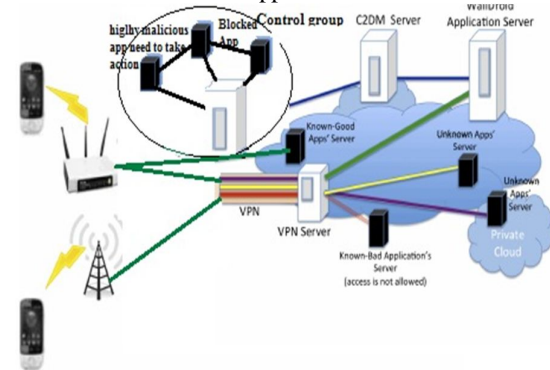

Fig 3: Proposed Solution Architecture along with control Group.

The Control Group in our proposed solution is added to improve the security of the user mobile device.The control contains a server which maintain information about the malicious apps exist in android market.walldroid app could block the traffic of this malicious app by not sending any personal data as clear text once if walldroid system figures out that the unknown app is malicious or it does not care about network security, VPN server blocks the data traffic and informs the walldroid Application server.But here the malicious app is at least entered as good may connect with another good may able behave as malicious app. So the control group maintains history both app behaviour to reduce this kind of vulnerability. Also the control group searching the market to see any other app belong to same App ID with this kind of behaviour so it block all the app that seems with this kind of risks.it block the app totally without entering user's device byt holding that as malicious app in its own server. It also maintains prehiatory other user specified information about this app and compare this app with that table which could also reduce risk vulnerability.The control group presented in this system to improve security performance of the user device those accessing cloud server for their personal user. Its cloud providers responsibility to protect user data by not accessing by any another malicious app.The control group also scanning the entire Android market to trace the

app with malicious behaviour further to reduce apps by delting them permanently which propose high risk to user device. Thus by Enhancing the performance of cloud assisted app by strengthening the firewall will make the user to interact with cloud service by without having the fear of that they could caught by malicious app. Also we are regularly updating the server .so vulnerability future attack is also greatly reducing due to this

EVALUATION

We based on solution on a rooted Android 2.2 OS. The reason is the following. The market share for Android phones, prior to 2.2, is extremely small. Our solutio n was tested on Android 2.2. However, future Android OS rele ases also support our solution, which requires NetFilter. Like all Linux distributions, the Android phone comes standard with a PPTP VPN client, which is he one we used.. We used a standard PPTP server on both +Linux Ubuntu Server 11.10 and Windows 2008 R2 Server.

Also, the Android phone comes standard with NetFilter (IPTables). This enables the redirection of certain flows via the VPN Server. The Android OS is quite uniq ue, in that each application has its own userid. We have taken advantage of that feature in the following way. What we hav e done, which is unique, is to use the application's unique userid. We have gathered all applications' unique IDs which are installed on our Android OS [18][19] and store the IDs in a HashMap which is called ApplicationIdMap.

The map tree holds the uniqueID as keyword and other information, e.g. Tag i nformation, as a value. When an application is requested to access Internet, we have iterated the ApplicationIdMap with the u nique ID and we configure NetFilter based on the Tag of that application if the Tag is Unknown. Running a script does the configuration, so that only that apps' traffic is sent via the VPN Server to the WallDroid Application Server. By doing this we are able to capture and observe the applications' traffic at the VPN Server and able to decide whether an app is malicio us or not. When we make a decision whether an app is malicious or not we inform the WallDroid Application Server using a push method. Once we have decided that it is a bad app we immediately block the traffic and the WallDroid app is updated (like a firewall) via the C2DM Server. Implemen ting the C2DM mechanism for an application has been des cribed clearly by [16]. If we decided that the app is good that app can, after an update, connect to the Internet directly. On the other hand, if an installed apps' tag is Known-Good it is allowed to access Internet directly. To the best of our knowled ge, no one in the industry or academia has so far come up with this approach.

AP P ID	Action	Tag	Status	Report

| 67 30 | Blocked | Unknown app x | Risky | Denied |
| 72 66 | Permitted | Adobe reader | Safe | Permitted |

Table :3

VI. CONCLUSION AND FUTURE WORK

Existing systems are too general. We therefore provide an ApplicationID-based solution for en hancing security which is a very fast mechanism in terms of actions being taken before any data is leaked. As a result of our work, we have implemented a prototype, to demonstrate the features of our proposed solution, see fig. 5. Our design and prototype ha s shown, that by taking advantage of the unique Android OS feature (unique user-id per application), that we can forward the live IP flows via a VPN, for cloud based analysis. Al so, our design allows us to send just a small subset of all the same application's traffic to the cloud. Last, our design also allows us to monitor statistics, on an application-by-application basis. Our future plans are to create an industrial strength version of our solution and to perform a pilot study with a larger study group. We are also planning to build up a controlled group of Android emulators. Then it will be easy for us to quickly analyze a wide variety of applications, including known malware.

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