© 2016 IJSRST | Volume 2 | Issue 2 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Implemented Mitigation of Security Attack in Android Application Using Pin Tool

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ABSTRACT

The popularity and adoption of smartphones has greatly stimulated the spread of mobile malware, especially on the popular platforms such as Android. In light of their rapid growth, there is a pressing need to develop effective solutions. In the past few years, mobile devices (smartphones, PDAs) have seen both their computational power and their data connectivity rise to a level nearly equivalent to that available on small desktop computers, while becoming ubiquitous. On the downside, these mobile devices are now an extremely attractive target for large-scale security attacks. Mobile device middleware is thus experiencing an increased focus on attempts to mitigate potential security compromises. In particular, Android incorporates by design many well-known security features such as privilege separation. In this thesis the Android security model and some potential weaknesses of the model is described. Thesis provides taxonomy of attacks to the platform demonstrated by real attacks that in the end guarantee privileged access to the device and mitigation technique for the same attack would be proposed. The result analysis and testing would be done on mitigation technique.

Keywords: Dynamic Analysis, Runtime, Binary Instrumentation, Pin, Pin tool, Intel, Just-in-time compiler, security attack, android Attack.

I. INTRODUCTION

Instrumentation is a simple technique for inserting any extra line of code in to an application to observe its behavior. It can be performed at various stages – inside the source code, at compile time, post link time, or even at run time. Source Code Instrumentation is a way to instrument source programs and Binary Instrumentation is to instrument binary executable directly Static binary instrumentation (SBI) occurs before the program is run phase, a phase in which we can rewrite executable code or object code. Dynamic binary instrumentation (DBI) is done at run time.

Program Analysis

	Static Category	Dynamic Category
Source Type	Static source analysis	Dynamic source analysis
Binary Type	Static binary analysis	Dynamic binary analysis

Table (1). Types of Program Analysis

Static Analysis and Dynamic Analysis:

Static analysis is the process of analyzing the source code or machine code of the program without need of running it **Dynamic analysis** is the process of analyzing program as it executes or at the runtime**.**

Source Analysis and Binary Analysis:

Source analysis is the process of analyzing programs at the level of source code. Source analysis are generally done for the points of programming language constructs such as expressions, statements, functions, and variables.

Binary analysis is the process of analyzing programs at the level of machine code, that stored either as object code (pre-linking) or executable code (post-linking). In this category, we have analysis that are performed at the level of executable intermediate representations, such as byte-codes, that runs on a particular virtual machine.

Binary analysis are generally done for the points machine entities, such as registers, memory locations, procedures, and instructions.

Pin :

Pin has been the framework of choice for researchers working on program analysis and related tools. It can be used for several purposes, but mostly for program analysis (memory allocation analysis, error detection, performance profiling, etc...) and for architectural study (processor and cache simulation, trace collection, etc…). PIN is a dynamic binary instrumentation engine or framework. Pin is used for the instrumentation of software programs. It supports many platforms like Windows, Linux, Mac OS and Android executable for IA-32, and Intel(R) 64[4]. The Pin allows a programmer to insert any arbitrary code (written in C or C++) at arbitrary places in the executable (run time of any program). The code is added dynamically while the executable (program) is in the running phase. The input to this compiler is not byte code, but a regular executable. Pin dynamically re-compiles the application during execution. The Pin kit includes many tools (they can be found at: pin-w-x-y-android/source/tools). The tools are provided as source files .Pin provides the framework and API.

Pin Architecture:

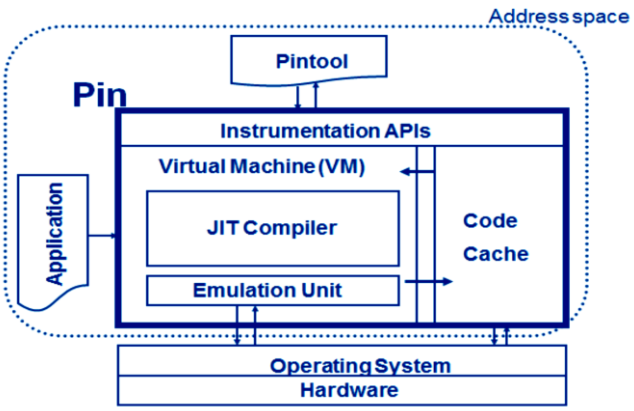


Figure 1. Pin architecture [1]

Pin consists of a virtual machine (VM), a code cache, and an instrumentation API invoked by Pin tools. The VM consists of a just-in-time compiler (JIT), an emulator, and a dispatcher. After Pin control of the application, the VM coordinates its components to execute the application. The JIT compiles and instruments application code, which is then launched by the dispatcher. The compiled code is stored in the code cache. The emulator interprets instructions that cannot be executed directly. It is used for system calls which require special handling from the VM. (E.g. system calls)

II. METHODS AND MATERIAL

A. Pin Tool

Pin tool is the instrumentation program. Pin tools run on Pin to perform meaningful tasks. The inscount pin tool is used to find out the number of instructions in the running program.

Instrumentation consists of two components:

1. A mechanism that decides where and what code is inserted
2. The code to execute at insertion points

These two components are instrumentation and analysis code.

B. Android

Android is a powerful Operating System supporting a large number of applications in Smart Phones. These applications make life more comfortable and advanced for the users. Hardware's that support Android are mainly based on ARM architecture platform. Android comes with an Android market which is an online software store. It was developed by Google. It allows Android users to select, and download applications developed by third party developers and use them. There are around 2.0 lack+ games, application and widgets available on the market for users. Android applications are written in java programming language. Android is available as open source for developers to develop applications which can be further used for selling in android market. There are around 200000 applications developed for android with over 3 billion+ downloads.
Android relies on Linux version 2.6 for core system services such as security, memory management, process management, network stack, and driver model. For software development, Android provides **Android SDK**

(Software development kit). Read more about open source software.

Android uses following Tools:

Eclipse, ADT Plugins, SDK toolkit, AVD toolkit.

Android Architecture

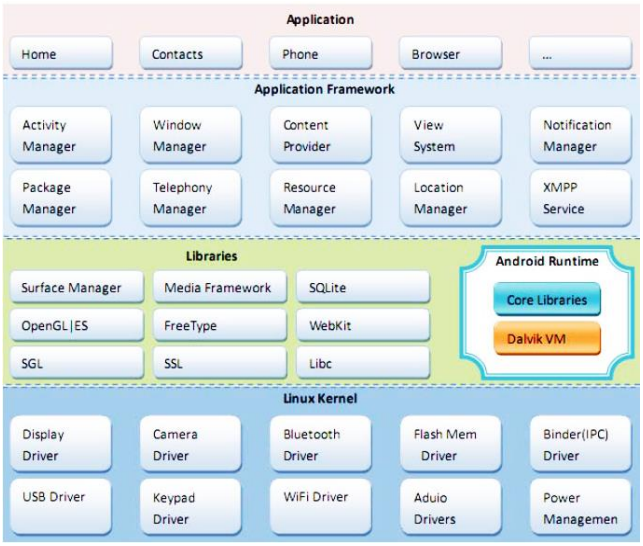


Figure 2. Android Architecture [3]

Android Activity Lifecycle

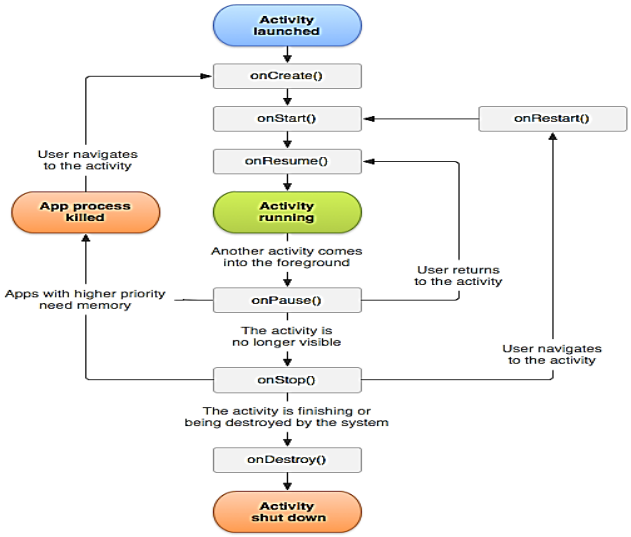


Figure 3. Android Activity Lifecycle [2]

C. Mitigation

Mitigation is the effort to reduce loss life and property by Lessing the impact of disasters.

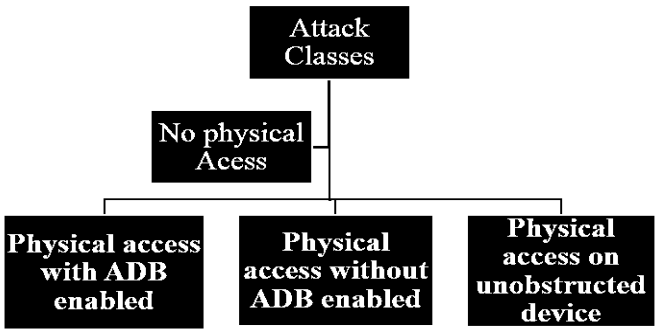


Figure 4. Attack Classes

No physical access

Attack circumstances where it is impossible to gain physical access to a user's device. Then the attacker must get the user to perform actions on the attacker's behalf. Such remote attacks commonly rely heavily on social engineering [5]. To achieve the appropriate initial access to the user's device an attacker must get some malicious software running on the device. To run code remotely on a user's device, the attacker typically must convince the user to either download a malicious application or access malicious content via one of the applications already installed on the device. If the attacker can exploit a vulnerability on the user's device, then this access may be used further to gain privileged access.

Physical access with ADB enabled

If the attacker finds a device left unattended, yet obstructed via a password or screen lock, the attacker may be able to exploit the device through the Android Developer Bridge.

Physical access without ADB enabled

If the attacker finds an obstructed Android device left unattended, but is unable to use the ADB service, the attacker may still gain privileged access via recovery boot.

Physical access on unobstructed device

In some cases the attacker may actually have access to a device without a password protected screen lock. Such a situation allows the attacker to actually leverage any

other attack method since the attacker can choose to install applications, visit malicious websites, enable ADB on the device, etc.

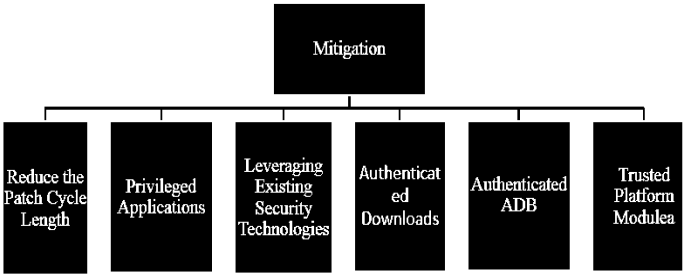


Figure 5. Type of Mitigation

Reduce the Patch Cycle Length

Attackers exploit some flaw in the operating system to gain root privileges. Reducing the patch cycle length would mitigate these threats with greater effectiveness. Zero-day exploits would still be possible, however the common lingering threat will be reduced. While Google has already demonstrated willingness to act quickly with out of band patch releases in reaction to certain attacks (e.g., [6]), reducing complete patch cycles is a more difficult problem. Indeed, manufacturers make changes to the Android source to create a competitive advantage. A fundamental separation between the core of Android and manufacturer modifications should be established.

Privileged Applications

To mitigate application attacks that take advantage of Android's permission model many solutions have been proposed. Propose lightweight application certification comparing the requested permissions of an application to a set of security rules. If the application does not pass any of the security rules, then possible malicious activity is brought to the attention of the user.

For example, Google could validate that certain software vendors create security software and grant applications created by these vendors additional API functionality. Applications signed by such a vendor could, for example, have read access to the file system in order to facilitate anti-virus scanning beyond limited scope typically granted to applications. Such a configuration would allow users to install security related applications without having to first root their device. Because privileged applications will have unrestricted access to the device, these applications should be certified by some governing entity before they can be downloaded. This certification process could also help mitigate some weaknesses of an unmodulated market. With access to trusted security tools, users would be able to monitor untrusted applications and provide appropriate feedback.

Leveraging Existing Security Technologies:

There are several existing operating system security enhancements that could be ported to Android. Instrumenting Android to monitor applications and understand how they interact with the user's sensitive information. A realized implementation of Taint Droid could give users real-time information about how an application uses the permissions it is granted. Generally, operating system level software modifications such as adding a firewall to Android involve porting existing technology to the Android kernel and creating an application to facilitation administration.

Authenticated Downloads:

Once an attacker has physical access to a device, adding malicious applications becomes simple and quick by posing as the legitimate user and downloading them from the Android Market. To ensure downloads are made only by the user, the market should require authentication before every transaction, similar to the model currently used by the iPhone.

Authenticated ADB:

Because of the power given through the ADB, it should not be accessible to unauthorized users. Android should require the device to be unlocked before ADB can be used. Any legitimate user should be able to unlock the device and once the connection is made, the session could be maintained by preventing the screen from locking while it is connected via USB. With ADB authentication, the attacker no longer has a backdoor to bypass the lock mechanism's authentication process, mitigating the ADB attack against obstructed devices.

Trusted Platform Module:

To secure a device in a managed model scenario a root of trust must be established. Using a Trusted Platform

Module (TPM) provides a ground truth on which device security could be built, providing authentication of device state. Using a TPM would mitigate the recovery image attack, which relies on the ability to change the boot image. Assuming signed byte code and authentication of the boot image, updates running unauthorized code would become extremely difficult.

III. LITERATURE REVIEW

1. Pin: Building Customized Program Analysis Tools with Dynamic Instrumentation

In this Paper they have described that pin is robust and powerful software instrumentation tool for program analysis tasks such as

1) Profiling
2) Performance Evaluation
3) Bug Detection

2. Behavioral Analysis of Android Applications Using Automated Instrumentation

In this paper, they present efforts on effective security inspection mechanisms for identification of malicious applications for Android mobile applications.

1) Count the number of Instruction in the original Application.
2) Count the number of Instruction in the Malicious Application.
3) If Number of Instruction are different then know there are some extra line of code in the application code

3. All Your Droid Are Belong to Us: A Survey of Current Android Attacks

In this paper we look to Android as a specific instance of mobile computing. We first discuss the Android security model and some potential weaknesses of the model. We then provide taxonomy of attacks to the platform demonstrated by real attacks that in the end guarantee privileged access to the device. Where possible, we also propose mitigations for the identified vulnerabilities.

4. Analysis and Research of System Security Based on Android

In this paper, it has analysis Android system's security mechanisms with widely used in mobile platforms. It has separately introduced its system architecture, security mechanism and safety problems. Through it has analysis Android security mechanisms and its components; it has set to the Android security, safety mechanism side, system security and data security. It has promoted system security to system permission. At the same time it analysis the Android security risks, it has deeply researched the attack based on Linux kernel. It has proposed security mechanisms based on SELinux policy theory to ensure system security on application program framework layer.

5. Patch droid: scalable third party security patches for android devices.

In this paper they have presented patch droid, a System to patch security vulnerabilities on legacy android Android devices, Patch droid uses dynamic instrumentation techniques to patch vulnerabilities in memory, and uses a path distribution service so that patches only have to be created once and can be deployed on every devices. Because patches are injected directly into the processes, Patch droid does not need to flash or modify system partitions or binaries, making it universally deployable even on tightly controlled devices.

Proposed System

6. Mitigation of security attack in android application using pin tool

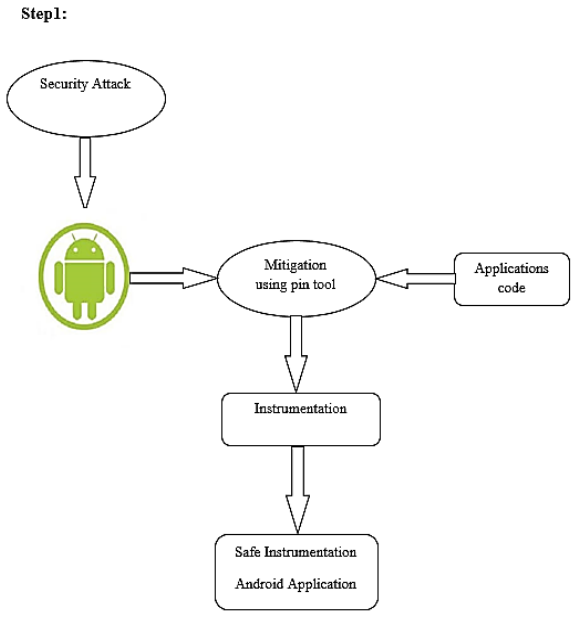


Figure 6. Instruction count in this android application

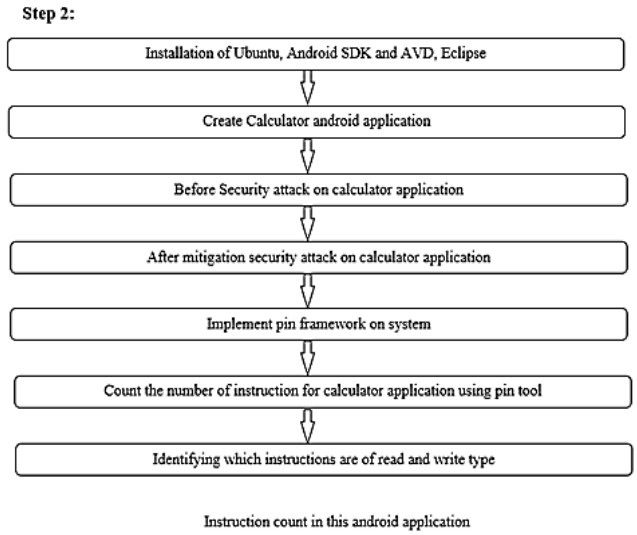
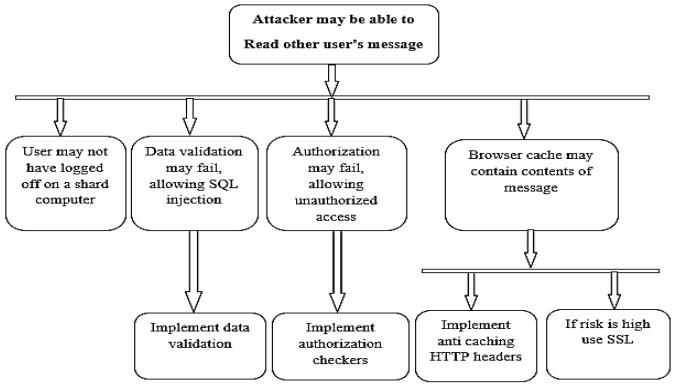


Figure 7. For Example: Attack



IV. RESULT AND DISCUSSION

Getting the system ready

Table 2. System Specification

Operating System	Ubuntu 14.04 32 Bit
Android	ADT Bundle with eclipse and sdk
API used for sdk	API 18,19
Android Device	INTEL AVD (x86)with hardware emulation
	Busy box and Pin installed
NDK Version	Ndk 9(gcc 4.6) 32 Bit
PIN Version	Pin 2.14-67254 gcc4.6

Installation on Ubuntu

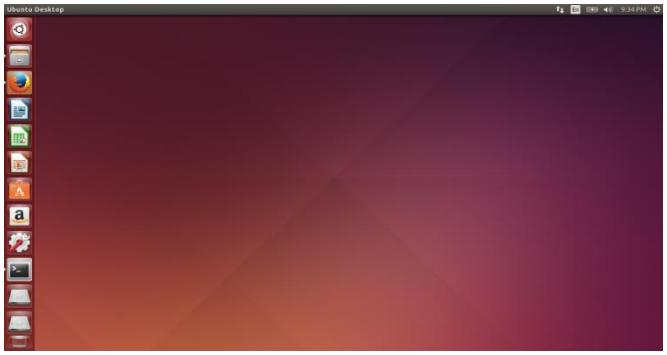


Figure 8. Install ubuntu in my system

Install Android SDK and AVD, Eclipse

Start eclipse and AVD.
Create calculator android application in eclipse.
There are two values add, mul, sub, div.

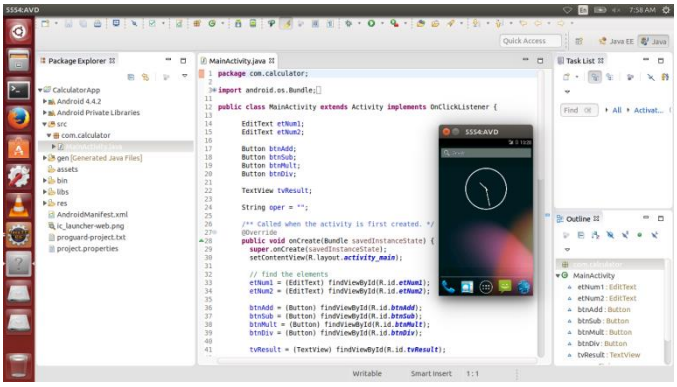


Figure 9. Install Android SDK and AVD, Eclipse in Ubuntu

Before Security attack on calculator application

Create calculator android application and the privilege escalation type attack will be performed.

- **Addition:**
- Before there are two values addition but attacker attack will be perform modification your output multiplication.

- **Subtraction:**
- Before there are two values subtraction but attacker attack will be perform modification your output division.

Figure 10. Before attack addition, subtraction

- **Multiplication:**
- Before there are two values multiplication but attacker attack will be perform modification your output addition.

- **Division:**
- Before there are two values division but attacker attack will be perform modification your output subtraction.

Figure 11. Before attack addition, subtraction

After mitigation Security attack on calculator application

- **After mitigation security attack on calculator application**
- **Addition:**
- After mitigation there are two values addition and your attack will be mitigate and your original output is addition.

- **Subtraction:**
- After mitigation there are two values subtraction and your attack will be mitigate and your original output is subtraction

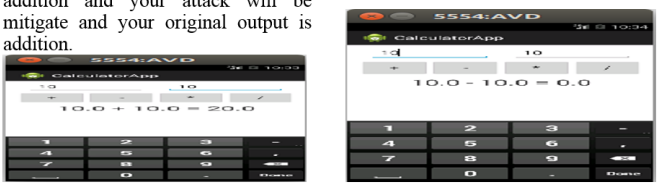


Figure 12. After mitigate attack in addition, subtraction

- **Multiplication:**
- After mitigation there are two values multiplication and your attack will be mitigate and your original output is multiplication.

- **Division:**
- After mitigation there are two values division and your attack will be mitigate and your original output is division.

Figure 13. After mitigate attack in multiplication division

Implement pin framework on system

Start the terminal and use to command
Run on pin this command. /pin –version and. /pin -- /system/bin/ls.

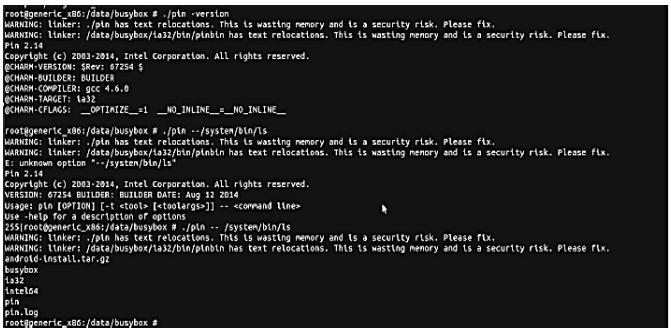


Figure 14. The pin framework version on android avd on system

Count the number of instruction for calculator application using pin tool

Inscount pin tool code used for count the number of instruction in calculator application

```
#include <stdio.h>
#include "pin.H"
using namespace std;
UINT64 icount = 0;
// Variable to keep running count of instructions
VOID docount()
{
        icount++;
}
// whenever any new instruction is executed.
VOID Instruction (INS ins, VOID *v)
{
      INS_InsertCall (ins, IPOINT_BEFORE, (AFUNPTR) docount, IARG_END);
     // this function insert a call to docount before every instruction.
}
// this function is called every time whenever any new instruction is encountered.
VOID Fini (INT32 code, VOID *v)
{
      fprintf (stderr, "%llu\n", icount);
}
// When the application exits, this function is called
// in following. argc, argv are the entire command line
int main (int argc, char * argv [])
{
         PIN_Init (argc, argv);
         // this will Initialize pin
         INS_AddInstrumentFunction (Instruction, 0);
         // this is called to instrument instructions (Register Instruction)
        PIN_AddFiniFunction (Fini, 0);
        // when the application exits, Fini is called
        PIN_StartProgram ();
        // to start the program
       return 0;
}
```

Run this code on pin framework.

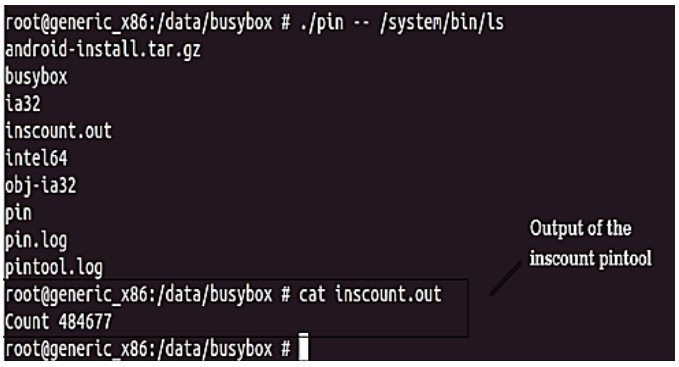


Figure 15 .Output of inscount pin tool

We have compiled the inscount pin tool in the android avd and then attached it to the running android application. The application we used is CalculatorApp.apk. As we can see the image that the directory of the bin in the android avd contains a file name “inscount.out”. This file is made when we have compiled and attached the pin tool to the application

process. When we open that file we see a value ”484677” which means that there are total 484677 instructions during the running of the Calculator Application.

V. CONCLUSION

We have presented a method of mitigation of security attack in Android Applications using Pin tool which allows the user to instrument an Android Application. Instrumented code alters the behavior of the original application and the attacker can’t find the right way to inject his own code into the running Application. Moreover instrumentation can also be used as a protecting weapon. So here we have used pin tool to mitigation of security attack in android application.

VI. FUTURE WORK

In future on any android application, the attack will be performed. Using pin tool, its mitigation will also be provided. Any types of attack will be done and mitigation technique will be developed to protect application from any attack. Any android application count the number of instructions and API read and write type and run on pin framework.

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