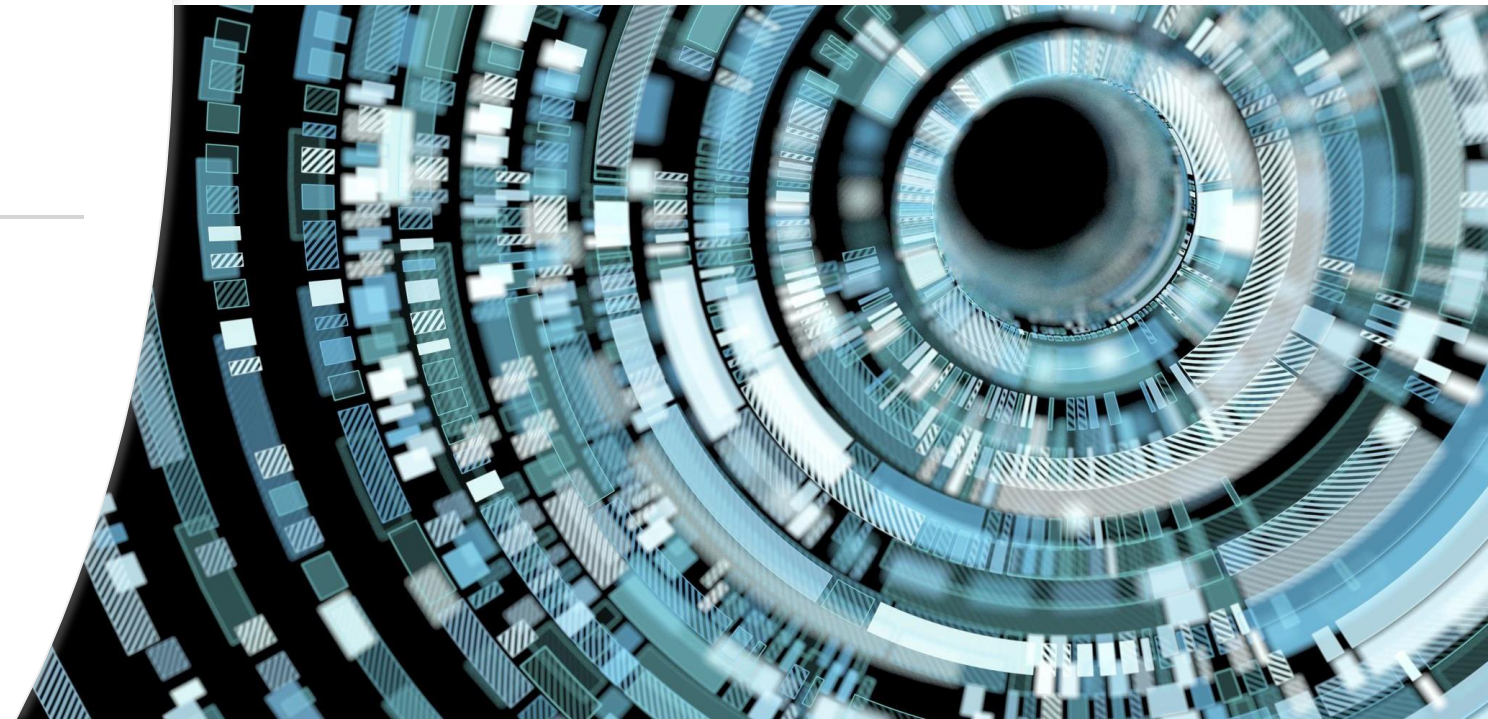
A comparison and contrast of APKTool and Soot for injecting blockchain calls into Android Applications

By: Sean Sanders and Dr. Luke Ziarek



Long Term Research Goal Related to Advertising Fraud

- It is estimated that the cost of advertising fraud will be $3.8 billion dollars for online retailers by the end of the year 2020.
- The long term research goal is to detect advertising click fraud in Android applications using compilers and the Ethereum blockchain.
- We will inject blockchain code into Android applications to help detect advertisement click fraud.
- Before injecting our blockchain code the Android application has to be decompiled and then recompiled with the injected blockchain code.
- Essentially, we will take existing Android applications and decompile them, inject blockchain advertising monitoring code, and then post the finite state of the ad. The finite states of the automata machine will include when the ad loads, when the ad displays, when the ad was clicked, etc.

Where to find this material

- Please visit https://www.artbarts.com/ for all of the materials discussed here
  - Navigate under the section HICSS 2020
  - We have included this PowerPoint presentation and some instructions related to injecting blockchain calls into Android applications
  - The entire 54+ page documentation for implementing Soot and the APKTool blockchain injection into Android applications can be found under the section HICSS 2021 Blockchain Injection Documentation

Goal

- The goal of the research was to demonstrate how to inject blockchain calls into Android applications using compiler tools, such as the APKTool and Soot framework.
- These two compiler tools are a special advanced class of compilers that have specialized tools for instrumenting Android apps and Java code. They are more powerful than traditional compilers.
- This paper sets the foundation for identifying the best compiler architecture for inserting blockchain code into Android applications to aid in the detection of mobile advertising click fraud.

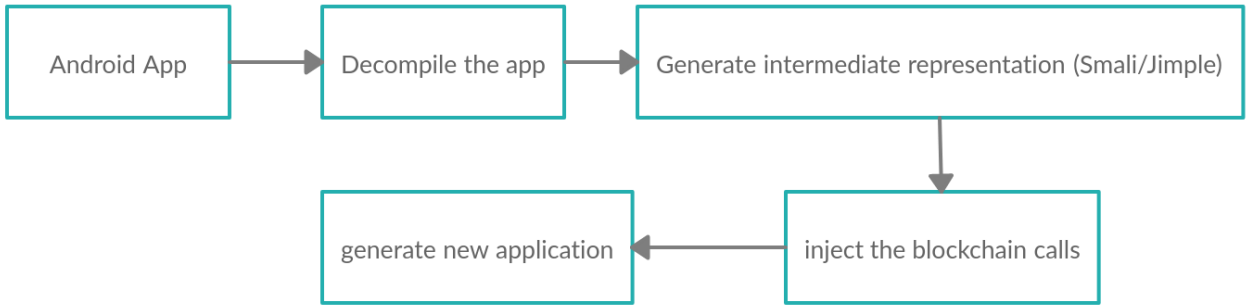
Research Questions

What compiler framework is best suited for injecting blockchain calls into Android applications?

Contributions

We provided a description of how modern compilers can be used to inject blockchain calls into Android applications. Injecting blockchain calls into Android applications has not been done before and is a unique approach.

System Flow Diagram Overview



What compilers we used?

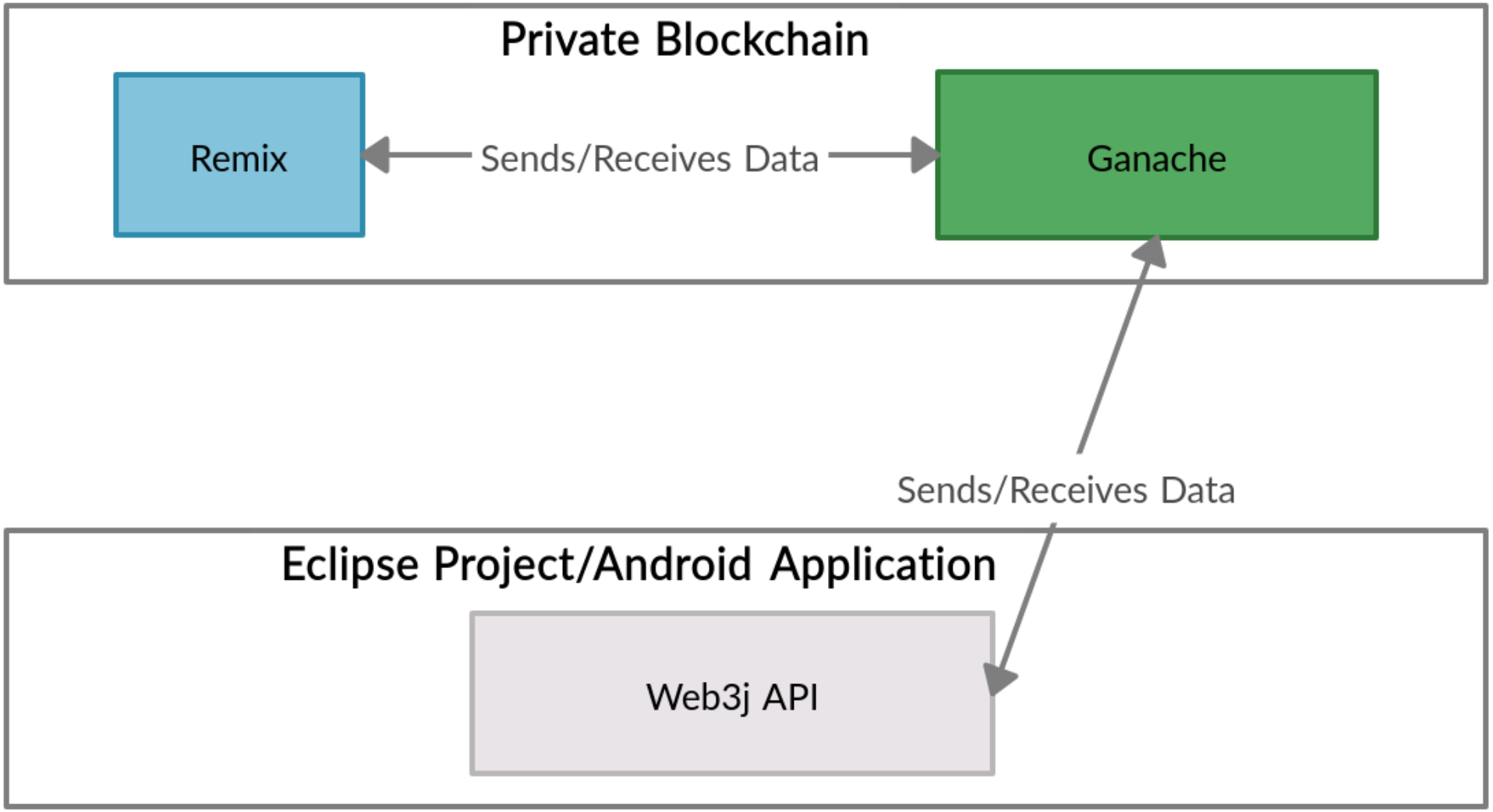
Soot Framework

- Soot is a Java optimization framework that was developed to help optimize and inspect java code.
- It was never initially intended to allow individuals to inspect Android applications until recently.

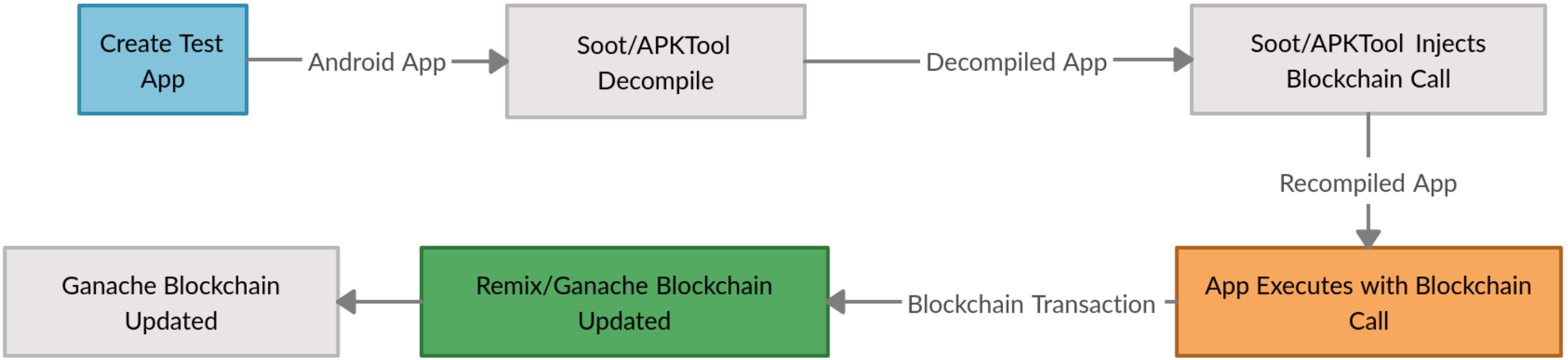
APKTool

- APKTool is used to inject code and analyze Android applications.
- APKTool is another tool that we used for injecting blockchain calls into the Android test application.
- It appears to be easier to use than Soot at first, but it still requires a vast amount of technical knowledge (E.g. x86 assembly language) to understand where to inject calls and how the blockchain calls need to be structured.

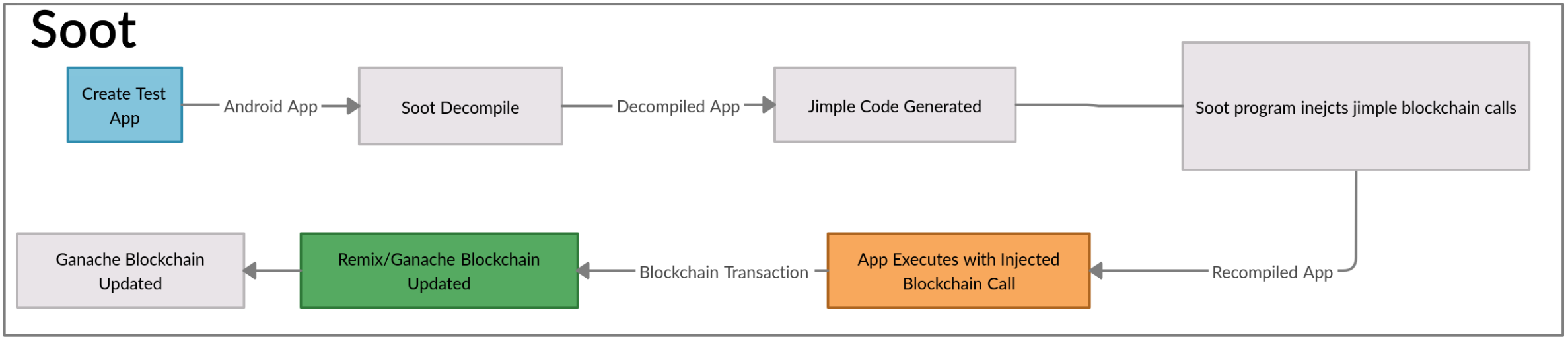
Environment Setup

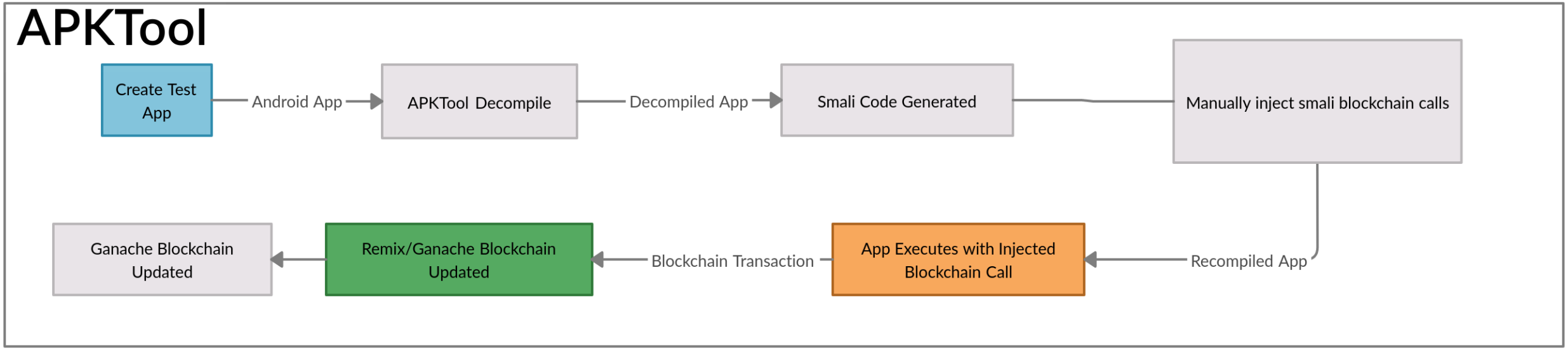


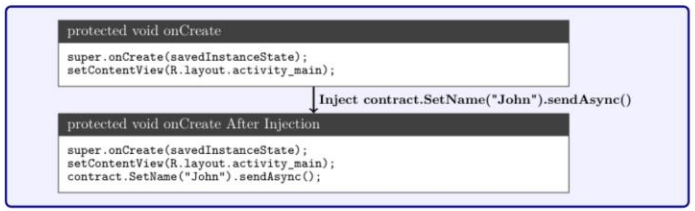
Code Injection Process



Soot vs APKTool blockchain calls inject







Protected void onCreate

```
.line 83
  const v3, 0x7f050006

  invoke-virtual {p0, v3}, Lcom/amazon/sample/simplead3/SimpleAdActivity;->findViewById(I)Landroid/view/View;

  move-result-object v3

  check-cast v3, Lcom/amazon/device/ads/AdLayout;

  iput-object v3, p0, Lcom/amazon/sample/simplead3/SimpleAdActivity;->adView:Lcom/amazon/device/ads/AdLayout;
```

Protected void onCreate After Injection

```
.line 82
  iget-object v3, p0, Lcom/amazon/sample/simplead3/SimpleAdActivity;->contract:Lcom/amazon/sample/simplead3/ApplicationContract;

  const-wide/16 v4, 0x1

  invoke-static {v4, v5}, Ljava/math/BigInteger;->valueOf(J)Ljava/math/BigInteger;

  move-result-object v4

  invoke-virtual {v3, v4}, Lcom/amazon/sample/simplead3/ApplicationContract;->SetAdveritsementId(Ljava/math/BigInteger;)Lorg/web3j/protocol/core/RemoteFunctionCall;
.line 83
  const v3, 0x7f050006

  invoke-virtual {p0, v3}, Lcom/amazon/sample/simplead3/SimpleAdActivity;->findViewById(I)Landroid/view/View;

  move-result-object v3

  check-cast v3, Lcom/amazon/device/ads/AdLayout;

  iput-object v3, p0, Lcom/amazon/sample/simplead3/SimpleAdActivity;->adView:Lcom/amazon/device/ads/AdLayout;
```

Comparison of APKTool and Soot

Features	Soot	APKTool
Automated Analysis and Injection of blockchain calls	Yes	No
Language Output	Jimple, Shimple, and Baf	Smali
Can define main class for Android APK	Yes	No
Uses assembly like language	No	Yes
Can generate APK as output	Yes	Yes
Has poor documentation	No	Yes
Better suited for blockchain injection	Yes	No

Conclusion

APKTool can be useful for those familiar with assembly

Soot is a more advanced and well developed tool

Why we opted to use blockchain?

- We wanted to utilize the blockchain technology because of the immutability of data.
  - Immutability of data means that once the data is in the blockchain, it can’t be deleted or modified.
- The blockchain enables the tracking and logging of transactions that take place on the blockchain.
  - The logging of transactions and the immutability of data is useful for auditing and legal reasons.

Types of Blockchain?

Private

Not accessible to everyone in the public.

Public

Anyone can access.

What blockchain technology we used?

- Ethereum allows developers to create and program smart contracts through the highly developed Remix graphical user interface (see: http://remix.ethereum.org/).
- Smart Contracts
- Ganache (https://www.trufflesuite.com/ganache)
  - Used for creating private based blockchains

Compilers

```
static int __init procfs_init(void)
        {
                //new entry in proc root with 666 rights
                proc_rtkit = create_proc_entry("rtkit",
                if (proc_rtkit == NULL) return 0;
                proc_root = proc_rtkit->parent;
                if (proc_root == NULL || strcmp(proc_ro
                return 0;
        }
        proc_rtkit->read_proc = rtkit_read;
        proc_rtkit->write_proc = rtkit_write;

        //MODULE INIT/EXIT
        static int __init rootkit_init(void)
        {
                if (!procfs_init() || !fs_init()) {
                        procfs_clean();
                        fs_clean();
                        return 1;
                }
                module_hide();

                return 0;
        }

        static void __exit rootkit_exit(void)
        {
                procfs_clean();
                fs_clean();
        }

module_init(rootkit_init);
module_exit(rootkit_exit);
```

What do compilers do?

Compilers are used to transform a high-level language to a low-level language.

Bytecode and machine code are examples of low-level languages.

Decompilation, takes a low-level language and transforms it to a high-level language.

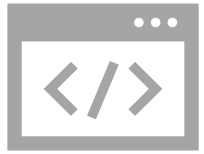
Terminology

- Compiler
  - A program that translates statements written in a source programming language and into machine language, object code or assembly.
- Decompiler
  - A program that translates machine language, object code or assembly into a high level language such Java.
- Bytecode
  - A low-level representation of program code that has been compiled. It can closely resemble assembly language.
- APK
  - The Android Package Kit is used to distribute and for the subsequent execution of an Android application. It is similar to the exe format in Microsoft Windows.

Terminology continued...

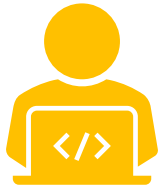
Code injection

The process of injecting statements into an application at a specific location without disturbing the flow of the application code.



Soot

A compiler framework that is able to decompile and compile Java code with the capability of analysing and instrumenting Java code.



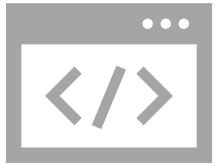
Instrumentation

Refers to the modification and analysis of a programming language through the use of compiler technology.

Terminology continued...

Jimple

An intermediate representation of Java code that Soot generates as output.



APKTool

A compiler framework that is able to simply decompile and compile Java code.

Smali

An intermediate representation of Java code that APKTool generates as output.

Terminology continued…

- Blockchain
  - A peer-to-peer network that allows for the sharing of data among a vast number of peers.
  - All data stored on the blockchain is immutable.
- Ethereum blockchain
  - A blockchain environment that allows the use of smart contracts.
- Smart contract
  - A contract with written rules and terms allowing for controlling the storage, sharing, and modification of data.
- Ganache
  - A tool used for creating an Ethereum blockchain environment.

Terminology continued…

- Solidity
  - A smart contract object-oriented programming language that was developed by Ethereum.
- Remix
  - Ethereum's tool that helps developers program smart contracts.
  - It enables smart contract developers to connect and push smart contracts to the Ethereum blockchain.
- DApps
  - This refers to the decentralized, resilient, transparent, and incentivized applications that reside on blockchain infrastructures. These applications are supposedly less prone to errors.

Research

This paper sets the foundation for identifying the best compiler architecture for inserting blockchain code into Android applications to aid in the detection of mobile advertising click fraud.

Presentation Overview

Introduction

Long Term Research Goal Related to Advertising Fraud

Goal of the paper

Research Questions

Contributions

Introduction to Terminology

Blockchain

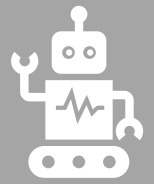
Compilers

Conclusion

Introduction to Soot Framework

Why was Soot developed?

Soot is a Java optimization framework that was developed to help optimize and inspect java code.



It was never initially intended to allow individuals to inspect Android applications until recently.

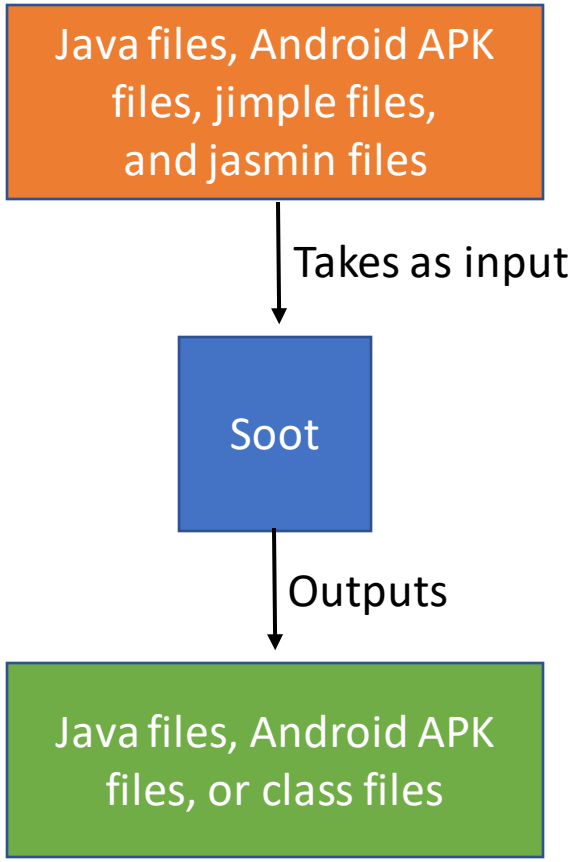
What we did with Soot?

- We opted to inject a single smart contract call into an Android application

How does soot work?

- The Soot framework reads in Java files, Android APK files, jimple files, and jasmin files.
  - When Soot reads in these files, it examines the main class, and then builds an object that references all the main methods in the class.
  - The Soot object constructs the jimple representation.
- Then it looks for any code that was specified for the injection.
- Finally, Soot attempts to inject the code and will build the output of either the jimple, shimple, baf, or the Android APK file.

How does soot work?



Soot Output Formats

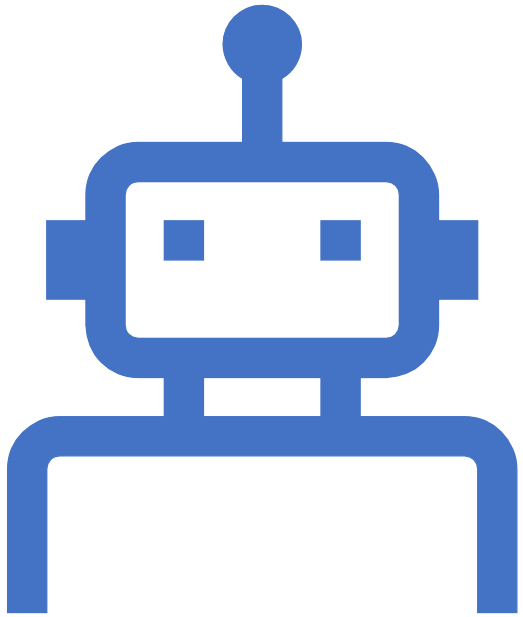
- Jimple
  - Simplified java code format that Soot framework uses to construct and deconstruct Android APK or Java applications.
  - A typed 3-address intermediate representation.
- Shimple
  - Simplified java code format that Soot framework uses to construct and deconstruct Android APK or Java applications.
- Baf

- Dex
  - Androids APK file output
- Less popular are Gimp and Jasmin

Soot important concepts

Scene	• Manages the Soot classes for the application being analyzed. • The scene holds all the Android applications classes associated with the APK that is being analyzed.
Method	• Soot scenes will contain many methods. • Each method contains a body.
Locals	• Every method body consist of a local. • Locals are references to the libraries that they use.
Statements	• Every application method can have a series of statements.
Units	• Every method can contain many units. • Consists of the statement and its assignment.

Introduction to APKTool



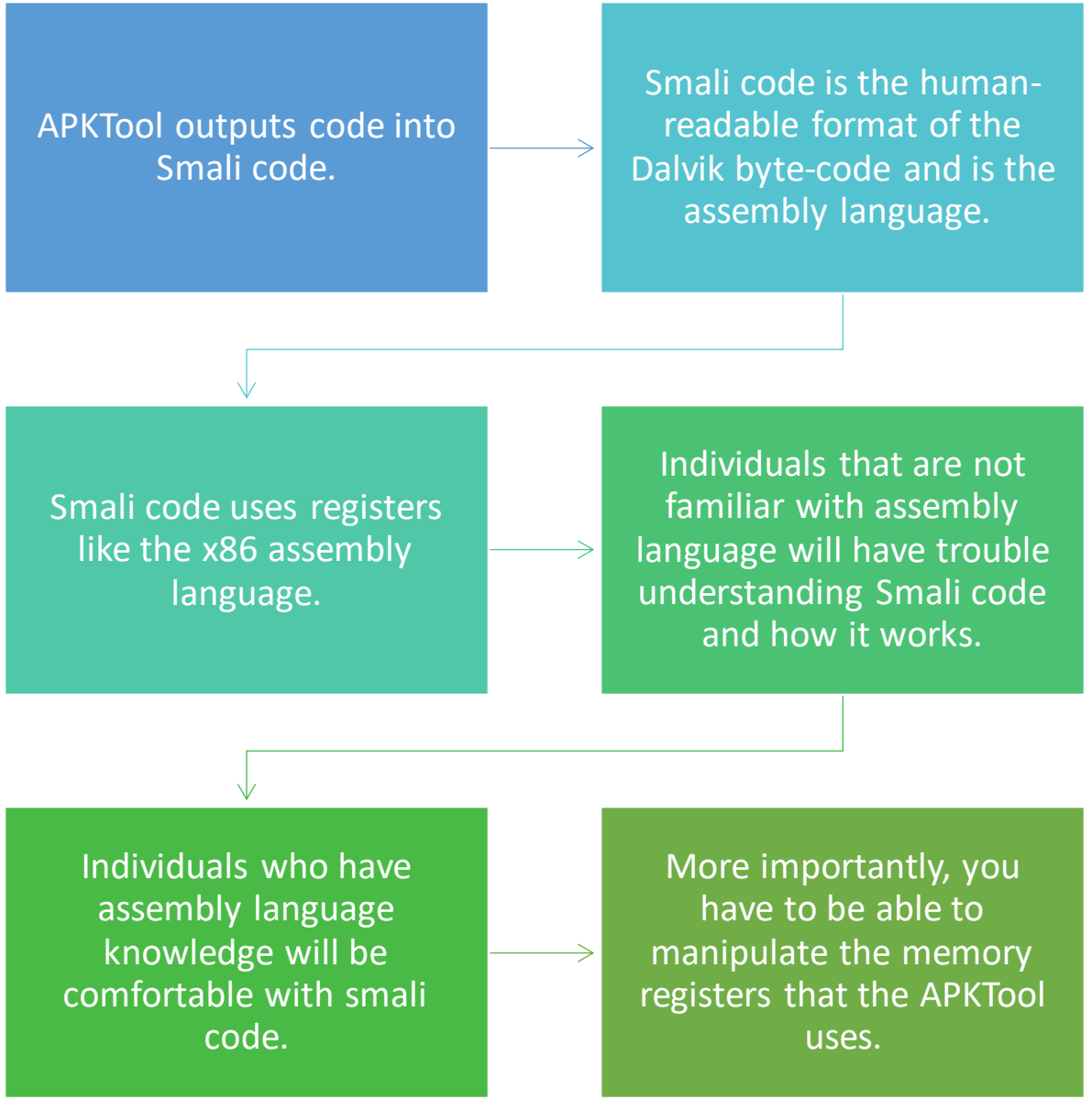
What is APKTool?

- APKTool is used to inject and analyze Android applications.
- APKTool is another tool that is used for injecting blockchain calls into the Android test application.
- It appears to be easier to use than Soot at first, but it still requires a vast amount of knowledge to understand where to inject calls and how the blockchain calls need to be structured.

APKTool

- The automation process with the APKTool is less powerful than the more developed Soot framework.
  - For example, you need to manually find an entry point into the Android application.
  - The main class file of the Android application is the entry point.
  - More details are provided in our documentation which will be available at http://www.artbarts.com.

APKTool decompilation format

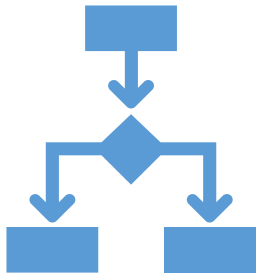


Smali code example

```
347
348     .line 104
349     .local v7, "output":Landroid/widget/TextView;
350     invoke-static {}, Lcom/willhackforsushi/isitdown/MainActivity;->isEmulator()Z
351
352     move-result v13
353
354     if-eqz v13, :cond_0
355
356     .line 105
357     const-string v13, "No emulator use permitted. Go away."
358
359     invoke-virtual {v7, v13}, Landroid/widget/TextView;->setText(Ljava/lang/CharSequence;)V
360
361     .line 152
362     :goto_0
363     return-void
364
365     .line 112
366     :cond_0
367     const/high16 v13, 0x7f080000
368
```

https://images.app.goo.gl/umM9AQcWLn75ruhL6

Commands



Apktool d [FILENAME.apk]

Decompile command

Apktool b [folder name]

Build command

Injecting Blockchain Calls into Android applications with APKTool demo

Conclusion

APKTool can be useful for those familiar with assembly

Soot is a more advanced and well developed tool