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Leveraging Software Instrumentation for Android Security Assessment

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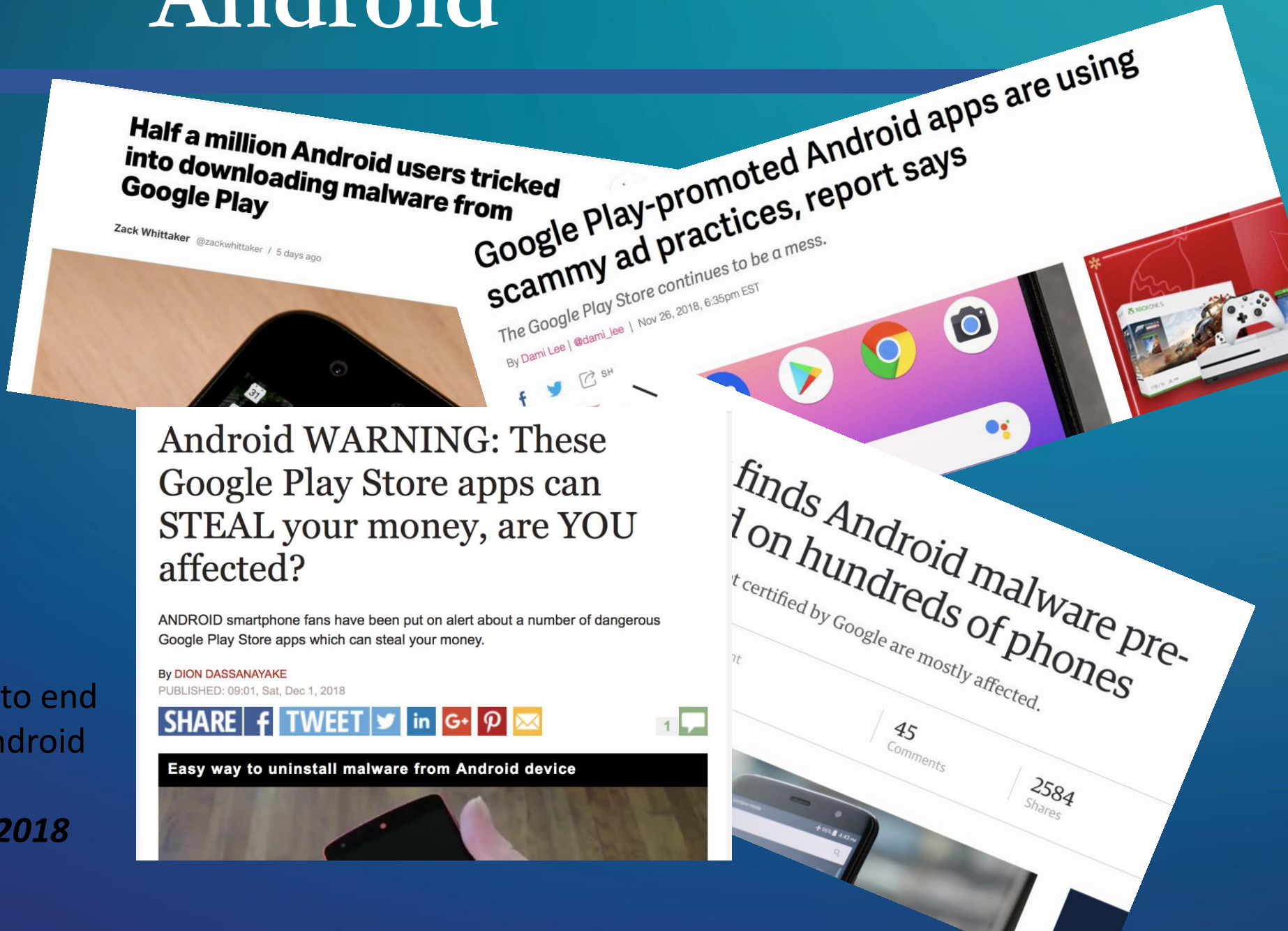
Outline

- Android Security
- Proposed App Vetting Technique
- Limitations and Current Research

Android

86.1% of all smartphones sold to end users were phones with the Android operating system.

- ***Statista 2018***



Android Security Challenges

- Challenges faced by Android - ***Applications***

Malware
Privacy-agnostic

- Spying on users and their communications
- Privilege escalation
- Resource abuse
- Data exfiltration
- Botnet
- ….

- 97% of all malware on mobile devices in 2014
- Over 2 million trojan applications have been detected in 2015 up by 50% from 2014

Malware Analysis Techniques

- Static Analysis/Fingerprinting
- Dynamic Analysis

Static Analysis

- Static analysis – examining program code base and its meta data
  - Permissions - Kirin (2009)
  - API calls, strings, and resources - Apposcopy (2014), DroidLegacy (2014), DroidAnalytics (2013)
  - Instruction sequences - DroidMoss(2012), Juxtapp (2012)

- Identifier transformation
- Encryption
- Dynamic class loading
- Java reflection
- Code reordering
- ……

Drawback – Obfuscation

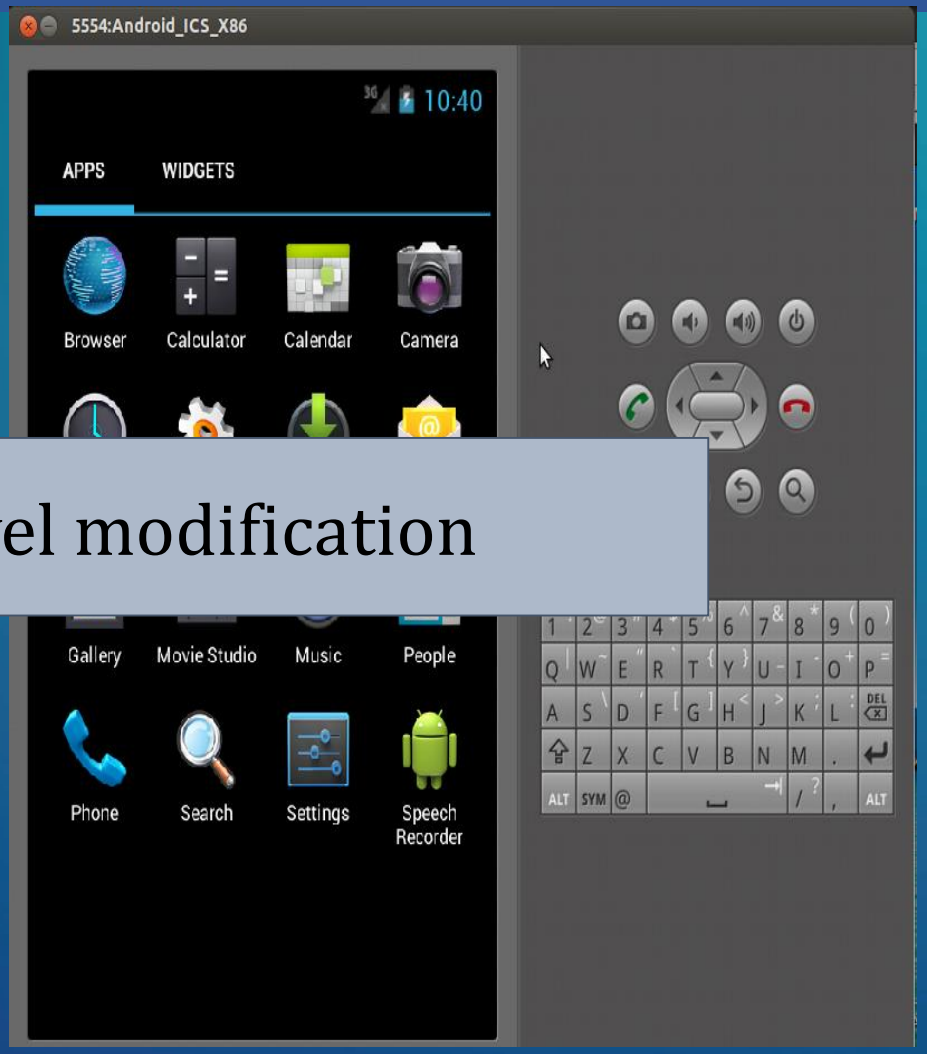
Rastogi et al. 2013 and Zhen et al. 2013

.....

Dynamic Analysis

- Dynamic Analysis
  - Modifying OS kernel/framework
  - Runtime dependent
  - OS dependent
  - Building a custom device is a painful process thus most runtime monitoring relies on emulation

Drawback - Low-level modification



Malware can detect emulation– *Vidas et al, 2014*

Research Question

How can we vet Android applications for unwanted (malicious) functionality **dynamically** on **real devices** without the need for **low-level modification** OS/Framework?

Software Instrumentation

- Analyzing programs by adding monitoring code:
  - execution environment
  - compiled code
  - source code

Normal program execution

```
public class test{
 public static void main(){
   int x=1;
   int y =2;
   int z = add(x,y);
   System.out.println(z);
 }
}
```

Program execution with instrumentation

```
public class test{
 public static void main(){
   int x=1;
   int y =2;
   int z = add(x,y);
```

hooking

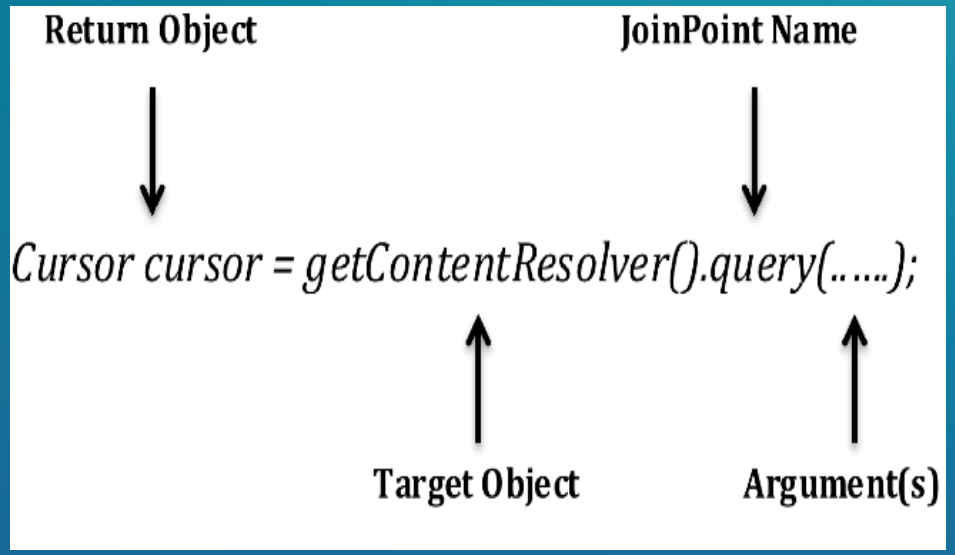
```
class inst{
  int routine(){
   log x;
   log y;
  }
}
```

```
   System.out.println(z);
 }
}
```

Monitoring code

Aspect-oriented Programming

- AspectJ - Bytecode Weaving
  - Aspect
  - Joinpoint
  - Advice (before, after and around)




```
pointcut getCurObj(Uri uri, String[] Projection,
      String Selection, String[] Selection_Args):
      call(*..*Cursor* *..*.query(..))
      || call(*..*Cursor* *..*.*Query(..)))
      && args(uri, Projection, Selection,
      Selection_Args,..) && NotNewLogger();
```

```
Object around(Object tar, Uri uri, String[] Projection,
      String Selection, String[] Selection_Args):
      target(tar) && getCurObj(uri, Projection,
      Selection, Selection_Args){
      //...
      //...
```

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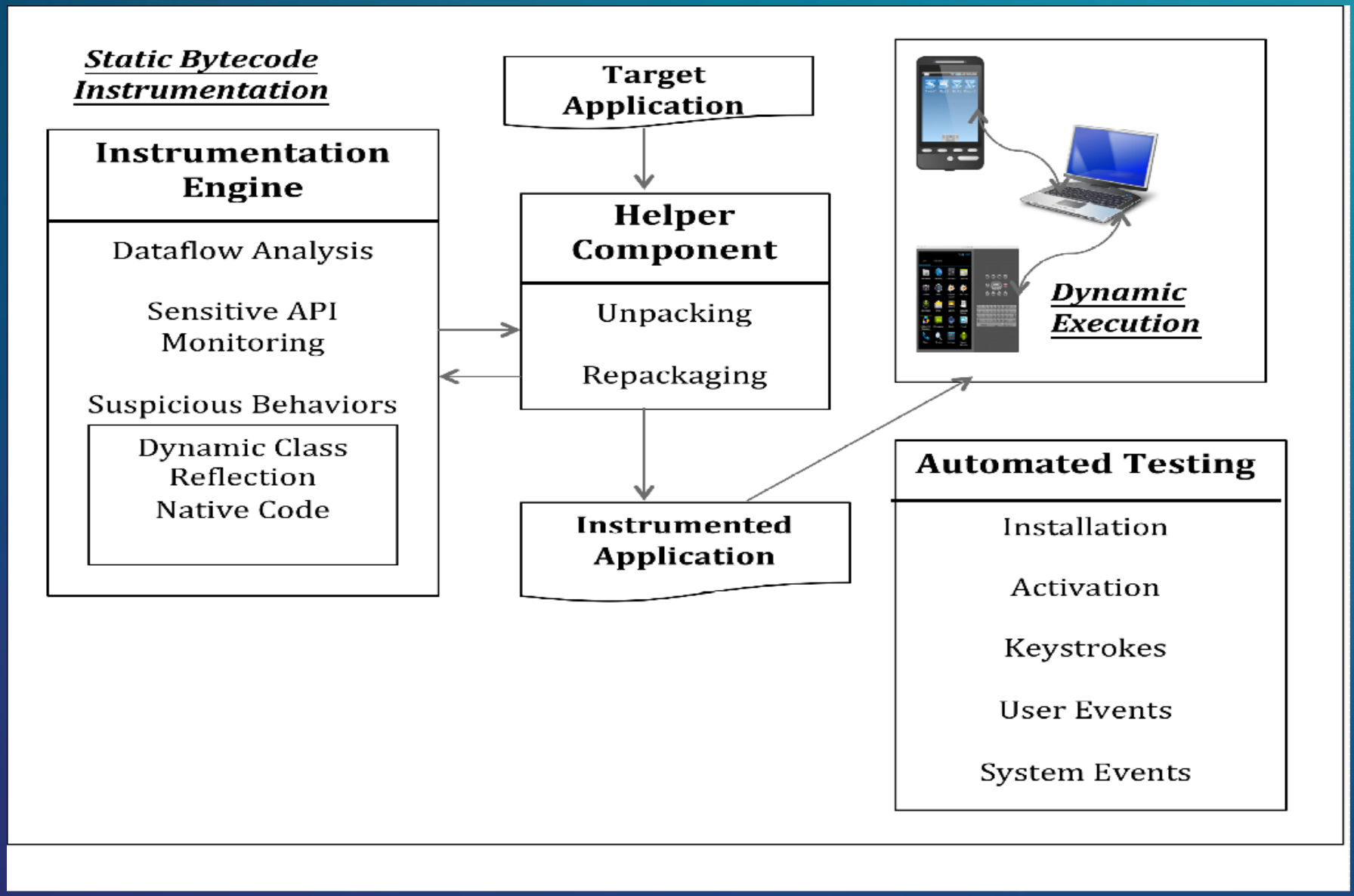
AspectDroid - Hybrid Analysis System

- Methodology
  - develops aspects to detect explicit data exfiltration, sensitive API monitoring (resource abuse) and analytics of suspicious behaviors
  - software instrumentation via static bytecode weaving
  - dynamic monitoring
- Objectives
  - analyze unknown Android application without need for custom kernel
  - adaptable to all Android runtimes
  - low performance overhead

AspectDroid - System Design

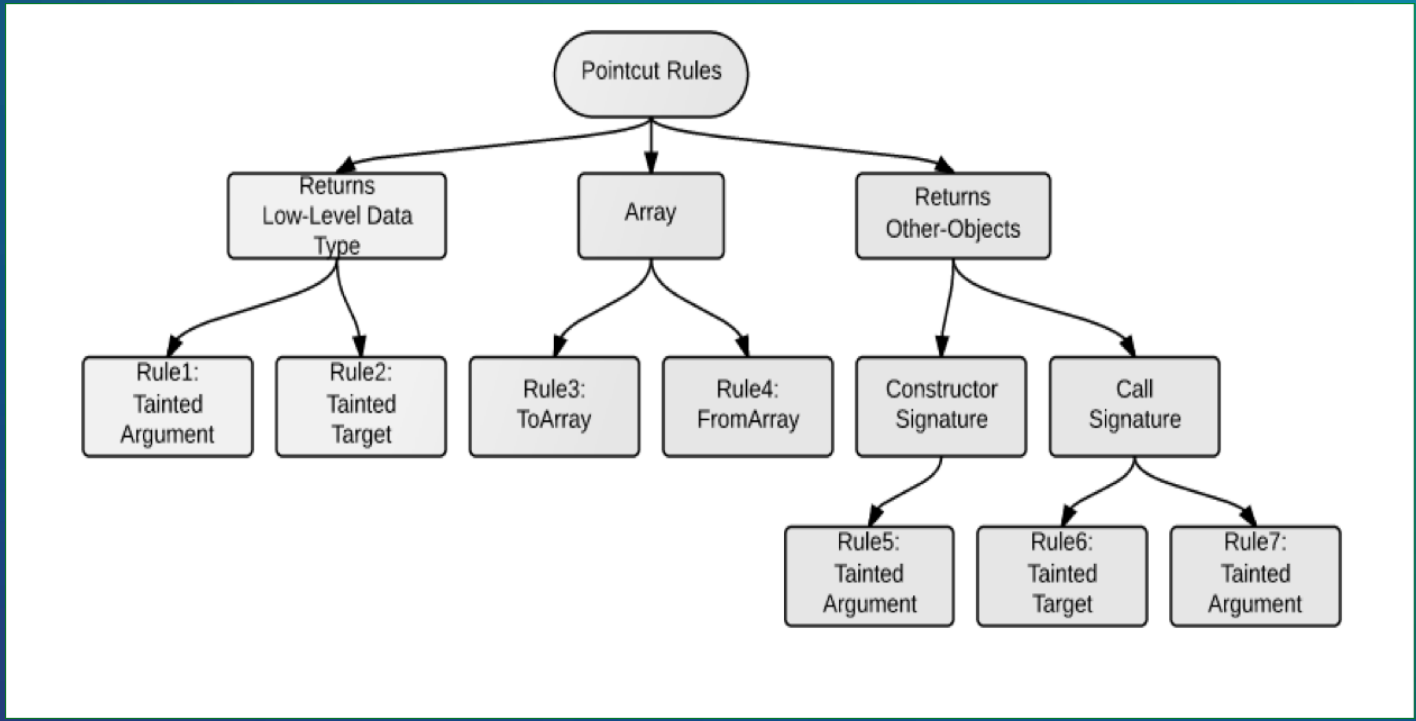


Dataflow Analysis

Taint Sources

(27 data sources e.g. IMEI, SMS)

Taint Propagation Rules



Taint Sink

(4 data sinks e.g. network)

Tracing

- Sensitive API Monitoring
  - Resource abuse tracing
    - SMS send, receive and read
    - Call send, receive and intercept
    - Access to content providers

    trace and trigger log

- Analytics of suspicious behaviors
  - Dynamic class loading

  Dynamic class call → halt execution → find class path → pull class to analysis machine → trigger instrumentation → push class to path → log → continue execution
  - Native code execution & Reflection

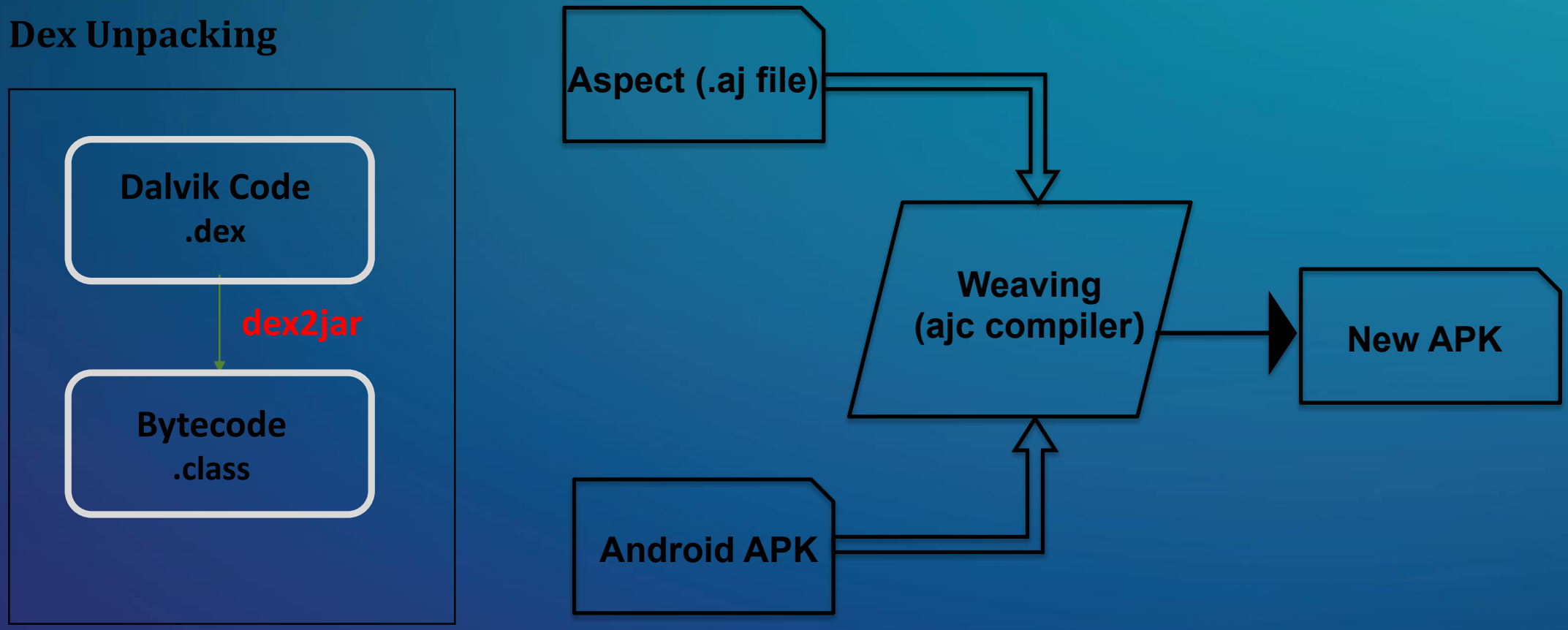
    trace and trigger log

```
pointcut getReflect(): !within(Logger) && call(*
    java.lang.reflect.Method.invoke(..));

Object around(): getReflect(){
   Object [] params = thisJoinPoint.getArgs();
   Object tar = thisJoinPoint.getTarget();
   logVals(tar, params); //Convert the objects to
       human readable form and log
}
```

Helper Component

- Repackaging an Android application



Evaluation

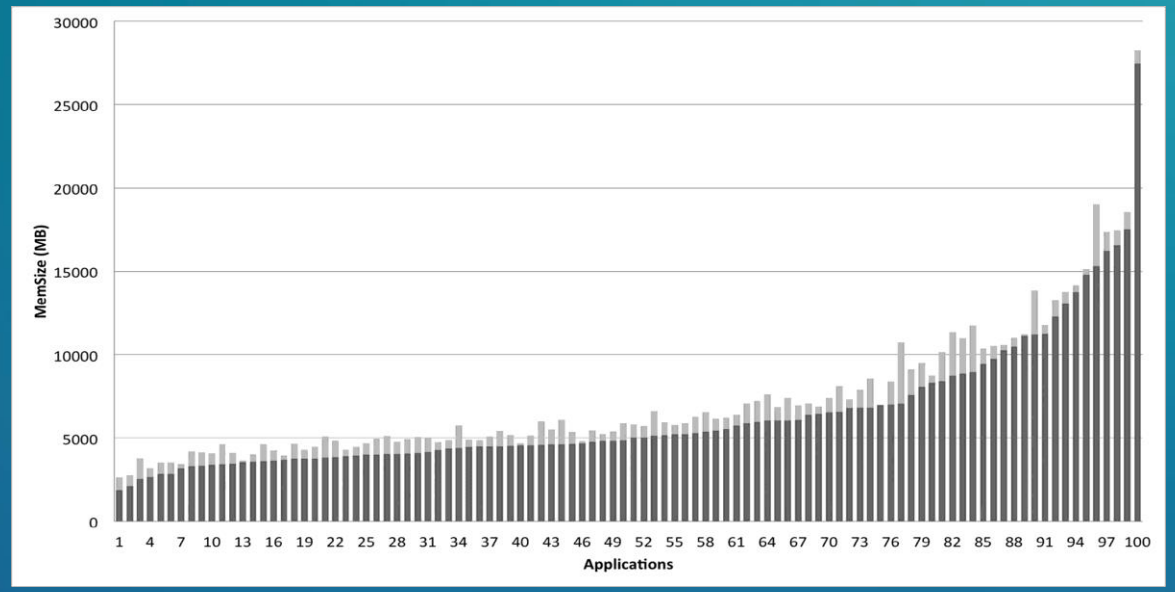
- Setup – HTC-One S9 (6.0), Samsung (4.4) & emulator
- 100 malware and 100 benign samples
- Runtime overhead
  - Memory size overhead ~ 1MB

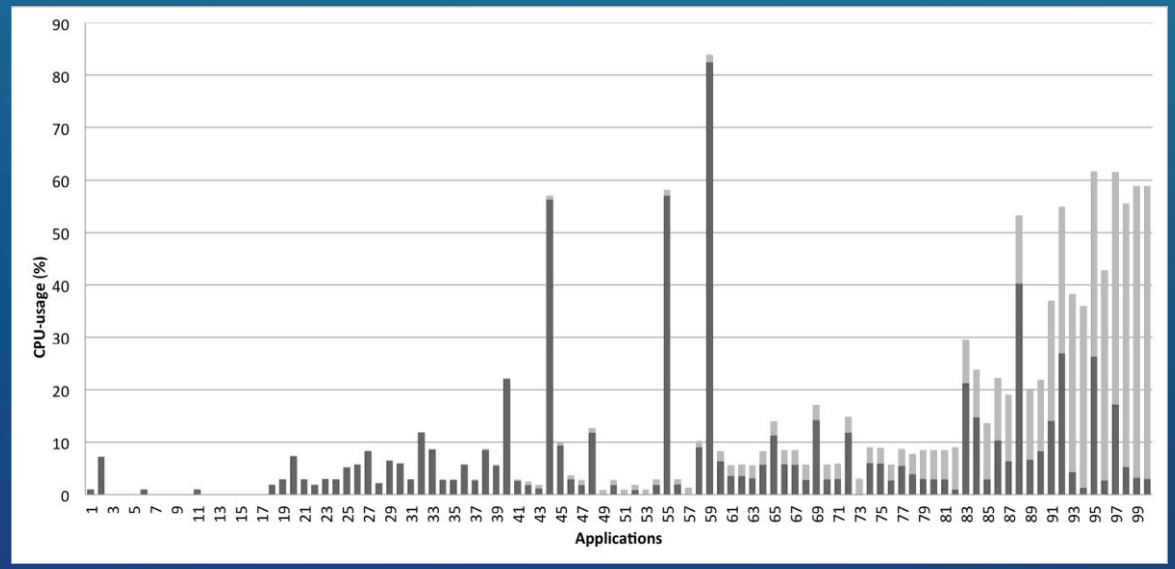
  *Memory size before and after instrumentation using **procrank** utility*
  - CPU usage ~ 5.91% increase

  $seconds = upTime - (startTime\ Hertz)$

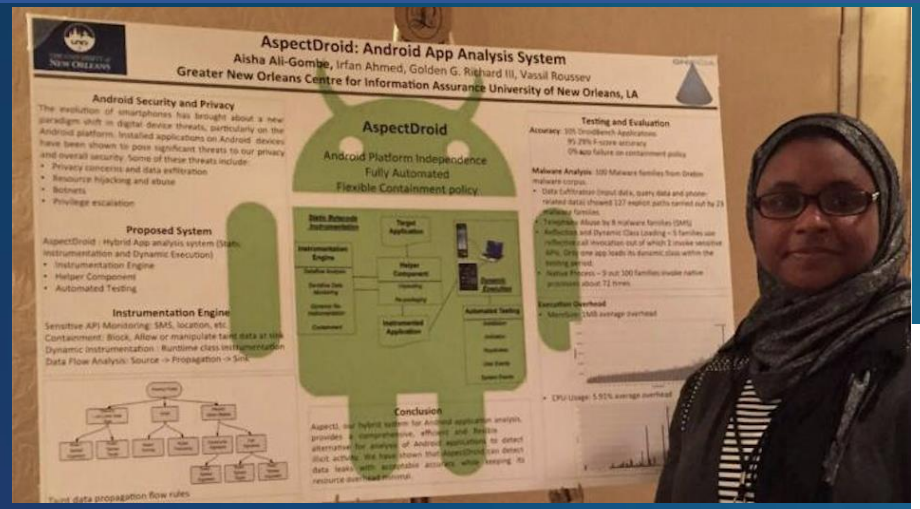
  $tTime = uTime + sTime + CuTime + csTime$

  $cpuUsage = ((tTime\ Hertz)\ seconds) * 100$
- Accuracy of Dataflow
  - DroidBench 2.0 – 105 simulated apps
  - Accuracy 94.68%, Precision - 96.4%, Recall - 93.02%





Preliminary Work & Award



Outstanding Poster Award @ ACM CODASPY 2016

AspectDroid: Android App Analysis System

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ABSTRACT

The growing threat to user privacy related to Android applications (apps) has tremendously increased the need for more reliable and accessible app analysis systems. This paper presents AspectDroid, an application-level system designed to investigate Android applications for possible unwanted activities. AspectDroid is comprised of app instrumentation, automated testing and containment systems. By using static

their consent. Andrubis [3] performed an analysis on over a million malicious and benign apps, and found that 38.79% of the apps have various forms data leakage. The security and privacy concerns surrounding these revelations increases the need for reliable and accessible app analysis systems.

In this paper, we present `AspectDroid`, a dynamic analysis system for Android applications based on the AspectJ instrumentation framework. AspectDroid performs static

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Computers & Security

Toward a more dependable hybrid analysis of android malware using aspect-oriented programming

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ABSTRACT

The growing threat to user privacy by Android applications (app) has tremendously increased the need for more reliable and accessible analysis techniques. This paper presents *AspectDroid*[1]—an offline app-level hybrid analysis system designed to investigate Android applications for possible unwanted activities. It leverages static bytecode instrumentation

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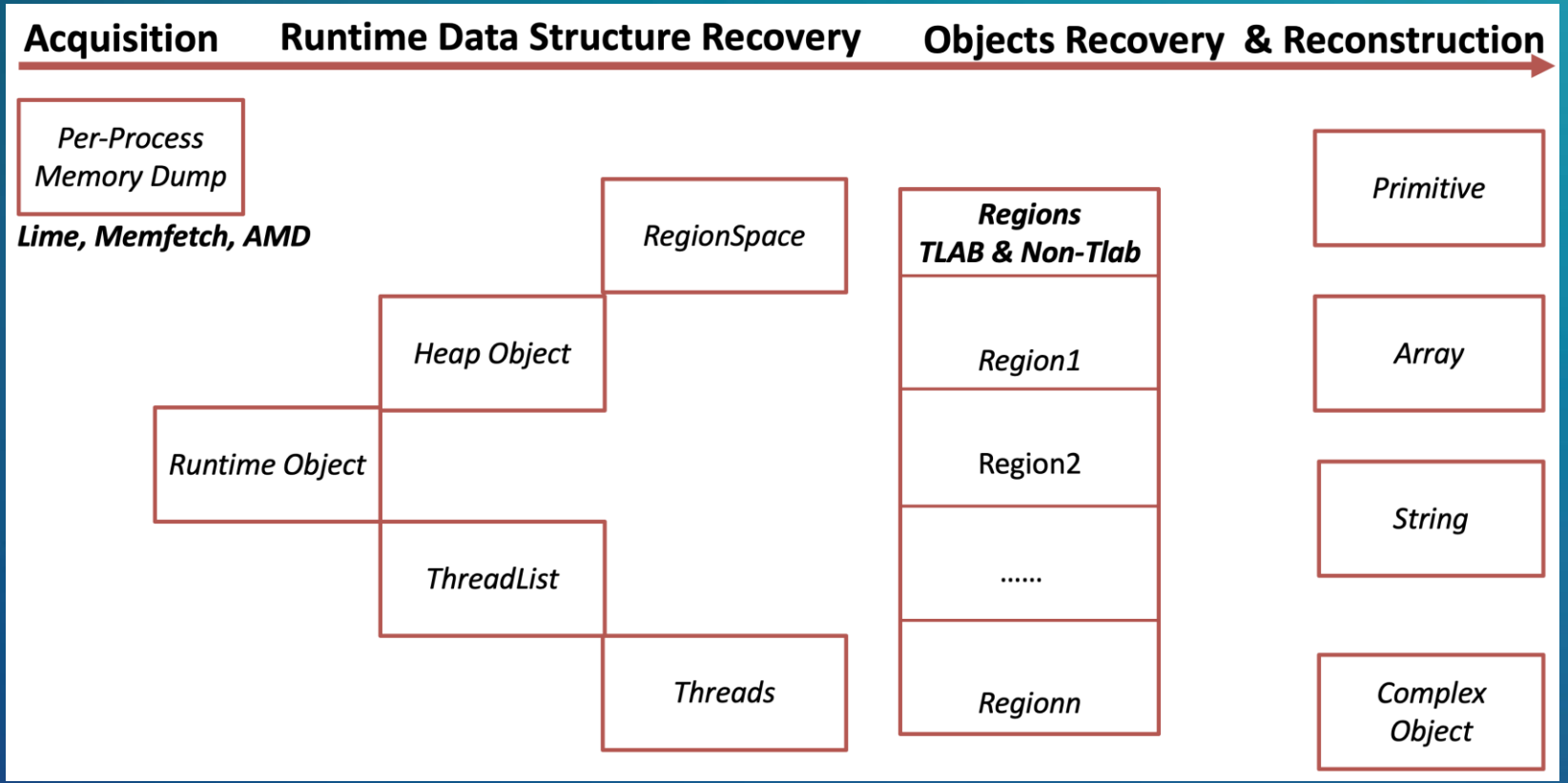
Limitations

- Signature verification that detects changes in the developer's original signature at runtime
- Anti-repackaging techniques that detect and crash Dalvik to Java bytecode backward translation process at recompilation time
- Native code monitoring

Userland Memory Forensics

- DroidScraper



- Presentation and Publication – RAID 2019
  - https://github.com/apphackuno/DroidScraper.git
- NSF CRII Grant 2019-2021

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