Program Transformation for Aiding Static Analysis in Android Applications

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Outline

1. Background
2. Motivation
3. Related work
4. Implementation
5. Evaluation
6. Future work

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Android JVM

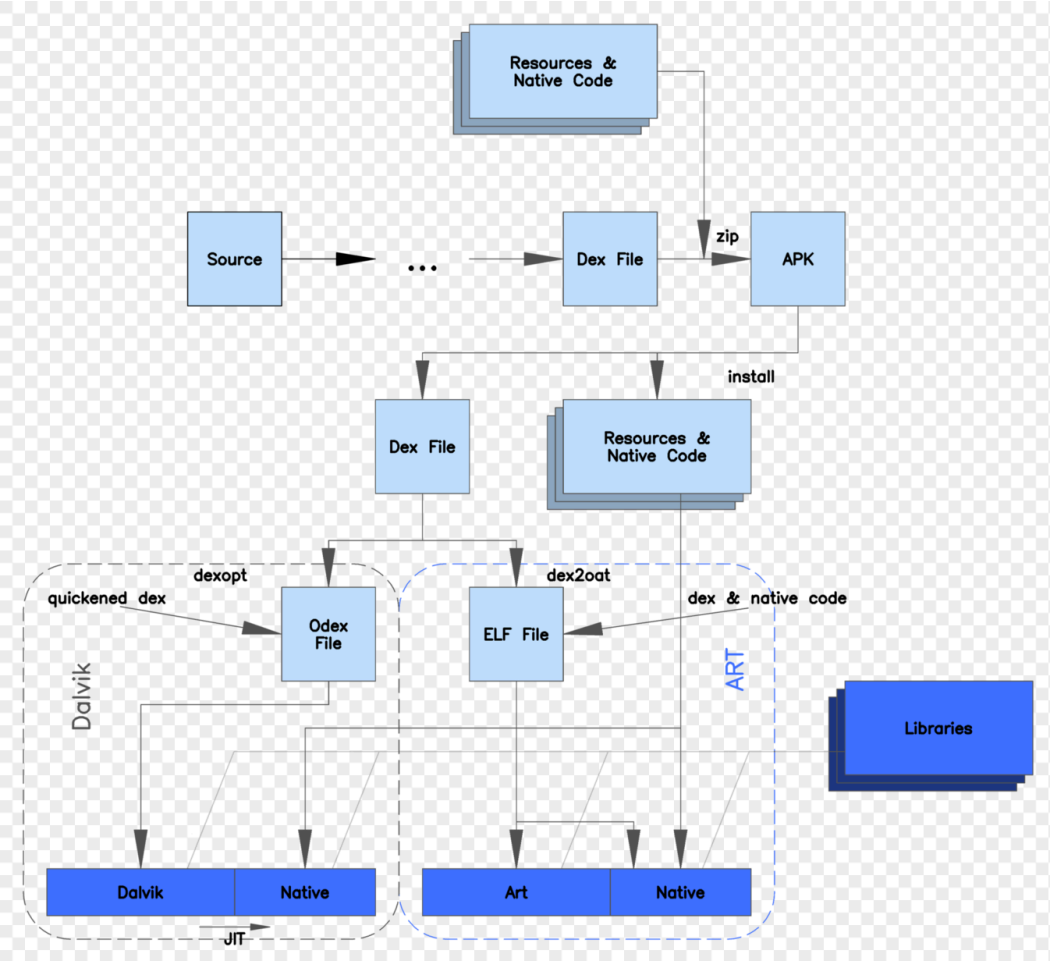

Figure from: https://en.wikipedia.org/wiki/Dalvik_(software)

Application Analysis

- Static Analysis

  Decompile the application, and analyze its byte codes.

  tools: dex2jar, jd-gui, etc.

- Dynamic Analysis

  Execute the application in an isolated execution environment, and analyze the execution.

  tools: Android emulator, QEMU, etc.

Background

- Static analysis

  FlowDroid, DroidSafe, HornDroid

- Dynamic analysis

  DroidScope, TaintDroid, TaintART

- Hybrid analysis

  Harvester

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Motivation

- Static analysis tools suffer from
  - Code obscuration and packing
  - Self-modifying code
- Dynamic analysis tools suffer from
  - Implicit taint flows
  - Performance vs. accuracy
  - Large-scale analysis

Motivation

- Use dynamic analysis to solve packed and self-modifying code.
- Use static analysis to detect implicit flows
- Make the analysis applicable in large-scale analysis.

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Relative Work

- DexHunter
  - Dump Dex file from memory
- AppSpear
  - Use runtime data structure to rebuild Dex file

Assume there exists a clear boundary between packer's code and the application's code

```
1  package com.test;
2
3  public class Main extends Activity {
4    private static final String PHONE = "800-123-456";
5    protected void onCreate(Bundle savedInstanceState) {
6      // ...
7      leak();
8    }
9
10   public void leak() {
11     String a = getSensitiveData(); // source
12     for (int i = 0; i < 2; ++i) {
13       normal(a);
14       bytecodeTamper(i);
15     }
16   }
17
18   public void normal(String param) {
19     // do something normal
20   }
21
22   public void sink(String param) {
23     // send param through text message.
24     SmsManager.getDefault().sendTextMessage(PHONE, null,
           param, null, null); // sink
25   }
26
27   /* While i = 0:
28    *  modify Line 11 to String a = "non-sensitive data"
29    *  modify Line 13 to sink(a)
30    * While i = 1:
31    *  modify Line 11 to String a = getSensitiveData()
32    *  modify Line 13 to normal(a) */
33   public void native bytecodeTamper(int i);
34 }
```

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Implementation

- Just-In-Time instruction-level collection
- Offline reassembling

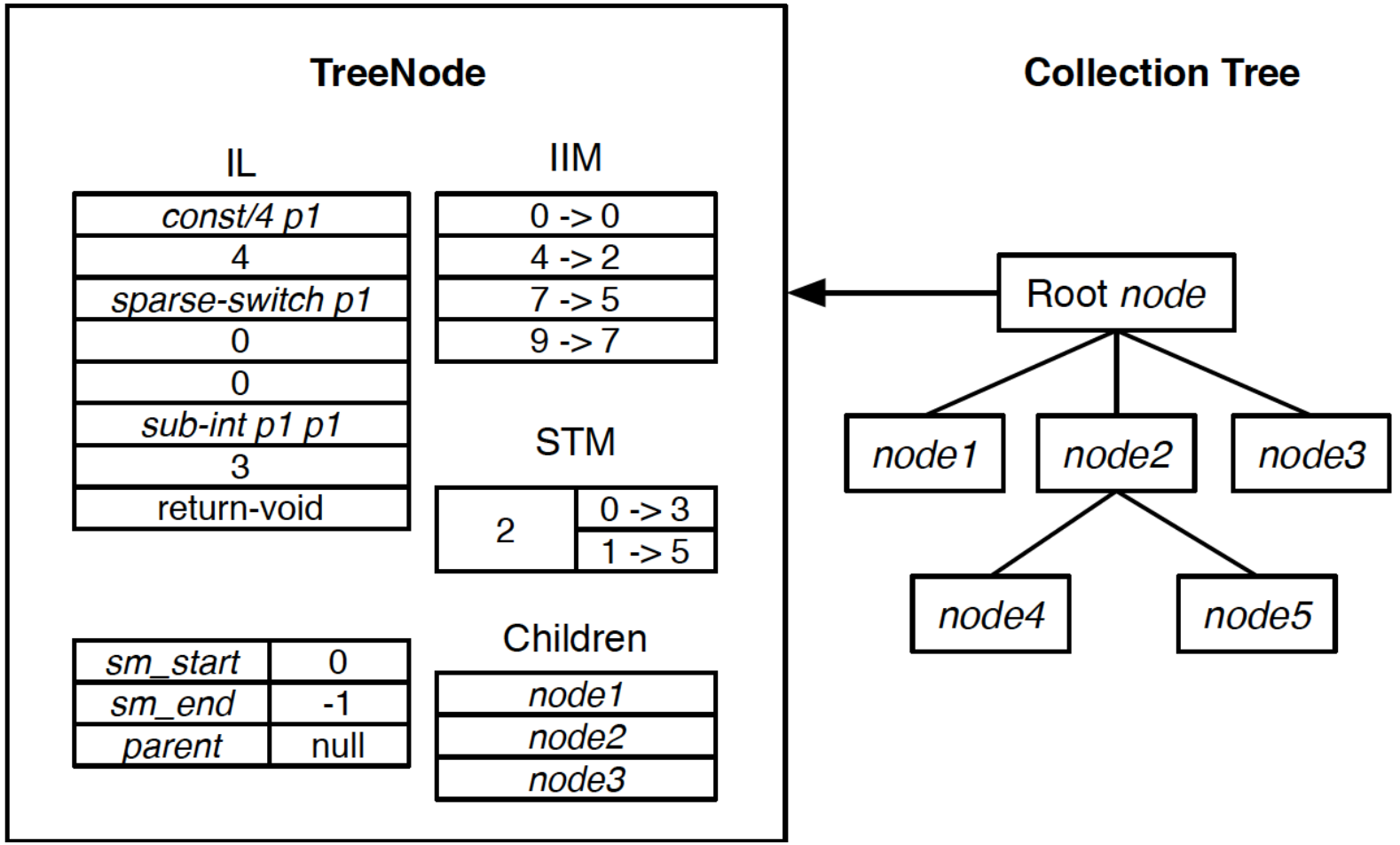
Implementation

- Code scale
  - Loops
- Self-modifying code

Implementation

- The bytecode of a method is organized in an 16-bit array
- A variable *dex_pc* indicates the index of the executing instruction
- **Solution**: Compare instructions with same *dex_pc*

Implementation



Implementation

```
1  Root Node:
2    String a = getSensitiveData();
3    for (int i = 0; i < 2; ++i) {
4      normal(a);
5      bytecodeTamper(i);
6    }
7
8  Child Node: (Line 13 in Code 1)
9    sink(a);
```

```
1  String a = getSensitiveData();
2  for (int i = 0; i < 2; ++i) {
3    if (EXPRESSION) {
4      normal(a);
5    } else {
6      sink(a)
7    }
8    bytecodeTamper(i);
9  }
```

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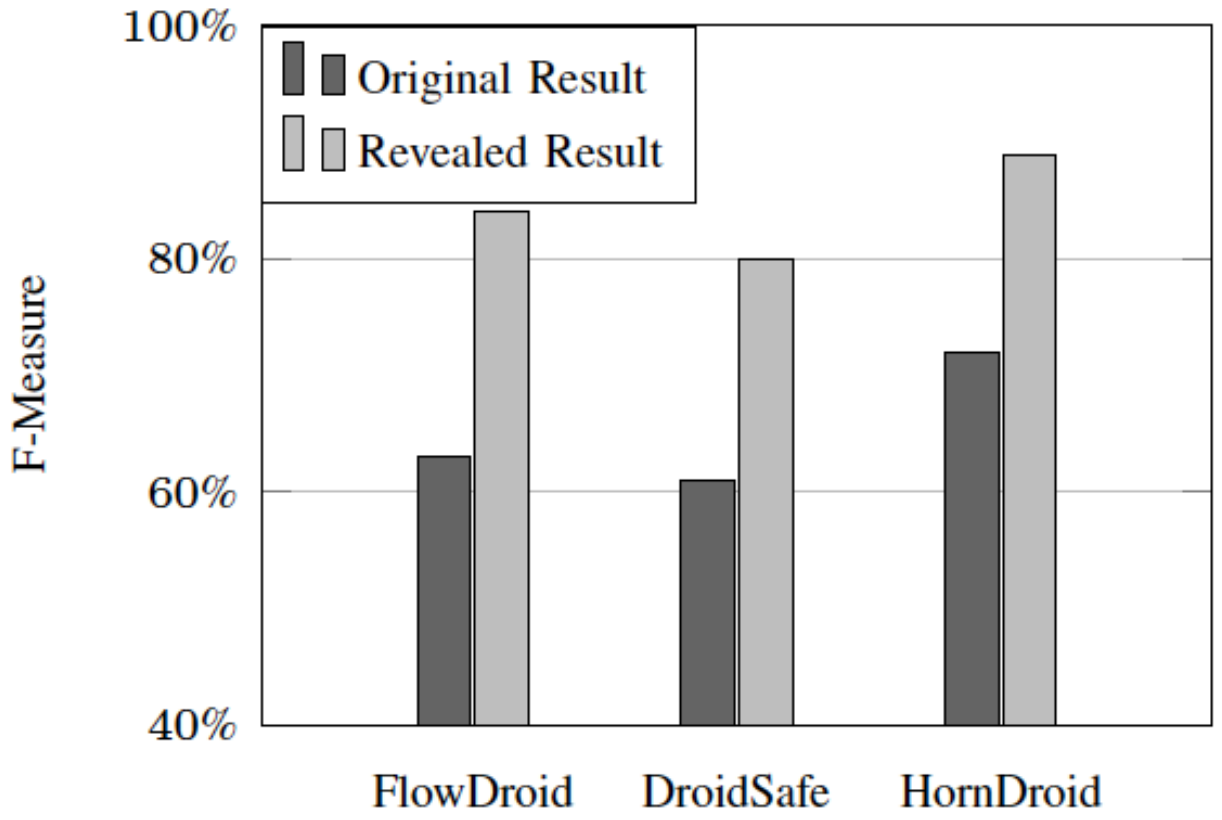
Evaluation on DroidBench



Evaluation on DroidBench

Samples	Leak #	# of Leak Detected		
		TaintDroid [15]	TaintART [39]	DROIDREVEALER
Button1	1	0	0	1
Button3	2	0	0	2
EmulatorDetection1	1	0	1	1
ImplicitFlow1	2	0	0	2
PrivateDataLeak3	2	1	1	1

Evaluation on real-world apps

Package Name	Version	Sample Set	# of Installs	Original	Revealed
com.lenovo.anyshare	3.6.68	A	100 million	0	4
com.moji.mjweather	6.0102.02	A	1 million	0	5
com.rongcai.show	3.4.9	A	100 thousand	0	3
com.wawoo.snipershootwar	2.6	B	10 million	0	4
com.wawoo.gunshootwar	2.6	B	10 million	0	5
com.alex.lookwifipassword	2.9.6	B	100 thousand	0	2
com.gome.eshopnew	4.3.5	C	15.63 million	0	3
com.szzc.ucar.pilot	3.4.0	C	3.59 million	0	5
com.pingan.pabank.activity	2.6.9	C	7.9 million	0	14

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Future work

- Code coverage
- Native code
- Regular JVM in x86

Thank you!