AppCaulk

Data Leak Prevention by Injecting Targeted Taint Tracking Into Android Apps

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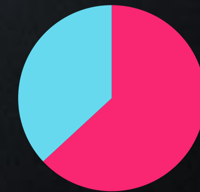
Motivation

- There is no data usage control in Android

91,4%
INTERNET

83,1%
ACCESS_NETWORK_STATE



63,1%
WRITE_EXTERNAL_STORAGE

- Among 10.000 most popular apps, 5 % send out IMEI immediately when started

→ Controlling data flows at application level is required

Static & dynamic data leak detection

- Tracking the ***taint state*** of registers
- Registers written by a ***source*** function become tainted with a flag
- ***Tainted*** registers written to a ***sink*** function impose a ***leak***

Source / **Sink**

```
TelephonyManager tm = (TelephonyManager) getSystemService(Context.TELEPHONY_SERVICE);
String imei = tm.getDeviceId();
Uri uri = Uri.parse("http://www.example.com?imei="+imei);
Intent intent = new Intent(Intent.ACTION_VIEW, uri);
startActivity(intent);
```

Static analysis

- e.g., FlowDroid[1]
- Overapproximative
- Tends to generate false positives

Dynamic analysis

- e.g., TaintDroid[2]
- Detects leaks only as they occur
- Requires modified system image

[1] http://sseblog.ec-spride.de/tools/flowdroid/
[2] http://appanalysis.org/

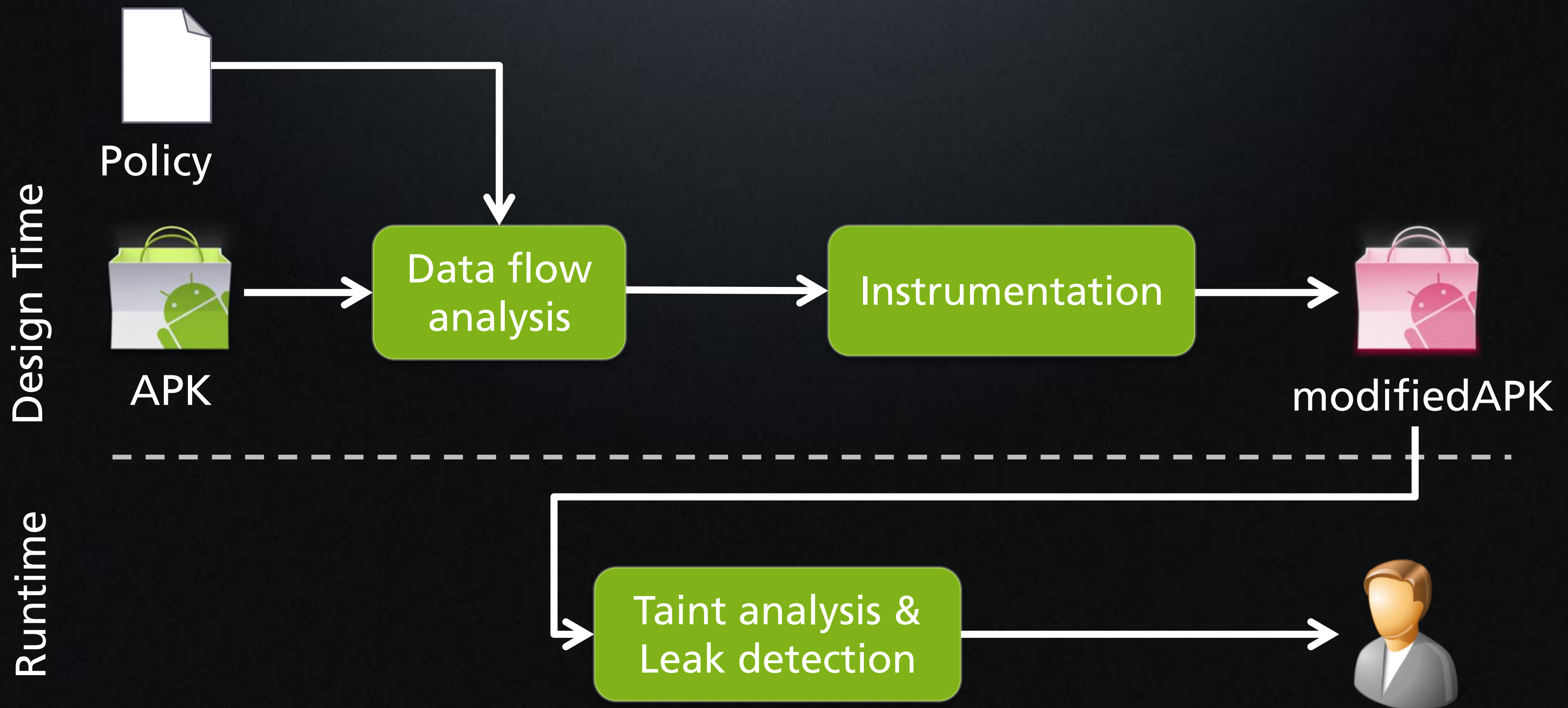
AppCaulk: Overview (1/2)

- Android platform does not provide data flow control
- Static data flow analysis overapproximates
- Simple dynamic taint analysis requires to monitor all registers + modified VM

AppCaulk

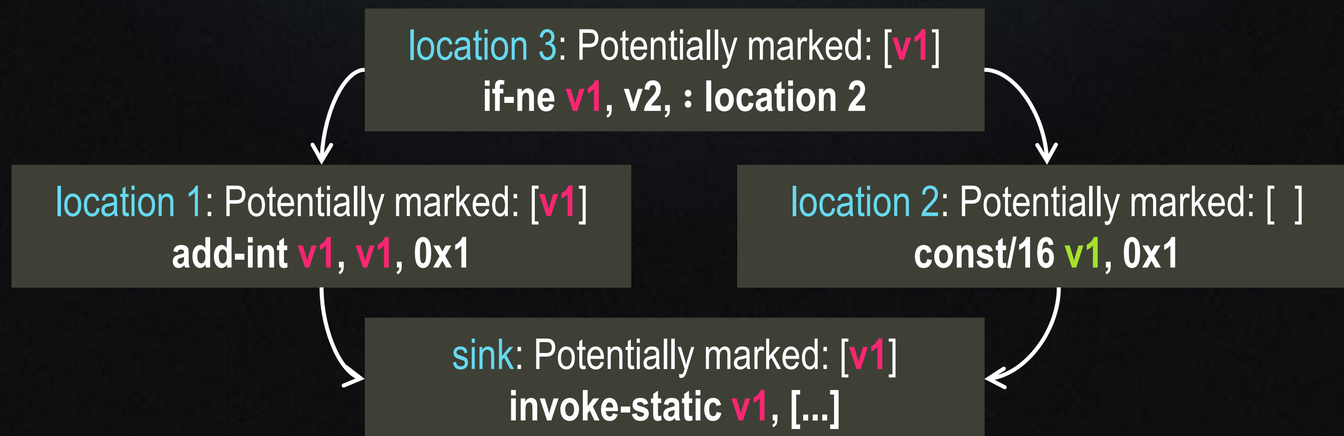
- Static data flow analysis to identify call paths of potential leaks
- Injection of a dynamic taint analysis into the app along call paths
- Policy-controlled definition of sources/sinks/countermeasures/…

AppCaulk: Overview (2/2)



Efficient Data Flow Analysis (1/2)

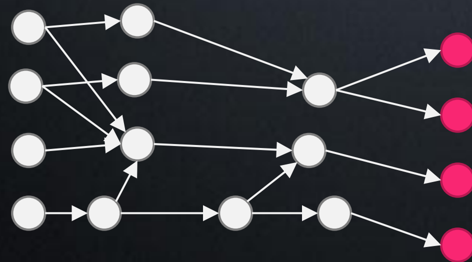
- Transformation into **smali** IR
- Starting at sinks (method name + argument position), mark argument register as ***potentially relevant***
- Create slicing, applying propagation logic to registers



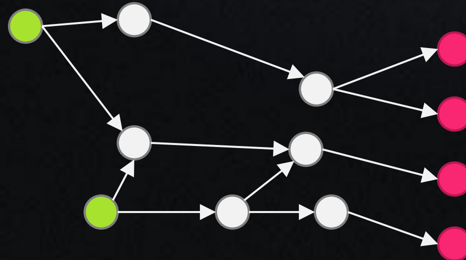
- When method parameter is reached, continue with callers
- Stop when no further relevant statements in worklist and taint states did not change since last iteration

Efficient Data Flow Analysis (2/2)

- Backwards slicing creates dfg to all sinks



- Forward slicing (analog to bwd) creates dfg from all sources



- Special cases
  - Writing to static field taints all registers it is assigned to
  - Array indices

Propagation across native methods

- Scope of static analysis: APK bytecode + Android framework.jar

→ Native methods would break taint propagation

- Android 4.3 has ~3600 native methods
- 1339 native methods may propagate data (arguments + return values)
- Many of them are overloaded (e.g., Math.sqrt(D):D vs Math.sqrt(F):F)

→ Manual definition of native methods propagation rules is feasible.

Propagation across external channels

- Writing tainted data into a file, reading from file
  → propagate taint flag
- Handled by predefined combinations of channel entry/exit methods

SQLite DB

```
Database.insert(X);
…
String result = Database.query(..);
```

Intents

```
Intent Y = intent.putExtra(String,X);
startActivity(Y);
…
Intent Y = getIntent();
```

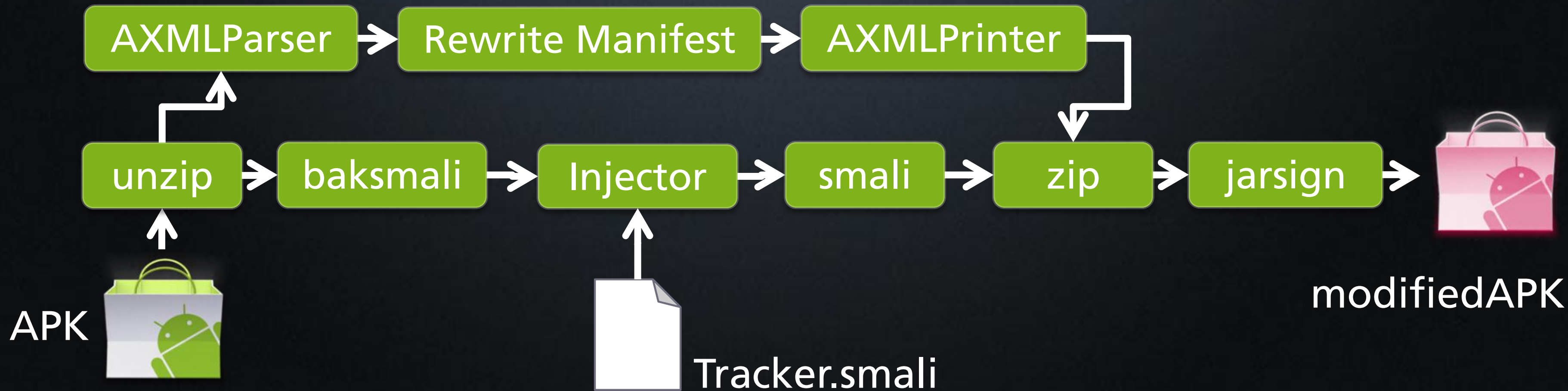
Files

```
FileWriter.write(X);
…
FileReader.read(X);
```

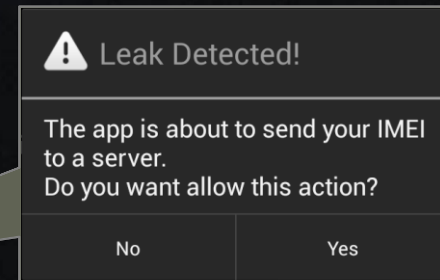
Shared Preferences

```
SharedPreferences.editor.put(Y,X);
SharedPrefrences.editor.commit();
…
SharedPreferences.getString(Y,X)
```

Instrumentation of Dalvik bytecode

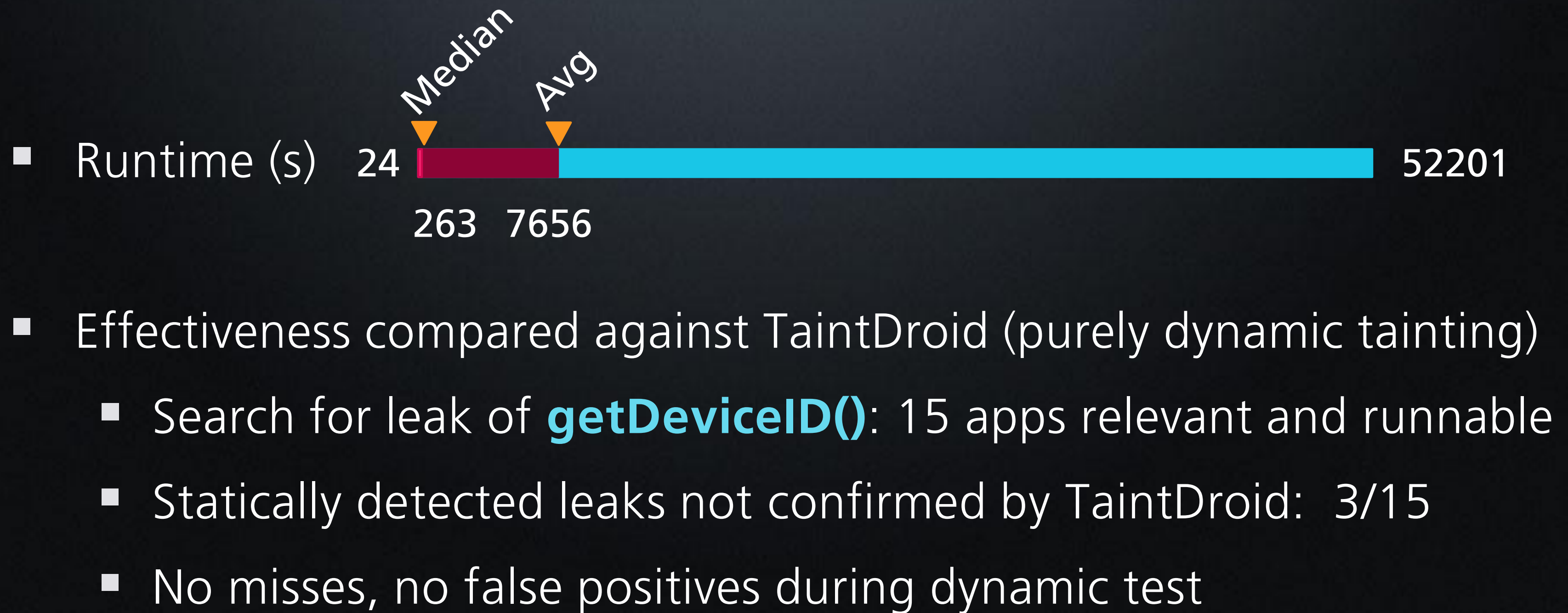


- Add Tracker class
  - Global taint table
  - Handlers for taint propagation
  - Handlers for leak detection



- Represent registers globally unique: **Thread id|class|method|register**
- For each statement along the call path, insert calls to propagation handler method

Effectiveness evaluation



→ Effectiveness keeps up with purely dynamic taint analysis

Conclusion

- AppCaulk "hardens" Android apps by combining static data flow analysis with injection of a dynamic taint analysis into the app
- Detection rate keeps up with TaintDroid
- Applicable to any Android application
- No modification of Android platform required