Seamless In-App Ad Blocking on Stock Android

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Motivation

Ads allow developers to easily monetize their apps.

Why to block ads on Android?

Ad libraries have shown to **exploit host app's permissions to access private data**.

Ads can be used to **lure users into installing malware**.

Streaming media files can be **expensive** on mobile networks.

Existing approaches lack deployability or effectiveness.

Existing approaches

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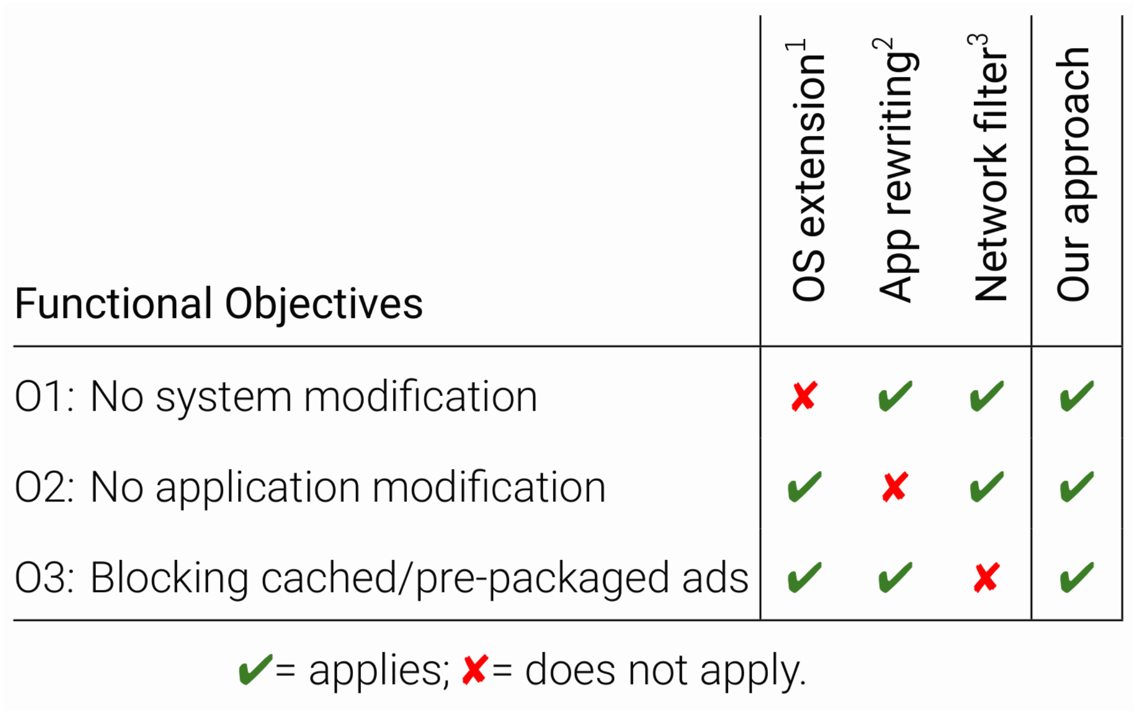


Functional Objectives	OS extension[1]	App rewriting[2]	Network filter[3]	Our approach
O1: No system modification	✗	✓	✓	✓
O2: No application modification	✓	✗	✓	✓
O3: Blocking cached/pre-packaged ads	✓	✓	✗	✓

✓= applies; ✗= does not apply.

[1] AdDroid Pearce et al, ASIACCS'12 , Adsplit Shekhar et al, Usenix'12 , Aframe Zhang et al, ACSAC'13

[2] PEDAL Liu et al., MobiSys'15 , Apklancet Yang et al., ASIACCS'14

[3] Privacyguard Song et al., SPSM'15 , Adguard

Contribution

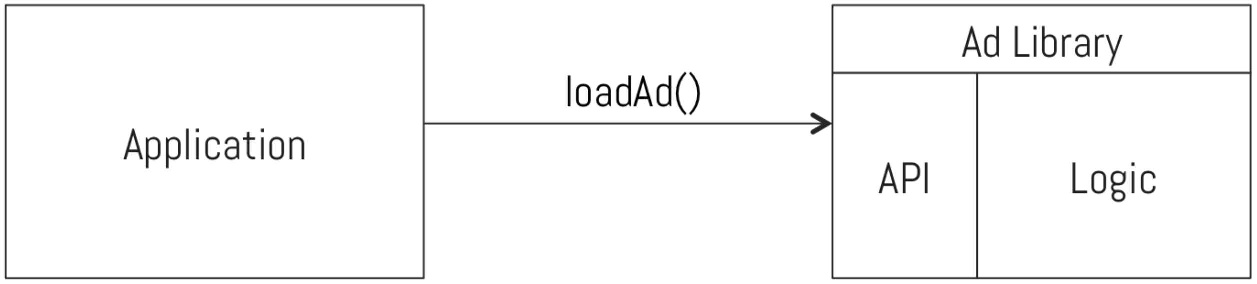
We developed an in-app ad blocking system, that

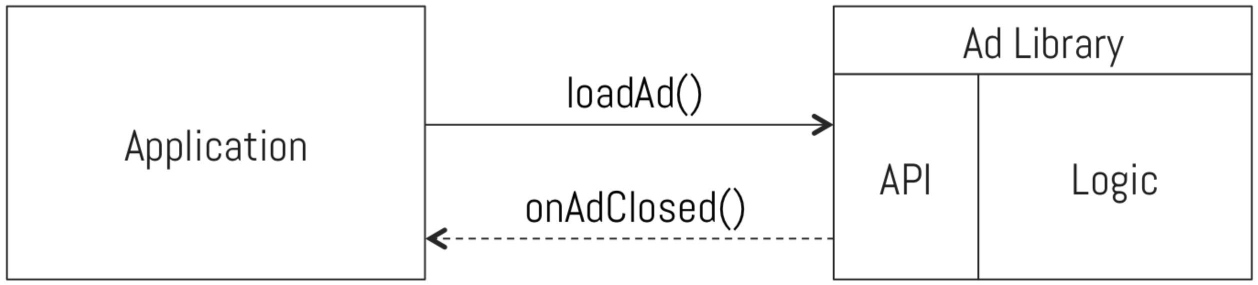
- is easy to deploy and runs on-device only.
- effectively blocks ad library code execution.
- has no side-effects on the applications.

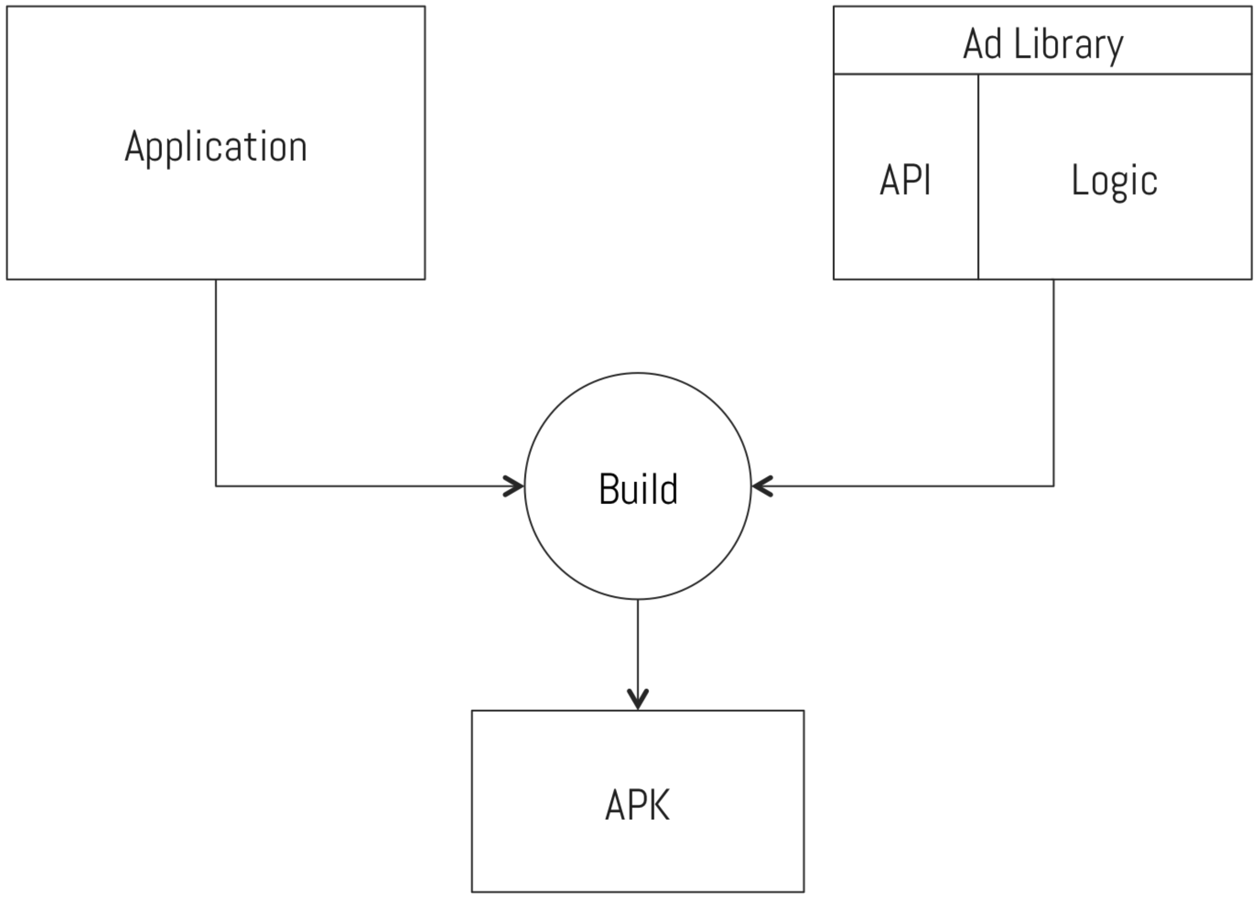
Ad library inclusion

Application
Ad Library

Application
Ad Library
API
Logic


Application
loadAd()
Ad Library
API
Logic


Application
loadAd()
onAdClosed()
Ad Library
API
Logic


Application
Ad Library
API
Logic
Build
APK

Approach

1. Identification

   Find ad library API c lasses inside app pac kage

2. Stub generation

   Create matching c lasses that preserve functionality

3. Injection

   Have the application use the created stub

Approach: 1. Identification

Find ad library API classes inside app package

Task: identify class `AdView` from included library `com.example.ads`.

~~Approach: find class with class name `com.example.ads.AdView`.~~

Problem: Identifier Renaming

Build process obfuscates names of classes, methods and fields:

```
com.example.ads.AdView -> a.b.a.a
com.example.ads.InterstitialAd -> a.b.a.b
```

... but when referenced in XML or string constants, **names are preserved**.

- Libraries contain a XML manifest referencing their package name.
- UI classes might be referenced in UI XML.

```
com.example.ads.AdView -> com.example.ads.AdView
com.example.ads.InterstitialAd -> com.example.ads.a
```

Task: identify class `AdView` from included library `com.example.ads`.

~~Approach: find class in package `com.example.ads` with **same superclass and members**~~.

Problem: Dead code elimination

Build process removes methods and classes that are not referenced.

Task: identify class `AdView` from included library `com.example.ads`.

Approach: find class in package `com.example.ads` with same superclass and **required members**.

Filter rules

Must contain for each class: package name, superclass, required members.

```
package com.example.ads
    class .AdView extends* android.view.View
        method exists void loadAd
    end class
    class .InterstitialAd
        method exists void openAd .AdListener
    end class
    class .AdListener
        method exists void onAdClosed
    end class
end package
```

Approach: 2. Stub generation

Create matching classes that preserve functionality

Task: create class replacing `InterstitialAd`.

~~Approach: Replace all methods with empty/null-return methods.~~

Problem: Callbacks

Some method calls must result in callback invocations to preserve app functionality

Task: create classes replacing `InterstitialAd`.

Approach: Replace all methods with empty/null-return methods or functionality preserving implementations.

Filter rules

Must contain for each class: package name, superclass, required members, stub generation info.

```
package com.example.ads
    class .AdView extends* android.view.View
        set filter-action empty-view
        method exists void loadAd
    end class
    class .InterstitialAd
        set filter-action empty-object
        method exists,replace void openAd .AdListener
    end class
    class .AdListener
        method exists void onAdClosed
    end class
end package
```

Approach: 3. Injection

Have the application use the created stub

Use app virtualization (Boxify Backes et al., Usenix'15) to instrument app.

Prepend stub classes to class loader search path, so they are loaded first.

Evaluation

Manual assessment

Created filter rules for 7 large advertisers

Tested against 22 random apps from Play Store (that contained ads)

Ads blocked in 19 apps, 3 failed because of missing filter rules.

No app crashed or misbehaved.

Real-world test

Made end-user version (with more filter rules) publicly available

5.700+ installs, 15.000+ different apps ad-blocked

Less than 200 reported apps that still showed ads.

Limitations

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- Only third-party libraries. This excludes
    - Content ads (ex. Spotify, Facebook)
    - Web-based ads (WebView, Browser)
- Dynamic class loading
- Stronger obfuscation
- Red Pill attacks

Summary

Built in-app ad blocking based on app virtualization.

Demonstrated deployability and efficiency by real-world evaluation.

www.srt-adversary.com