AdDroid
Privilege Separation for Applications andAdvertisers in Android

Paul Pearce¹, Adrienne Porter Felt¹, Gabriel Nunez²,
David Wagner¹

¹ University of California, Berkeley
² Sandia National Laboratory

May 4, 2012
SCARY CAMPFIRE STORY
Android Market
Android Market

Android Market Search

flashlight

- flashlight app
- flashlight widget
- flashlight led
- flashlight free
- flashlight apps
Market Search Results

- Brightest Flashlight Free™
  GoldenShores Technologies, LLC
  ★★★★★
  Free

- Tiny Flashlight + LED
  Nikolay Ananiev
  ★★★★★
  Free

- Flashlight
  Intellectual Flame Co., Ltd.
  ★★★★★
  Free

- Color Flashlight
  Notes
  ★★★★★
  Free

- TeslaLED Flashlight
  TeslaCoil Software
  ★★★★★
  Free

- Color Flashlight HD
  Notes
  ★★★★★
  Free

- Flashlight HD LED
Market Search Results

- Brightest Flashlight Free™
  GoldenShores Technologies, LLC
  🌟🌟🌟🌟🌟
  Free

- Tiny Flashlight + LED
  Nikolay Ananiev
  🌟🌟🌟🌟🌟
  Free

- Flashlight
  Intellectual Flame Co., Ltd.
  🌟🌟🌟🌟🌟
  Free

- Color Flashlight Notes
  🌟🌟🌟🌟🌟
  Free

- TeslaLED Flashlight
  Tesla Coil Software
  🌟🌟🌟🌟🌟
  Free

- Color Flashlight HD Notes
  🌟🌟🌟🌟🌟
  Free

- Flashlight HD LED

App Install Dialog

Brightest Flashlight Free™
GOLDENSHORE...
Download

🌟🌟🌟🌟🌟 370,235
10,000,000+ downloads
February 20, 2012
1.72 MB

+1 24K people +1’d this.

DESCRIPTION

Brightest Flashlight App – Free of Charge
* Turns on all available lights on the device
* Camera Flash LED at Maximum
Market Search Results

App Install Dialog

App Permissions Dialog

**Brightest Flashlight Free™**
GoldenShores Technologies, LLC  
Free

**Tiny Flashlight + LED**
Nikolay Ananiev  
Free

**Flashlight**
Intellectual Flame Co., Ltd.  
Free

**Color Flashlight**
Notes  
Free

**TeslaLED Flashlight**
TeslaCoil Software  
Free

**Color Flashlight HD**
Notes  
Free

**Flashlight HD LED**

**Brightest Flashlight Free**
GOLDENSHORES TECHNOLOGIES, LLC  
Free

**DESCRIPTION**
Brightest Flashlight App – Free of Charge  
* Turns on all available lights on the device  
* Camera Flash LED at Maximum

**Your location**
Coarse (network-based) location, fine (GPS) location

**Phone calls**
Read phone state and identity

**Network communication**
Full Internet access

**Hardware controls**
Take pictures and videos
Market Search Results

App Install Dialog

App Permissions Dialog

Your location
Coarse (network-based) location, fine (GPS) location

Phone calls
Read phone state and identity

Network communication
Full Internet access

Hardware controls
Take pictures and videos
Market Search Results

- Brightest Flashlight Free™
  - GoldenShores Technologies, LLC
  - ★★★★★
  - Free

- Tiny Flashlight + LED
  - Nikolay Ananiev
  - ★★★★★
  - Free

- Flashlight
  - Intellectual Flame Co., Ltd.
  - ★★★★★
  - Free

- Color Flashlight
  - Notes
  - ★★★★★
  - Free

- TeslaLED Flashlight
  - TeslaCoil Software
  - ★★★★★
  - Free

- Color Flashlight HD
  - Notes
  - ★★★★★
  - Free

- Flashlight HD LED
Market Search Results

- Brightest Flashlight Free™
  GoldenShores Technologies, LLC
  ★★★★★
  Free

- Tiny Flashlight + LED
  Nikolay Ananiev
  ★★★★★
  Free

- Flashlight
  Intellectual Flame Co., Ltd.
  ★★★★★
  Free

- Color Flashlight
  Notes
  ★★★★★
  Free

- TeslaLED Flashlight
  Tesla Coil Software
  ★★★★★
  Free

- Color Flashlight HD
  Notes
  ★★★★★
  Free

- Flashlight HD LED
Market Search Results

Tiny Flashlight + LED
Nikolay Ananiev

APPs

Brightest Flashlight Free™
GoldenShores Technologies, LLC

Flashlight
Intellectual Flame Co., Ltd.

Color Flashlight
Notes

TeslaLED Flashlight
TeslaCoil Software

Color Flashlight HD
Notes

Flashlight HD LED

App Install Dialog

Tiny Flashlight + LED
NIKOLAY ANAN... Download

DESCRIPTION
Flashlight for your device! Incredibly simple and yet very useful flashlight application. Will use your device's camera LED as a torch.
Market Search Results

Tiny Flashlight + LED
Nikolay Ananiev

App Install Dialog

Tiny Flashlight + LED
NIKOLAY ANANIEV

App Permissions Dialog

Phone calls
Read phone state and identity

Network communication
Full Internet access

System tools
Prevent phone from sleeping

Hardware controls
Take pictures and videos
Market Search Results

App Install Dialog

App Permissions Dialog

Tiny Flashlight + LED
Nikolay Ananiev

Phone calls
Read phone state and identity

Network communication
Full Internet access

DESCRIPTION
Flashlight for your device! Incredibly simple and yet very useful flashlight application. Will use your device's camera LED as a torch.
Market Search Results

[Screen capture showing search results for "flashlight" with applications listed:
- Brightest Flashlight Free
- Tiny Flashlight + LED (highlighted)
- Flashlight
- Color Flashlight
- TeslaLED Flashlight
- Color Flashlight HD
- Flashlight HD LED]
Market Search Results

- Brightest Flashlight Free™
  GoldenShores Technologies, LLC
  Free

- Tiny Flashlight + LED
  Nikolay Ananiev
  Free

- Flashlight
  Intellectual Flame Co., Ltd.
  Free

- Color Flashlight
  Notes
  Free

- TeslaLED Flashlight
  TeslaCoil Software
  Free

- Color Flashlight HD
  Notes
  Free

- Flashlight HD LED
Market Search Results

- **Brightest Flashlight Free™**
  - GoldenShores Technologies, LLC
  - Free

- **Tiny Flashlight + LED**
  - Nikolay Ananiev
  - Free

- **Flashlight**
  - Intellectual Flame Co., Ltd.
  - Free

- **Color Flashlight**
  - Notes
  - Free

- **TeslaLED Flashlight**
  - TeslaCoil Software
  - Free

- **Color Flashlight HD**
  - Notes
  - Free

- **Flashlight HD LED**
Market Search Results

- **Brightest Flashlight Free**
  - GoldenShores Technologies, LLC
  - **Free**

- **Tiny Flashlight + LED**
  - Nikolay Ananiev
  - **Free**

- **Flashlight**
  - Intellectual Flame Co., Ltd.
  - **Free**

- **Color Flashlight**
  - Notes
  - **Free**

- **TeslaLED Flashlight**
  - TeslaCoil Software
  - **Free**

- **Color Flashlight HD**
  - Notes
  - **Free**

- **Flashlight HD LED**
Market Search Results

- Brightest Flashlight Free™
  - GoldenShores Technologies, LLC
  - Free
- Tiny Flashlight + LED
  - Nikolay Ananiev
  - Free
- Flashlight
  - Intellectual Flame Co., Ltd.
  - Free
- Color Flashlight
  - Notes
  - Free
- **TeslaLED Flashlight**
  - TeslaCoil Software
  - Free
- Color Flashlight HD
  - Notes
  - Free
- Flashlight HD LED

App Install Dialog

**TeslaLED Flashlight**
- TESLACOIL SOFTWARE
- Download

**DESCRIPTION**

TeslaLED is an LED flashlight app and widget, allowing you to use the camera flash as a flashlight. This thing is bright!
**Market Search Results**

- Brightest Flashlight Free™
- Tiny Flashlight + LED
- Flashlight
- Color Flashlight
- TeslaLED Flashlight
- Color Flashlight HD
- Flashlight HD LED

**App Install Dialog**

- TeslaLED Flashlight
  - TESLAJOI SOFT...
  - Download
  - 15,380 ratings
  - 1,000,000+ downloads
  - December 12, 2011
  - 512KB
  - 2.9K people +1’d this.

**App Permissions Dialog**

- Permissions
  - Hardware controls: Take pictures and videos
  - System tools: Display system-level alerts, prevent phone from sleeping

**Description**

TeslaLED is an LED flashlight app and widget, allowing you to use the camera flash as a flashlight. This thing is bright!
What’s happening here?

Advertisements
• App developers use ads for revenue

• Ad networks *overprivilege* apps
  – Ads are part of apps
  – Ads require permissions that apps may not
Key Points

• Advertising overprivileges 49% of ad-supported applications (28% of all applications) on Android

• We present AdDroid, a privilege separated advertising framework to solve this problem
ANDROID AND ADVERTISING BACKGROUND
Ads in Applications

Market Search Results

- **Brightest Flashlight Free™**
  - GoldenShores Technologies, LLC
  - Rating: ★★★★★
  - Free

- **Tiny Flashlight + LED**
  - Nikolay Ananiev
  - Rating: ★★★★★
  - Free

- **Flashlight**
  - Intellectual Flame Co., Ltd.
  - Rating: ★★★★★
  - Free

- **Color Flashlight**
  - Notes
  - Rating: ★★★★★
  - Free

- **TeslaLED Flashlight**
  - TeslaCon Software
  - Rating: ★★★★★
  - Free

- **Color Flashlight HD**
  - Notes
  - Rating: ★★★★★
  - Free

- **Flashlight HD LED**
Ads in Applications

Market Search Results

- Brightest Flashlight Free™
  - GoldenShores Technologies, LLC
  - Free

- Tiny Flashlight + LED
  - Nikolay Ananiev
  - Free

- Flashlight
  - Intellectual Flame Co., Ltd.
  - Free

- Color Flashlight Notes
  - Free

- TeslaLED Flashlight
  - TeslaCoil Software
  - Free

- Color Flashlight HD Notes
  - Free

- Flashlight HD LED
Ads in Applications

Market Search Results

Brightest Flashlight App

Settings

Sound

Timer

Display
Ads in Applications

Market Search Results

Brightest Flashlight App

Settings

- Sound
- Timer
- Display
Ads in Applications
Android Permissions

• A permission gives an app the ability to perform a privacy- or security- relevant action
  – E.g. INTERNET controls network access, ACCESS_FINE_LOCATION control GPS access

• Permissions are requested by apps at install-time.
  – Once granted, users are not asked again

• Permissions are enforced by the Android Platform
Advertising Libraries

• Advertising networks distribute advertising libraries for app developers to use

• Developers integrate these libraries into their applications
  – Permissions are enforced at the granularity of applications
  – Advertising libraries and host applications share permissions
Current Android System Design

Application

Host Application

Advertising Library

API Calls

API Permission Checks

Android Platform

Advertising Network

Phone → Web

http

http
What Can Go Wrong

• Users can’t determine if an app uses ads

• Users can’t differentiate permissions used by an app from those used by ads
  – What if I trust one principal more than the other?

• Ad libraries can introduce vulnerabilities to apps
  – Some ad libraries download code over HTTP

• Ad libraries may not be trustworthy
  – Some ad libraries opportunistically use host app permissions
MEASURING THE PROBLEM
Methodology

• Analyze a set of 964 applications collected from the Android Market
  – 764 most popular free
  – 100 most popular paid
  – 100 most recent free

• Disassemble each application into the host application and the advertising library components

• Use static analysis to determine which component used each permission
### Measurement Results: Ad Usage

<table>
<thead>
<tr>
<th></th>
<th>Percent of apps using at least 1 ad library</th>
<th>Total apps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Free Apps</td>
<td>50.4%</td>
<td>764</td>
</tr>
<tr>
<td>Top Paid Apps</td>
<td>16.0%</td>
<td>100</td>
</tr>
<tr>
<td>Recent Free Apps</td>
<td>72.0%</td>
<td>100</td>
</tr>
</tbody>
</table>

- 49% of applications in our dataset contain 1 or more advertising library
Measurement Results: Overprivilege

<table>
<thead>
<tr>
<th>Permission to access</th>
<th>Percent of apps requesting permission only for ads</th>
<th>Total apps requesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Internet (INTERNET)</td>
<td>16.2%</td>
<td>809</td>
</tr>
<tr>
<td>Location (LOCATION)</td>
<td>33.5%</td>
<td>361</td>
</tr>
<tr>
<td>IMEI identifier (READ_PHONE_STATE)</td>
<td>12.8%</td>
<td>312</td>
</tr>
<tr>
<td>Network information (ACCESS_NETWORK_STATE)</td>
<td>9.1%</td>
<td>395</td>
</tr>
</tbody>
</table>

• Advertising libraries overprivilege:
  – 46% of applications with advertisements
  – 28% of all apps

• Breakdown of applications that use location only for advertising
  – 56% of ad-supported applications
  – 34% of all applications
ADDROID: A SOLUTION TO OVERPRIVILEGING
Design Overview

• Key idea: Separate privacy-sensitive ad functionality from applications

• AdDroid is an extension to Android that provides special support for ads

• Applications that want advertisements now request new **ADS** permissions, not **INTERNET** or **LOCATION**
  – Gives apps the ability to have ads without **INTERNET** or **LOCATION**
AdDroid Design

Application

Host Application
Advertising Library

API Calls

API Permission Checks

Android Platform

Phone  Web

Advertising Network

http

http
AdDroid Design

Application

Host Application

Advertising Library

API Calls

API Permission Checks

Android Platform

Phone | Web

Advertising Network
AdDroid Design

Application

Host Application

API Calls

API Permission Checks

Android Platform

Phone | Web

Advertising Network
AdDroid Design

Application

Host Application

API Calls

API Permission Checks

Android Platform

Advertising Service

Advertising Network

Phone | Web
AdDroid Design

Application

Host Application

API Calls

API Permission Checks

Android Platform

Advertising Service

Advertising Network

Phone | Web
New Permissions

Advertising

Do you want to install this application?

Allow this application to:

- **Advertising**
  Retrieve ads from ad networks

Location based Advertising

Do you want to install this application?

Allow this application to:

- **Advertising**
  Retrieve ads from ad networks, Transmit your location to ad networks
What Can Go Wrong Right

• Users can determine if an app uses ads

• Users can differentiate permissions used by an app from those used by ads
  – Apps don’t request additional permissions for ads, besides the ads permissions themselves

• Ad libraries can’t introduce vulnerabilities or abuse app permissions
  – Ad libraries replaced with standard Android library code
Compatibility and Practicality

- Compatible with existing applications and libraries
  - If you don’t want to use the AdDroid API, you just don’t get the benefits

- Easy for app developers to adopt
  - API based on existing advertising libraries

- Incremental system change
  - Advertising Service model similar to existing services
Conclusion

• Advertising related overprivilege impacts much of the Android ecosystem
  – 49% of all ad-supported apps (28% of all apps) are overprivileged by advertising libraries

  – This poses a variety of problems for users and developers

• AdDroid solves these problems by isolating privileged privacy-sensitive ad functionality from applications

• Questions?