

AdDroid

Privilege Separation for Applications and Advertisers in Android

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¹ University of California, Berkeley

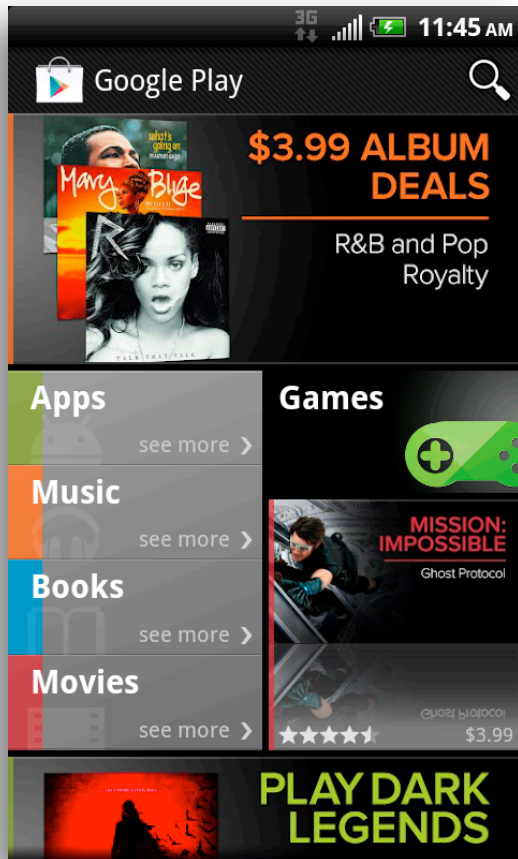
² Sandia National Laboratory

May 4, 2012

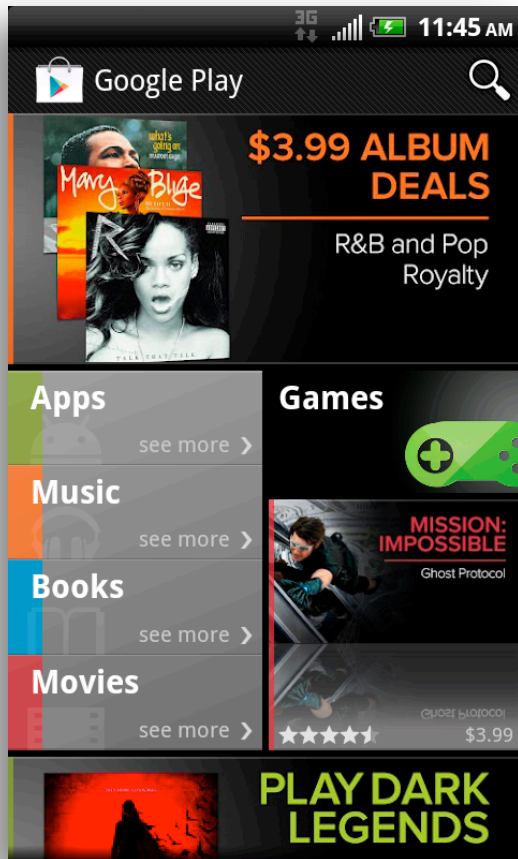


SCARY CAMPFIRE STORY

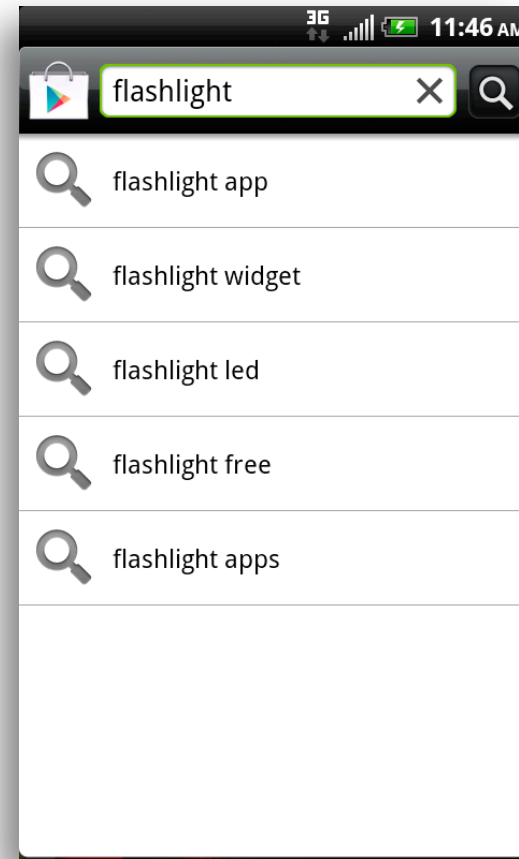
Android Market



Android Market



Android Market Search



Market Search Results

The screenshot shows an Android app store search interface. At the top, the search bar contains the word 'flashlight'. Below the search bar, the word 'APPS' is displayed. A list of search results is shown, with the first result, 'Brightest Flashlight Free™', highlighted by a blue border. The status bar at the top of the screen shows 3G connectivity, signal strength, battery level, and the time 11:47 AM.

App Icon	App Name	Developer	Rating	Price
	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

3G 11:47 AM

flashlight

APPS

- 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

3G 11:48 AM

Apps

Brightest Flashlight Free
GOLDENSHORE... [Download](#)

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

+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

3G 11:47 AM

flashlight

APPS


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

App Install Dialog

3G 11:48 AM

Apps

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DESCRIPTION

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

App Permissions Dialog

3G 11:49 AM

Apps

Brightest Flashlight Free
GOLDENSHORES TECHNOLO... Accept & download

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

3G 11:47 AM

flashlight

APPS

- 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

3G 11:48 AM

Apps

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DESCRIPTION

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

App Permissions Dialog

3G 11:49 AM

Apps

Brightest Flashlight Free
GOLDENSHORES TECHNOLO... Accept & download

- 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

The screenshot shows an Android app store search interface. At the top, there's a status bar with '3G', signal strength, battery, and '11:47 AM'. Below that is a search bar with 'flashlight' and a magnifying glass icon. A green bar with 'APPS' and a right-pointing arrow is below the search bar. The search results are a list of flashlight apps, each with an icon, title, developer, rating, and price. The first app, 'Brightest Flashlight Free™', is highlighted with a blue border.

App Icon	App Name	Developer	Rating	Price
	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

The screenshot shows an Android app store search interface. At the top, the search bar contains the word 'flashlight'. Below the search bar, the word 'APPS' is displayed. A list of search results follows, each with an app icon, title, developer name, a five-star rating, and the word 'Free'.

App Icon	App Name	Developer	Rating	Price
	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

3G 11:47 AM

flashlight

APPS

- 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

3G 11:50 AM

Apps

Tiny Flashlight + LED
NIKOLAY ANAN... Download

Tiny Flashlight®
Fastest & Brightest

★★★★★ 1,188,217 February 23, 2012
10,000,000+ downloads 1.26MB

+1 93K people +1'd this.

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

3G 11:47 AM

flashlight

APPS

- 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

3G 11:50 AM

Apps

Tiny Flashlight + LED
NIKOLAY ANANIEV Download

Tiny Flashlight®
Fastest & Brightest

★★★★★ 1,188,217 February 23, 2012
10,000,000+ downloads 1.26MB

+1 93K people +1'd this.

DESCRIPTION

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

App Permissions Dialog

3G 11:51 AM

Apps

Tiny Flashlight + LED
NIKOLAY ANANIEV

Accept & download

PERMISSIONS

- 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

A screenshot of an Android market search results page for the keyword 'flashlight'. The search results are listed under the 'APPS' tab. The second result, 'Tiny Flashlight + LED' by Nikolay Ananiev, is highlighted with a blue border. Other results include 'Brightest Flashlight Free™', 'Flashlight', 'Color Flashlight', 'TeslaLED Flashlight', 'Color Flashlight HD', and 'Flashlight HD LED'. All apps are listed as 'Free'.

App Name	Developer	Price
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

A screenshot of the app install dialog for 'Tiny Flashlight + LED' by Nikolay Ananiev. The dialog shows the app icon, a 'Download' button, and a video player. Below the video, it displays the app's rating (4.5 stars), 1,188,217 reviews, 10,000,000+ downloads, and a size of 1.26MB. A social media share button shows '+1' and '93K people +1'd this.' The 'DESCRIPTION' section reads: 'Flashlight for your device! Incredibly simple and yet very useful flashlight application. Will use your device's camera LED as a torch.'

App Permissions Dialog

A screenshot of the app permissions dialog for 'Tiny Flashlight + LED' by Nikolay Ananiev. The dialog shows the app icon and an 'Accept & download' button. Below this, the 'PERMISSIONS' section lists several permissions, with 'Phone calls' and 'Network communication' highlighted by orange boxes. Other permissions include 'Read phone state and identity', 'Full Internet access', 'System tools', 'Prevent phone from sleeping', and 'Hardware controls', 'Take pictures and videos'.

Permission
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

The screenshot shows an Android app store search for 'flashlight'. The search results are listed under the 'APPS' category. The second result, 'Tiny Flashlight + LED', is highlighted with a blue border. The status bar at the top shows 3G connectivity, signal strength, battery level, and the time 11:47 AM.

App Name	Developer	Rating	Price
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

The screenshot shows an Android app store search interface. At the top, the search bar contains the text 'flashlight'. Below the search bar, a list of app results is displayed. The app 'Flashlight' by Intellectual Flame Co., Ltd. is highlighted with a blue border. The status bar at the top shows 3G connectivity, signal strength, battery level, and the time 11:47 AM.

App Icon	App Name	Developer	Rating	Price
	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

The screenshot shows an Android app store search for 'flashlight'. The search results are listed under the 'APPS' category. The 'Color Flashlight' app is highlighted with a blue border. The status bar at the top shows 3G connectivity, signal strength, battery level, and the time 11:47 AM.

App Name	Developer	Price
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

The screenshot shows an Android app store search for 'flashlight'. The top status bar displays '3G', signal strength, battery, and '11:47 AM'. The search bar contains 'flashlight' and a magnifying glass icon. Below the search bar is a section titled 'APPS'. A list of seven flashlight-related apps is shown, each with an icon, title, developer name, star rating, and price. The 'TeslaLED Flashlight' app is highlighted with a blue border.

App Icon	App Name	Developer	Rating	Price
	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

3G 11:47 AM

flashlight

APPS

- 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

3G 12:31 PM

Apps

TeslaLED Flashlight
TESLACOIL SOF... [Download](#)

TeslaLED

★★★★★ 15,380
1,000,000+ downloads
December 12, 2011
512KB

+1 2.9K people +1'd this.

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

3G 11:47 AM

flashlight

APPS

- 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

3G 12:31 PM

Apps

TeslaLED Flashlight
TESLACOIL SOF... Download

306 307

306 307

★★★★★ 15,380 December 12, 2011
1,000,000+ downloads 512KB

+1 2.9K people +1'd this.

DESCRIPTION

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

App Permissions Dialog

3G 12:31 PM

Apps

TeslaLED Flashlight
TESLACOIL SOFTWARE

Accept & download

PERMISSIONS

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

See all v

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

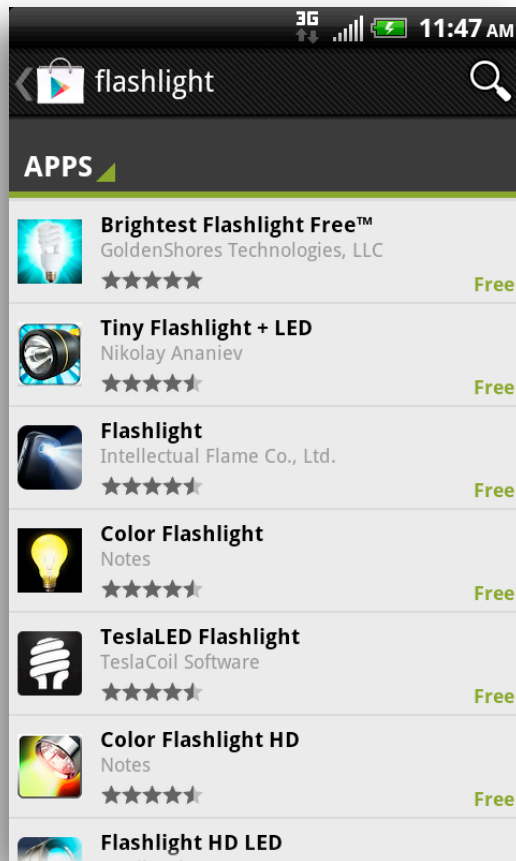
Key Points

- 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

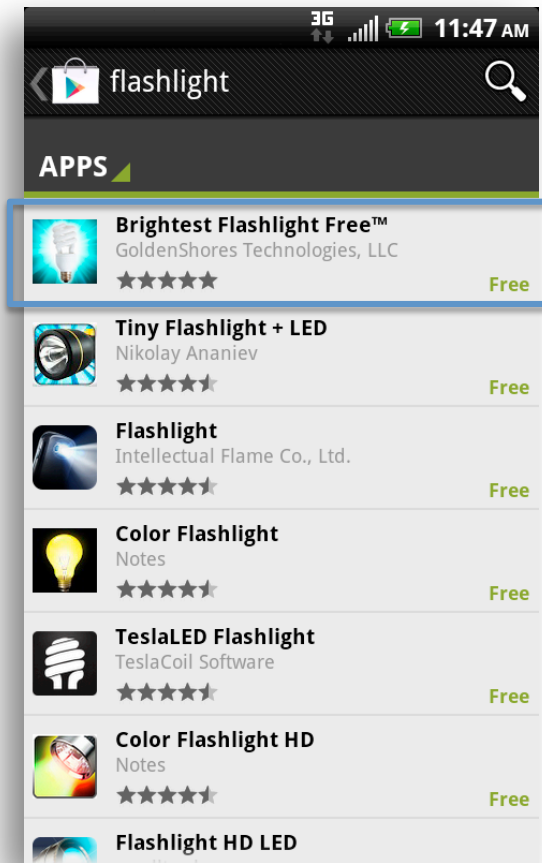
Ads in Applications

Market Search Results



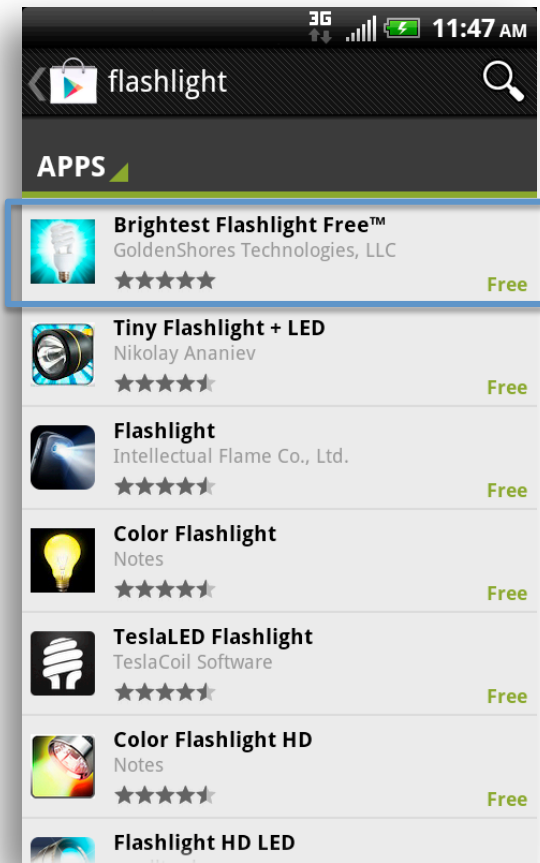
Ads in Applications

Market Search Results

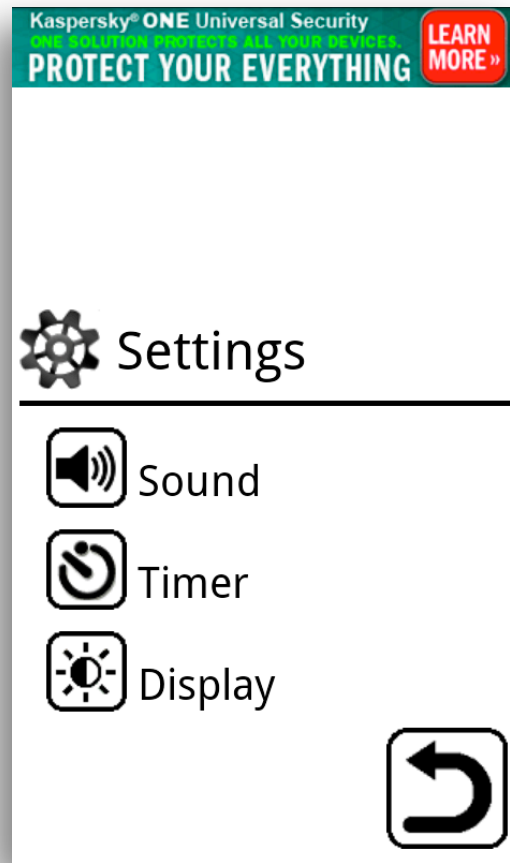


Ads in Applications

Market Search Results

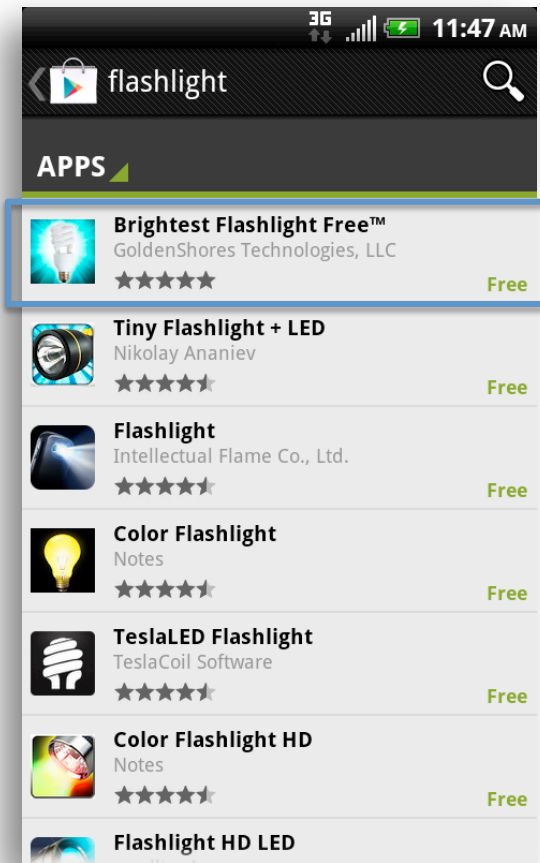


Brightest Flashlight App

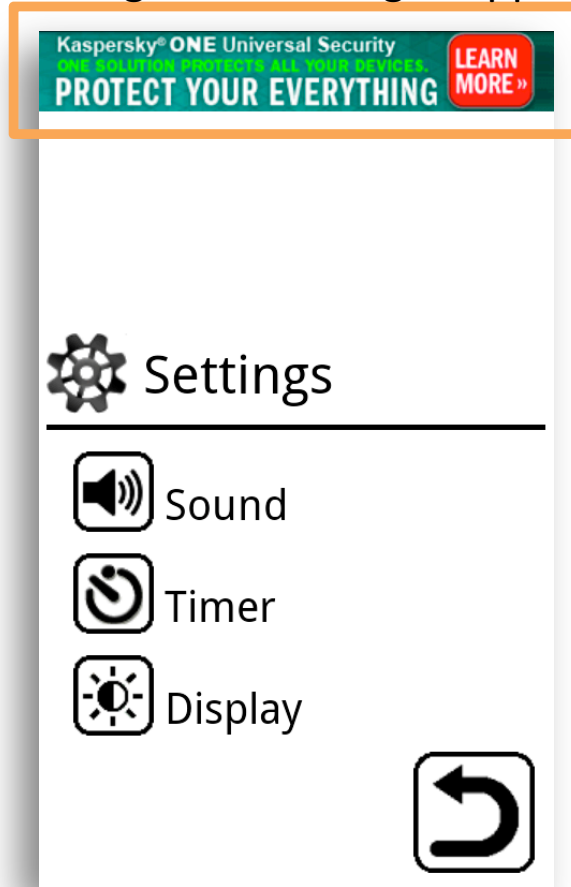


Ads in Applications

Market Search Results



Brightest Flashlight App



Ads in Applications

Market Search Results

3G 11:47 AM

flashlight

APPS

- 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 App

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Settings

- Sound
- Timer
- Display

Android Browser

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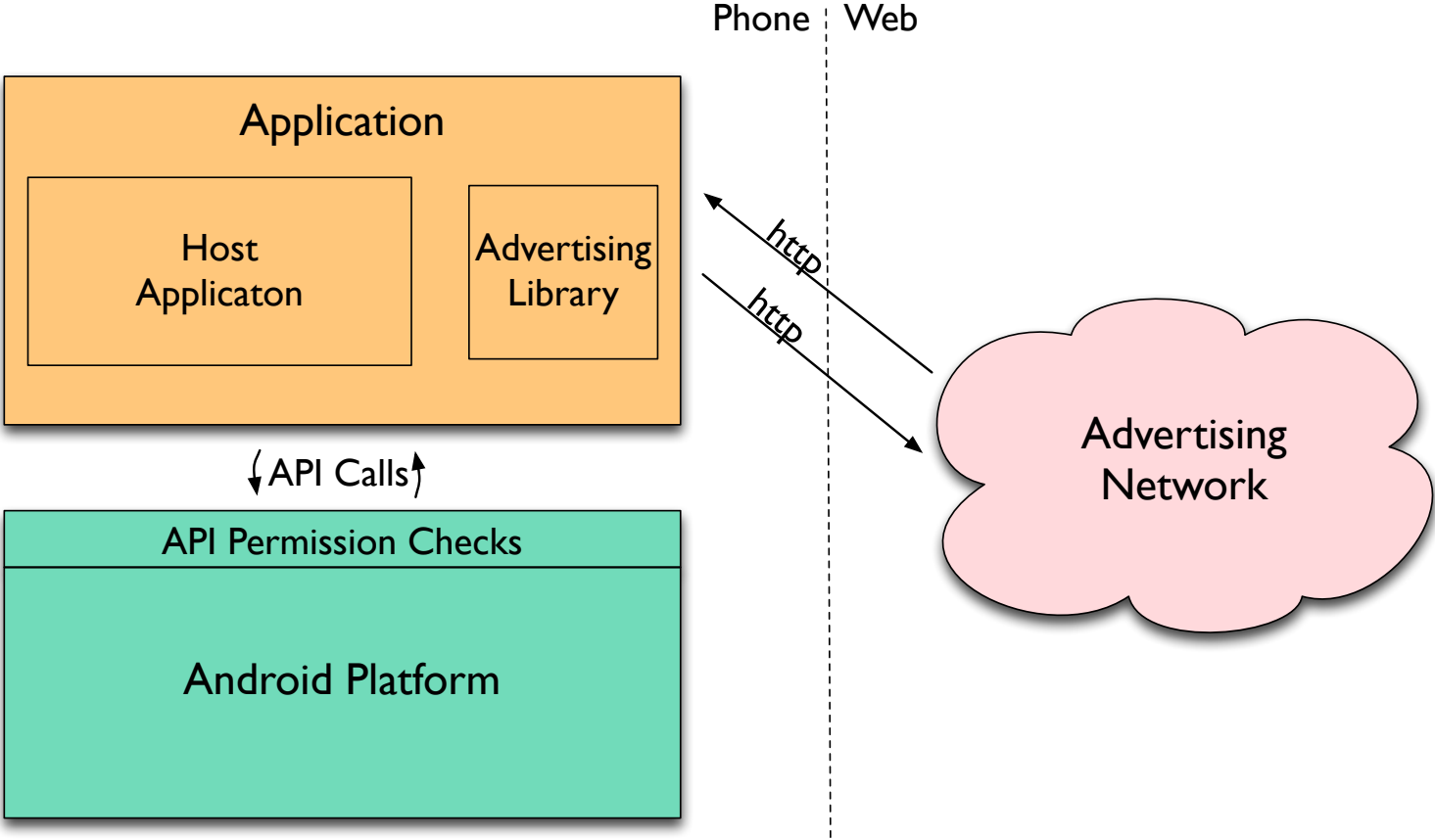
Android Permissions

- 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



WHAT CAN GO WRONG

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

	Percent of apps using at least 1 ad library	Total apps
Top Free Apps	50.4%	764
Top Paid Apps	16.0%	100
Recent Free Apps	72.0%	100

- 49% of applications in our dataset contain 1 or more advertising library

Measurement Results: Overprivilege

Permission to access	Percent of apps requesting permission only for ads	Total apps requesting
The Internet (INTERNET)	16.2%	809
Location (LOCATION)	33.5%	361
IMEI identifier (READ_PHONE_STATE)	12.8%	312
Network information (ACCESS_NETWORK_STATE)	9.1%	395

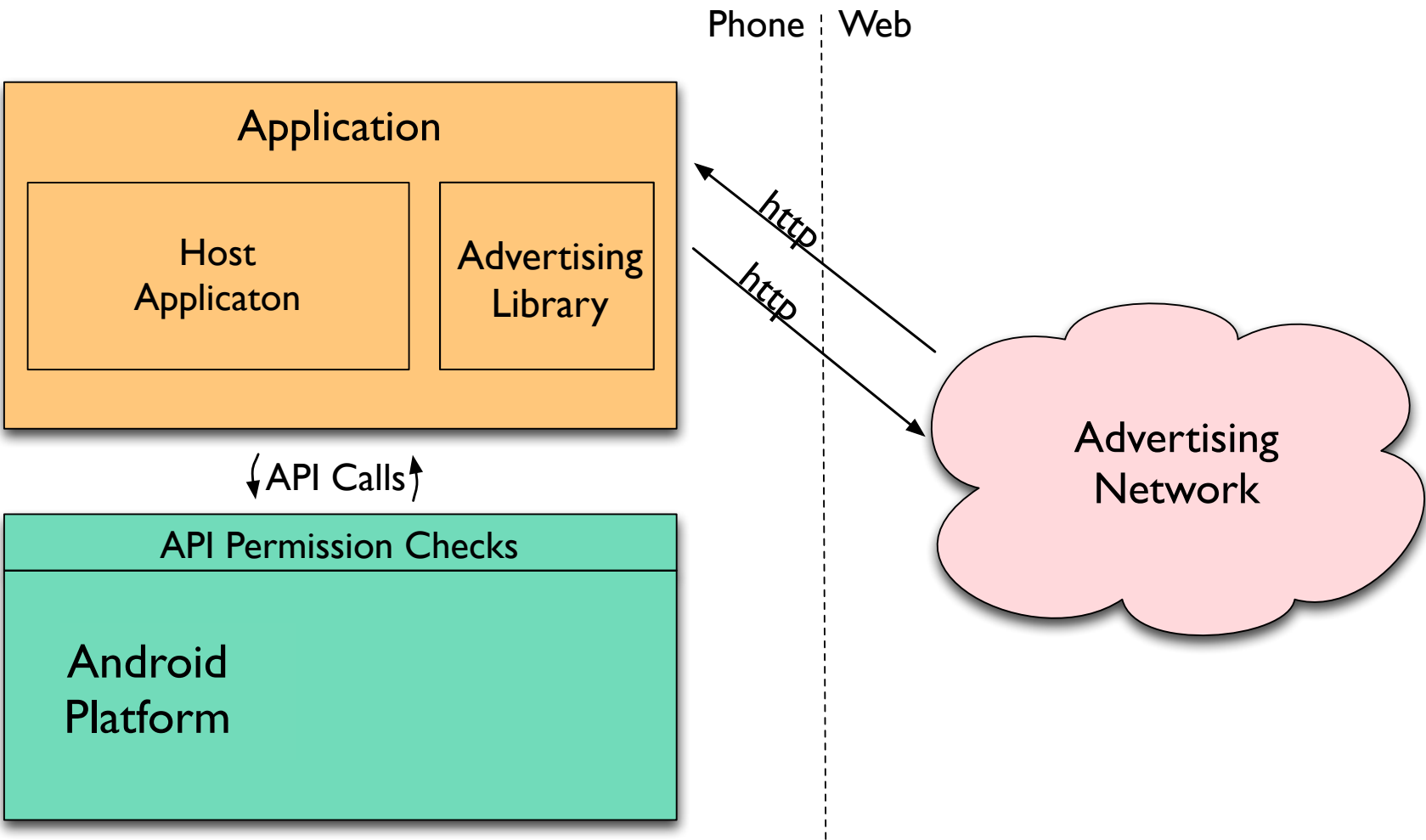
- Advertising libraries overprivilege:
 - 46% of applications with advertisements
 - 28% of all apps
- Breakdown of applications that use location **only** for advertising
 - 56% of ad-supported applications
 - 34% of all applications

ADDROID: A SOLUTION TO OVERPRIVILEGING

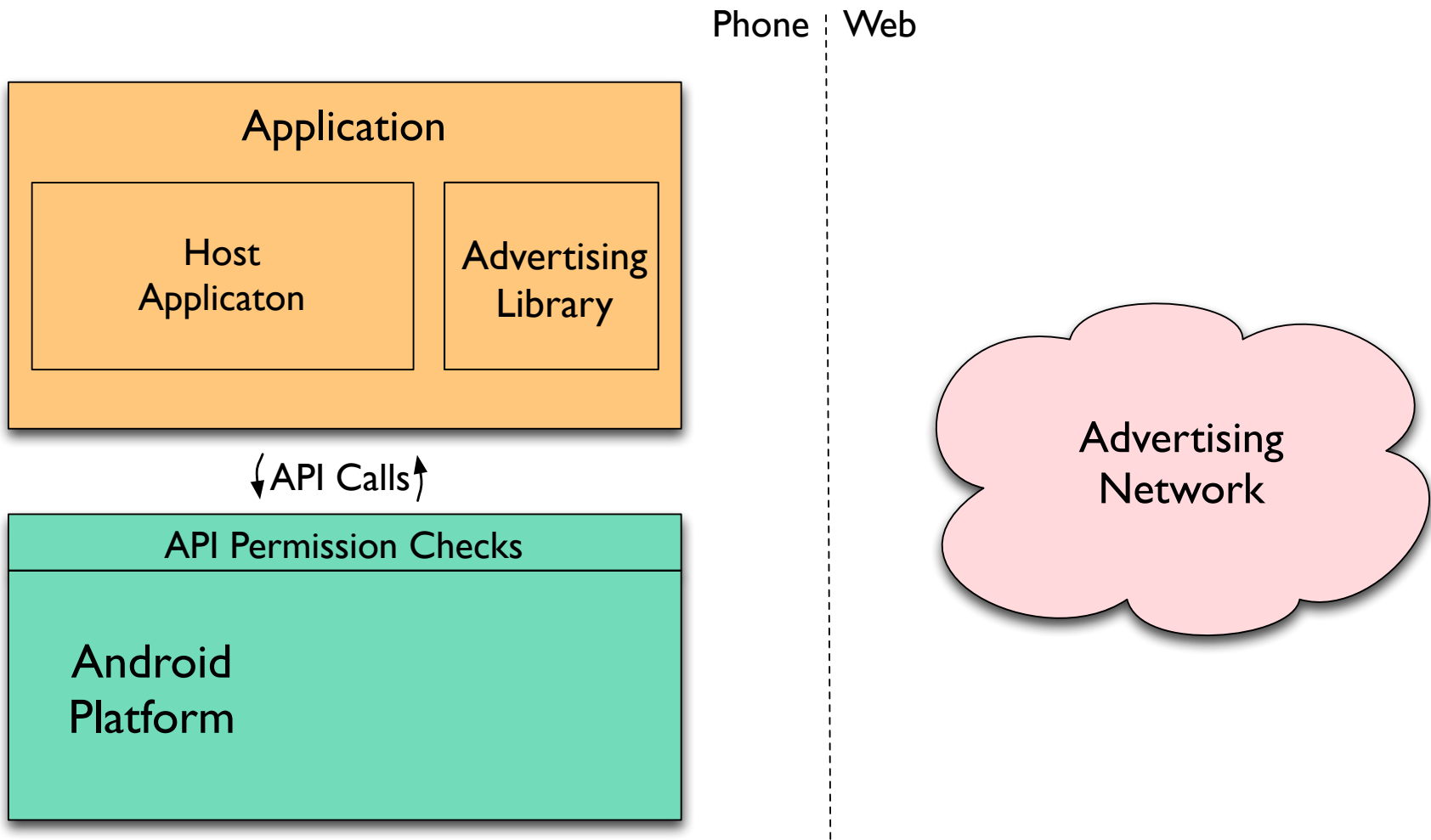
Design Overview

- **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**

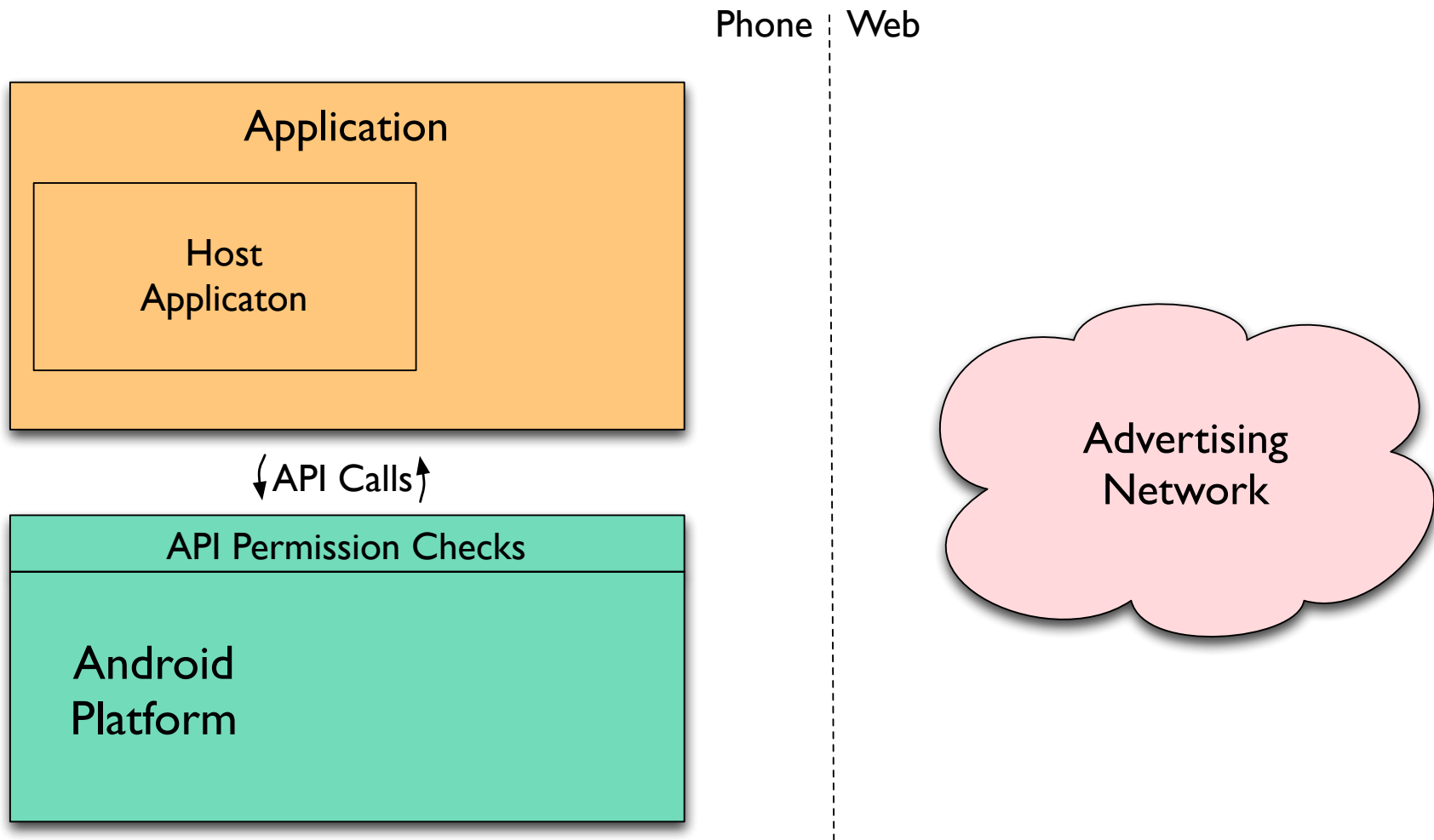
AdDroid Design



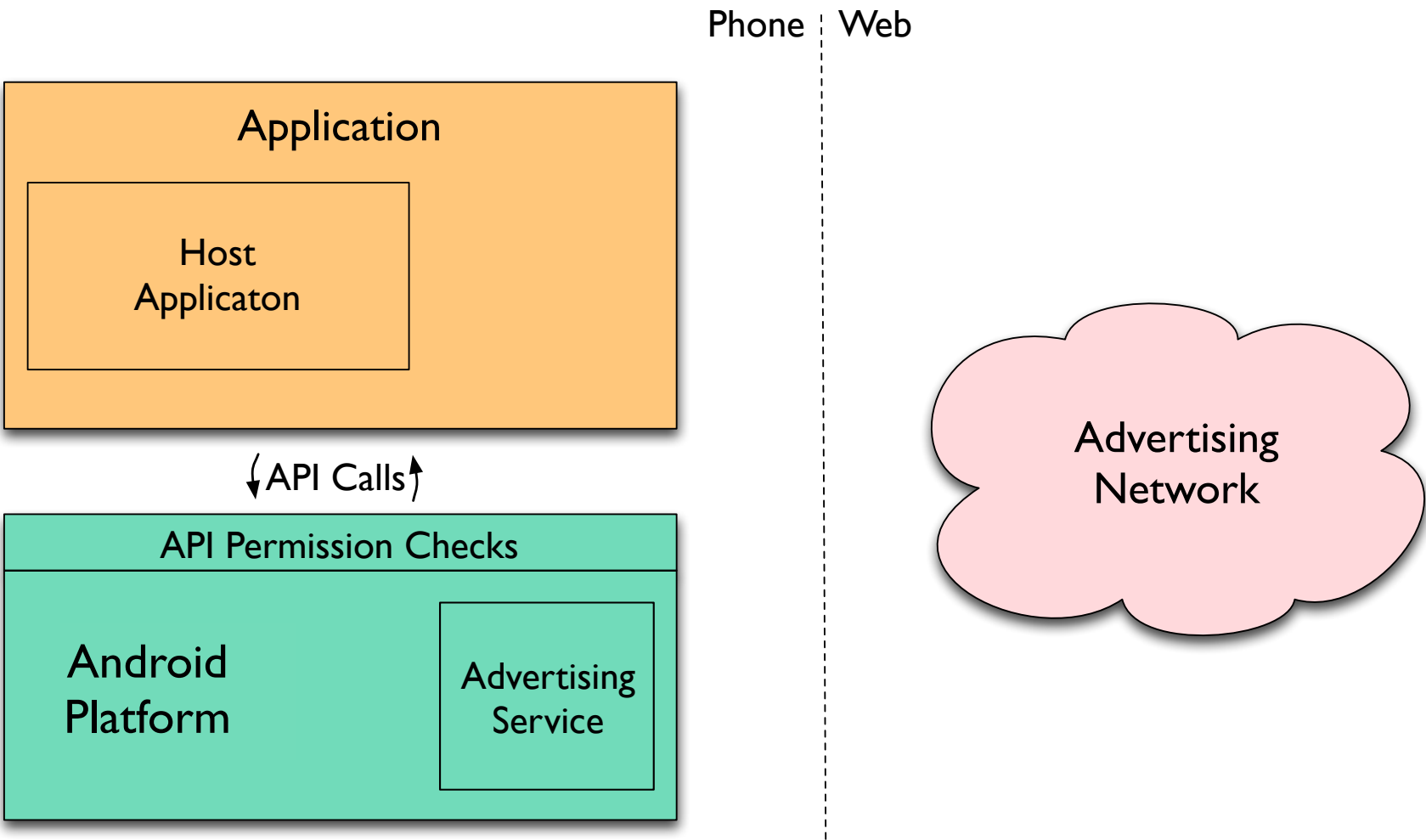
AdDroid Design



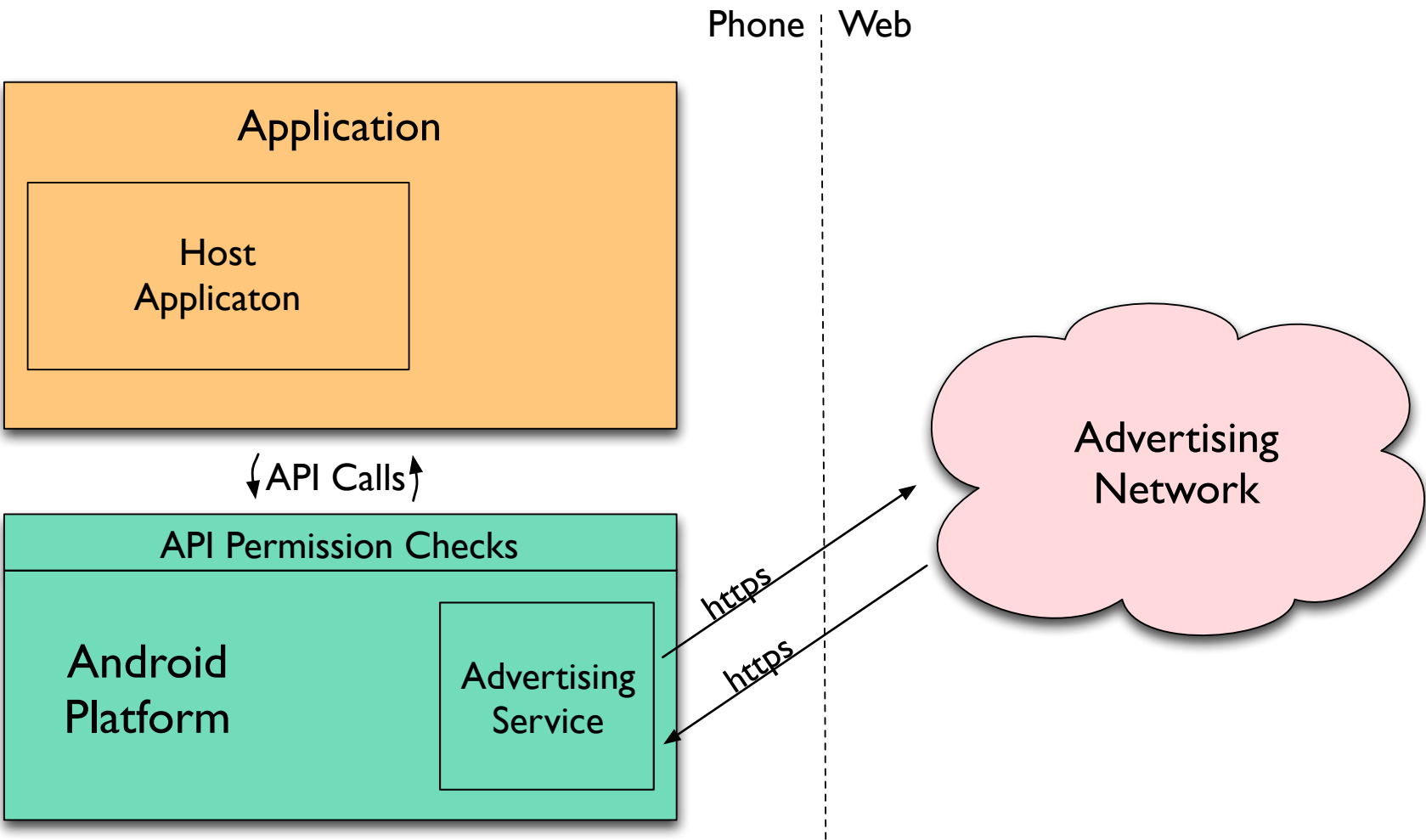
AdDroid Design



AdDroid Design

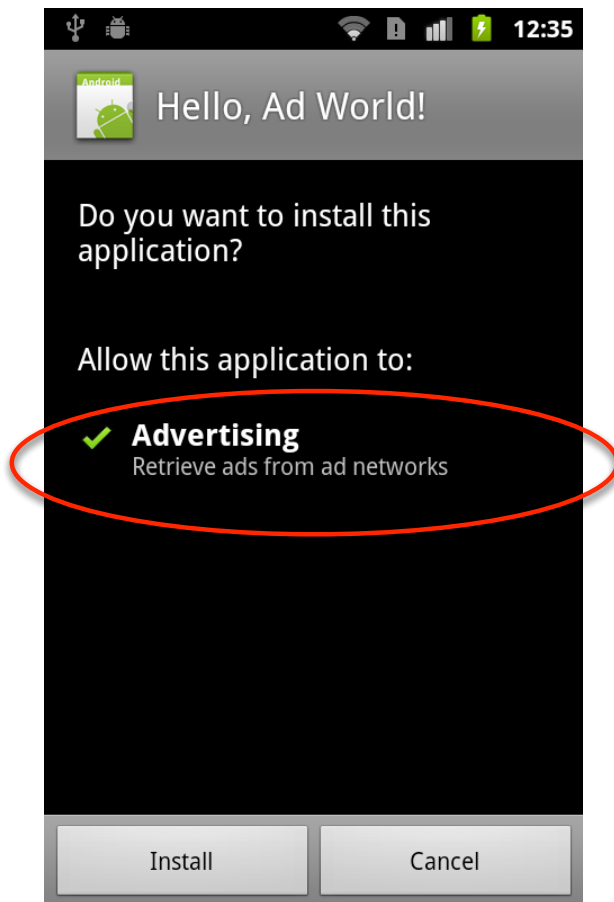


AdDroid Design

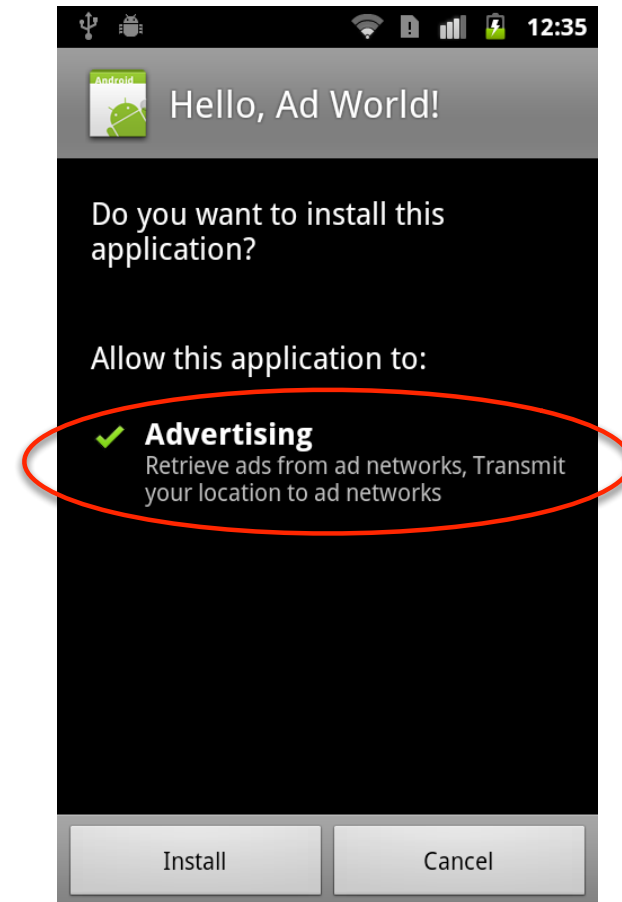


New Permissions

Advertising



Location based Advertising



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

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?**