CSE 484 / CSE M 584: Computer Security and Privacy

Mobile Platform Security

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Roadmap

- Mobile malware
- Mobile platforms vs. traditional platforms
- Deep dive into Android

Mobile Malware: Threat Modeling

Q1: How might malware authors get malware onto phones?

Q2: What are some goals that mobile device malware authors might have, or technical attacks they might attempt? How might this differ from desktop settings?

What can go wrong?

"Threat Model" 1: Malicious applications

Over 60% of Android malware steals your money via premium SMS, hides in fake forms of popular apps

By Emil Protalinski, Friday, 5 Oct '12 , 05:50pm

Android flashlight app tracks users via GPS, FTC says hold on

By Michael Kassner in IT Security, December 11, 2013, 9:49 PM PST

What can go wrong?

Threat Model 1: Malicious applications

Example attacks:

- Premium SMS messages
- Track location
- Record phone calls
- Log SMS
- Steal data
- Phishing

Some of these are unique to phones (SMS, rich sensor data)

What can go wrong?

Threat Model 2: Vulnerable applications

Example concerns:

- User data is leaked or stolen
  - (on phone, on network, on server)
- Application is hijacked by an attacker

Why All These Problems?

Not because smartphone OS designers don't care about security…

Background: Before Mobile Platforms

Assumptions in traditional OS (e.g., Unix) design:

1. There may be multiple users who don't trust each other.
2. Once an application is installed, it's (more or less) trusted.

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```
FranziBook:Desktop franzi$ whoami
franzi

FranziBook:Desktop franzi$ id
uid=501(franzi) gid=20(staff) groups=20(staff),401(com.apple.sharepoint.group.1),5
02(access_bpf),12(everyone),61(localaccounts),79(_appserverusr),80(admin),81(_apps
erveradm),98(_lpadmin),33(_appstore),100(_lpoperator),204(_developer),395(com.appl
e.access_ftp),398(com.apple.access_screensharing),399(com.apple.access_ssh)

FranziBook:Desktop franzi$ ls -l hello.txt
-rw-r--r--  1 franzi  staff  0 Nov 29 10:08 hello.txt

FranziBook:Desktop franzi$ chmod 700 hello.txt
FranziBook:Desktop franzi$ ls -l hello.txt
-rwx------  1 franzi  staff  0 Nov 29 10:08 hello.txt
```

Background: Before Mobile Platforms

Assumptions in traditional OS (e.g., Unix) design:

1. There may be multiple users who don't trust each other.
2. **Once an application is installed, it's (more or less) trusted.**

Apps can do anything the UID they're running under can do.

What's Different about Mobile Platforms?

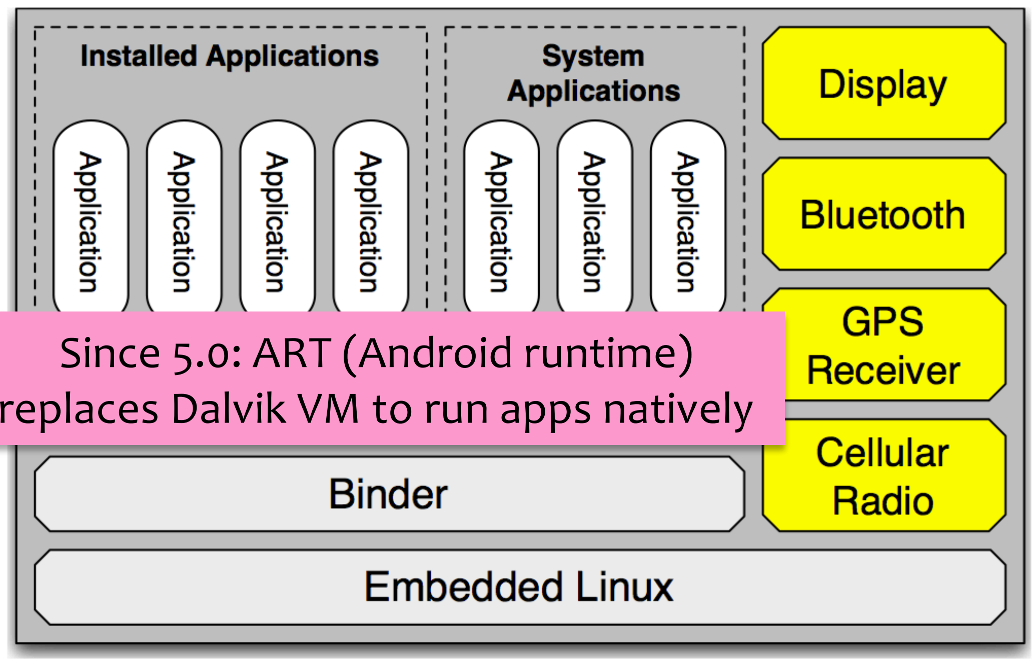
- Applications are **isolated**
  - Each runs in a separate execution context
  - No default access to file system, devices, etc.
  - **Different than traditional OSes** where multiple applications run with the same user permissions!

- **App Store:** approval process for applications
  - Market: Vendor controlled/Open
  - App signing: Vendor-issued/self-signed
  - User approval of permissions

More Details: Android

[Enck et al.]

- Based on Linux
- Application sandboxes
  - Applications run as separate UIDs, in separate processes.
  - Memory corruption errors only lead to arbitrary code execution in the context of the **particular** application, not complete system compromise!
  - (Can still escape sandbox – but must compromise Linux kernel to do so.) ← allows rooting



Since 5.0: ART (Android runtime) replaces Dalvik VM to run apps natively

Rooting and Jailbreaking

- Allows user to run applications with root privileges
  - e.g., modify/delete system files, app management, CPU management, network management, etc.
- Done by exploiting vulnerability in firmware to install `su` binary.
- Double-edged sword…

- Note: iOS is more restrictive than Android
  - Doesn't allow "side-loading" apps, etc.

Challenges with Isolated Apps

So mobile platforms isolate applications for security, but…

1. Permissions: How can applications access sensitive resources?
2. Communication: How can applications communicate with each other?

(1) Permission Granting Problem

Smartphones (and other modern OSes) try to prevent such attacks by limiting applications' access to:

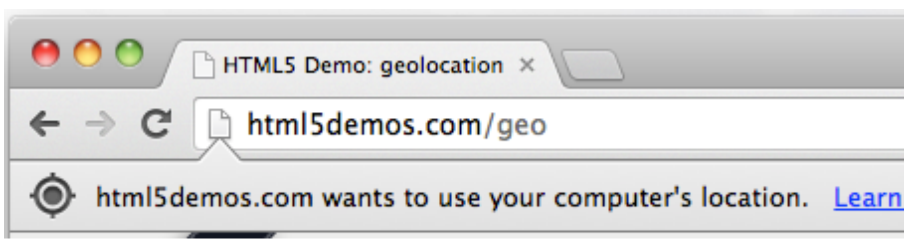
- System Resources (clipboard, file system).
- Devices (camera, GPS, phone, …).

How should operating system grant permissions to applications?

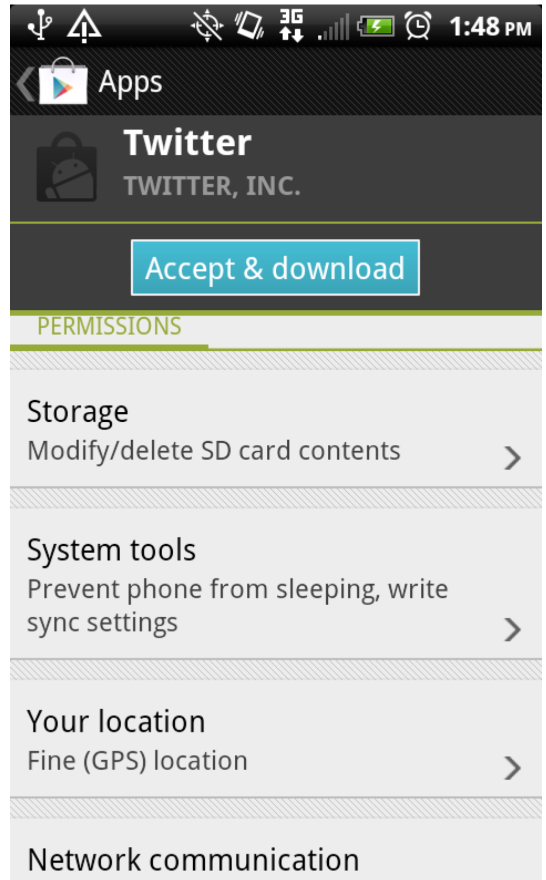
Standard approach: Ask the user.

State of the Art

Prompts (time-of-use)



Manifests (install-time)



State of the Art

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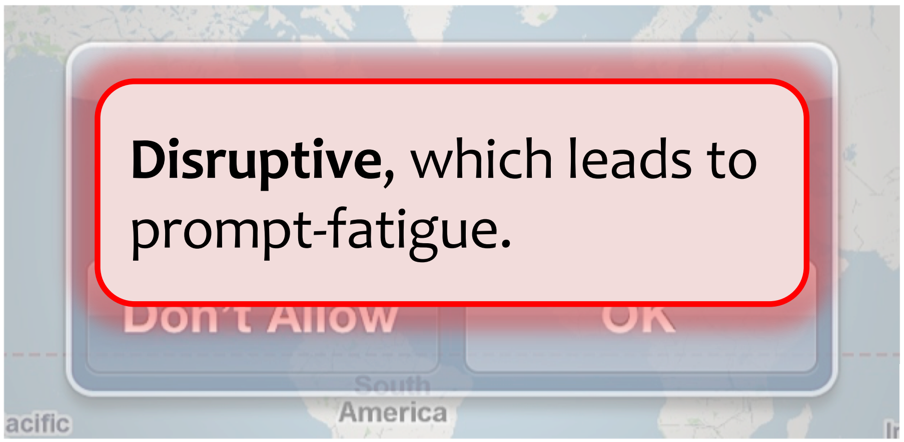
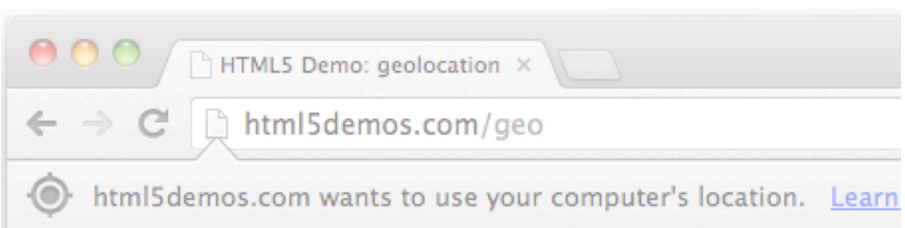


Disruptive, which leads to prompt-fatigue.



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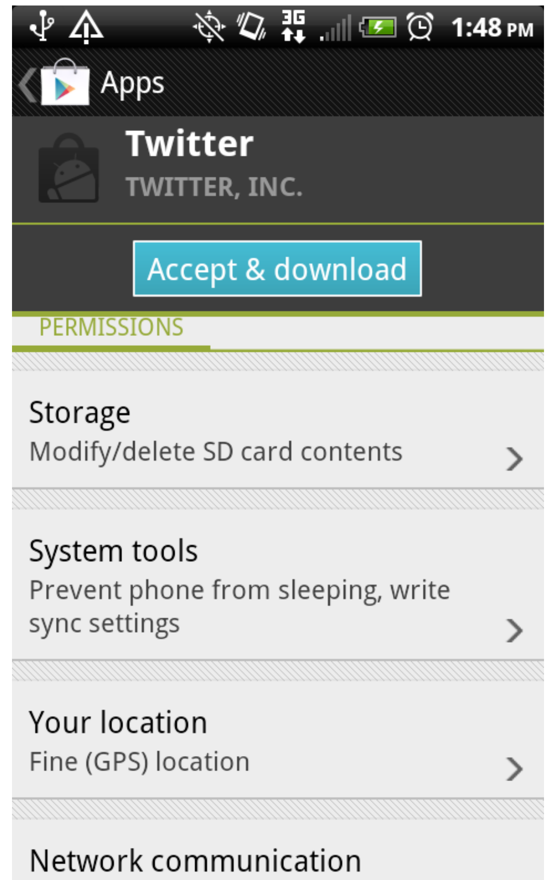

State of the Art

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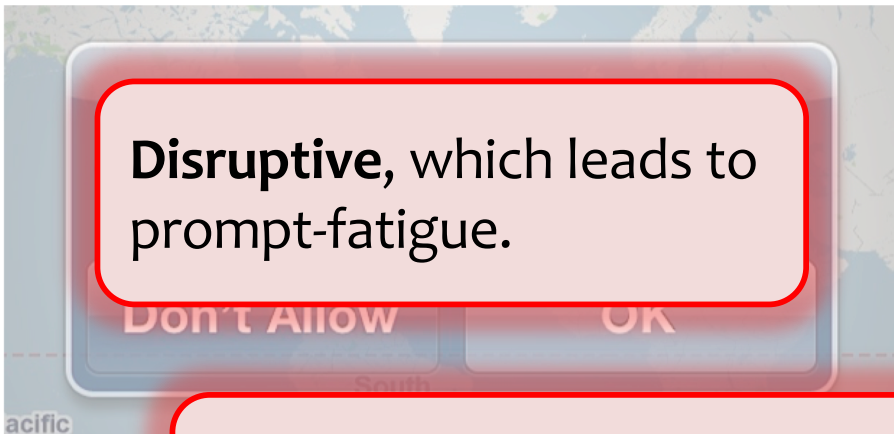

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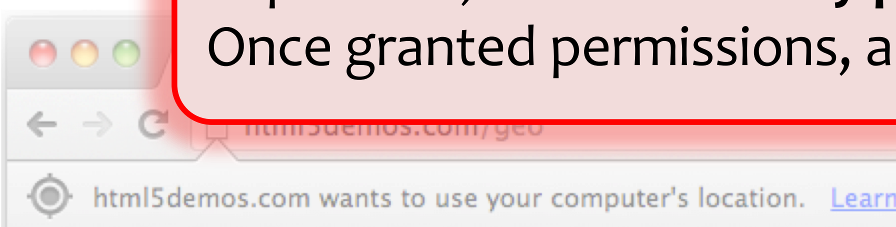

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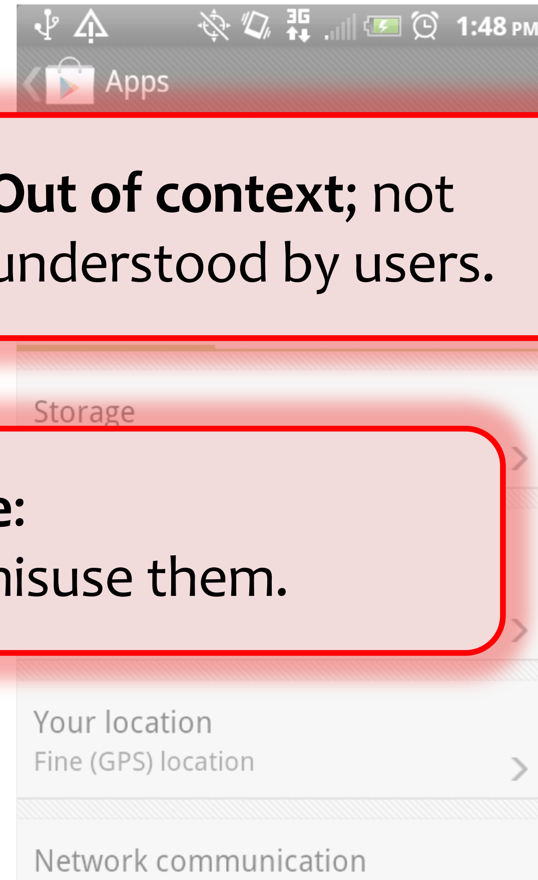


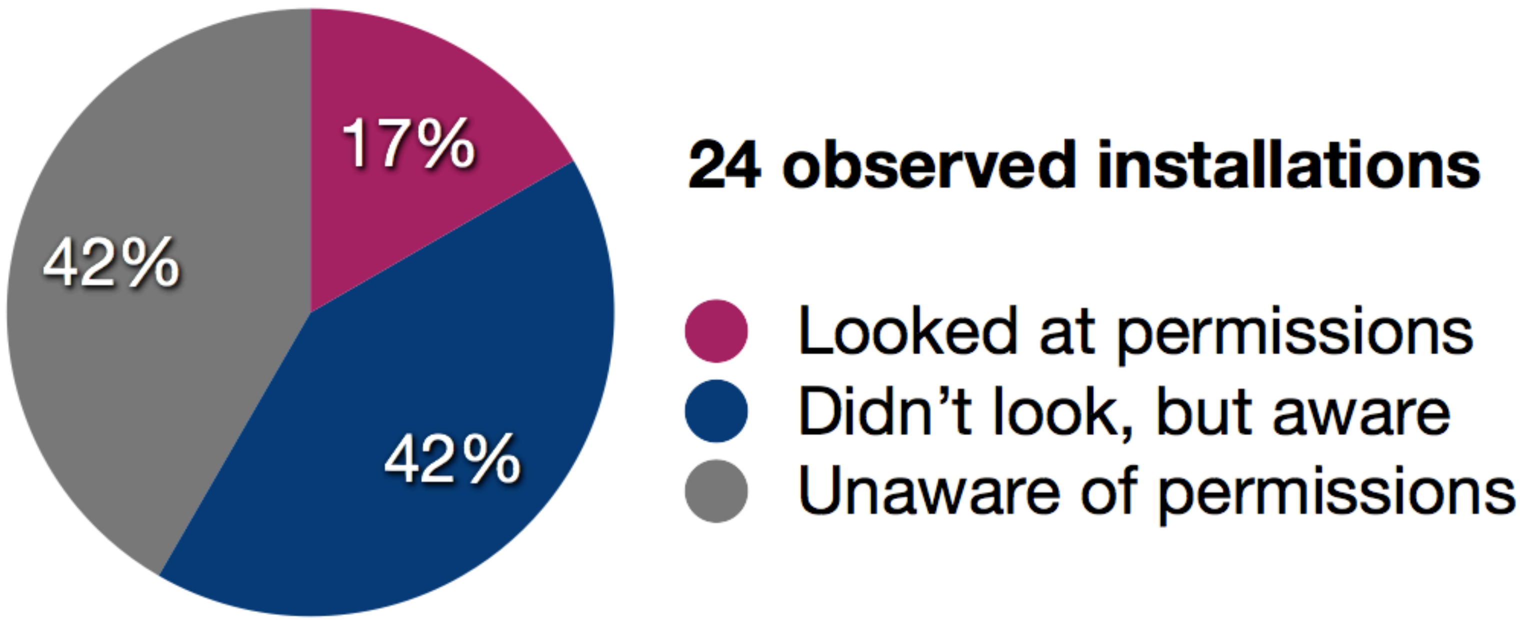
Out of context; not understood by users.

In practice, both are **overly permissive:**
Once granted permissions, apps can misuse them.

[Felt et al.]

Are Manifests Usable?

Do users pay attention to permissions?



… but 88% of users looked at reviews.

[Felt et al.]

Are Manifests Usable?

Do users understand the warnings?

	Permission	n	Correct Answers	
1 Choice	READ_CALENDAR	101	46	45.5%
	CHANGE_NETWORK_STATE	66	26	39.4%
	READ_SMS$_1$	77	24	31.2%
	CALL_PHONE	83	16	19.3%
2 Choices	WAKE_LOCK	81	27	33.3%
	WRITE_EXTERNAL_STORAGE	92	14	15.2%
	READ_CONTACTS	86	11	12.8%
	INTERNET	109	12	11.0%
	READ_PHONE_STATE	85	4	4.7%
	READ_SMS$_2$	54	12	22.2%
4	CAMERA	72	7	9.7%

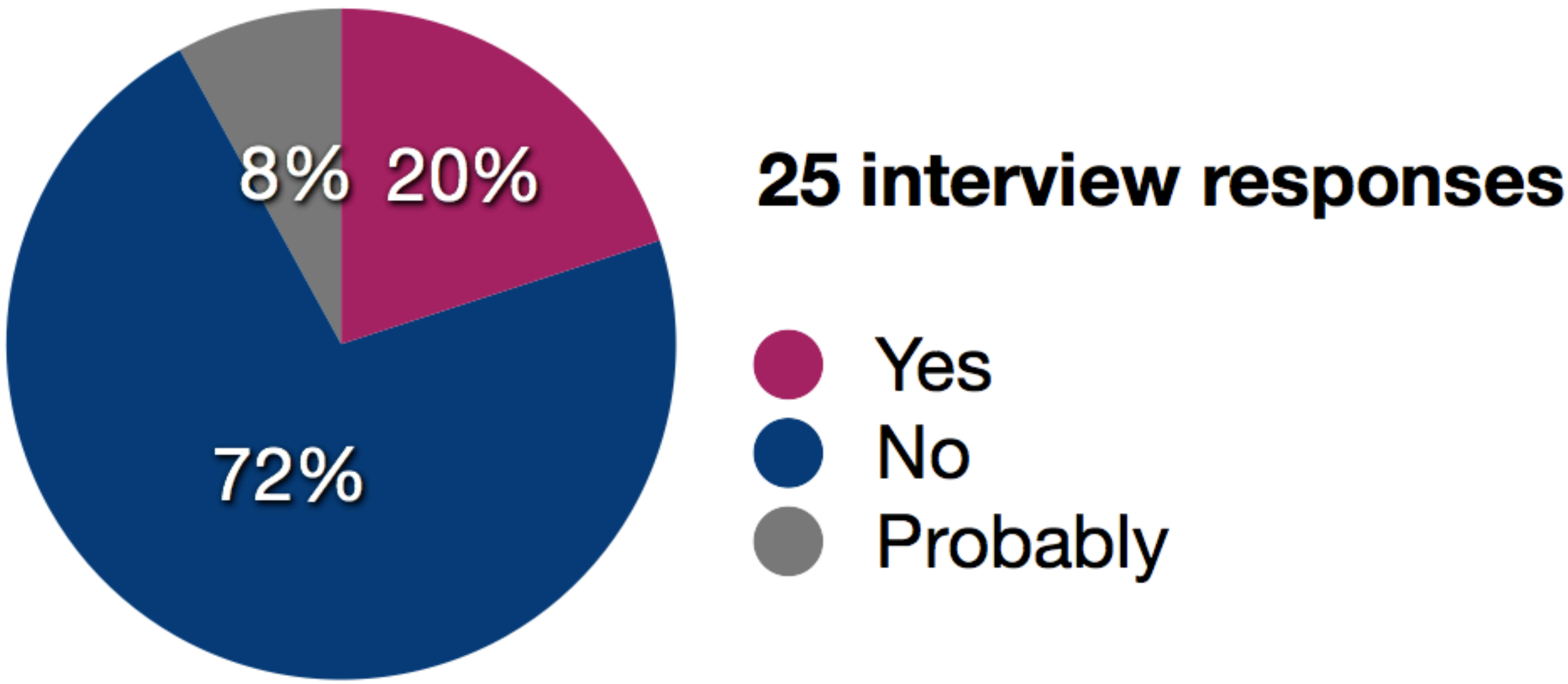
Table 4: The number of people who correctly answered a question. Questions are grouped by the number of correct choices. n is the number of respondents. (Internet Survey, $n = 302$)

[Felt et al.]

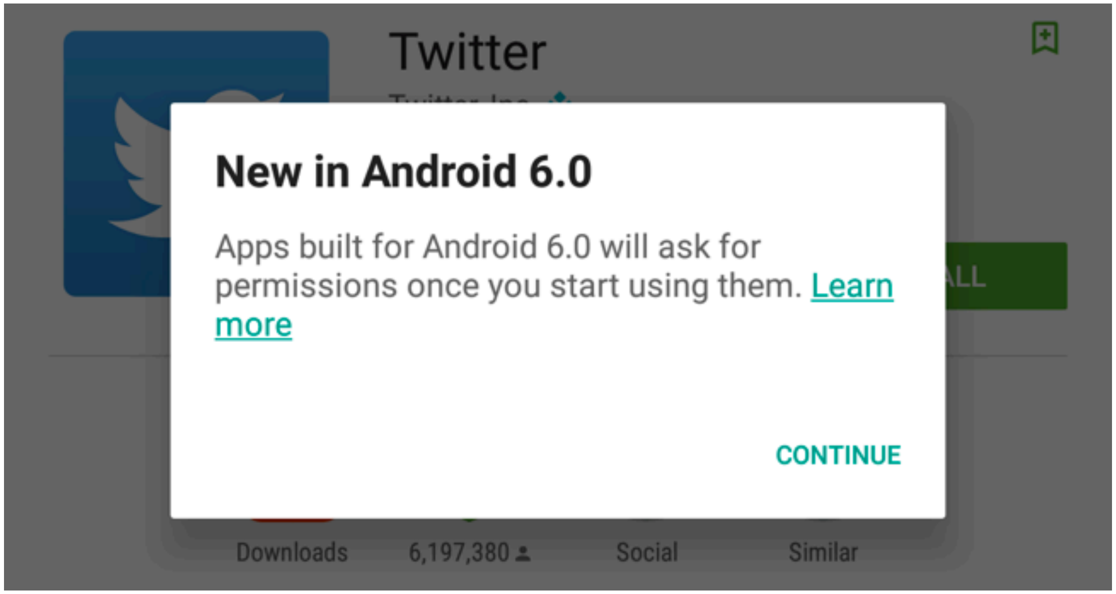
Are Manifests Usable?

Do users act on permission information?

"Have you ever not installed an app because of permissions?"



Android 6.0: Prompts!



- First-use prompts for sensitive permission (like iOS).
- Big change! Now app developers needed to check for permissions or catch exceptions.

(2) Inter-Process Communication

- Primary mechanism in Android: Intents
  - Sent between application components
    - e.g., with `startActivity(intent)`
  - Explicit: specify component name
    - e.g., com.example.testApp.MainActivity
  - Implicit: specify action (e.g., ACTION_VIEW) and/or data (URI and MIME type)
    - Apps specify Intent Filters for their components.

[Chin et al.]

Eavesdropping and Spoofing

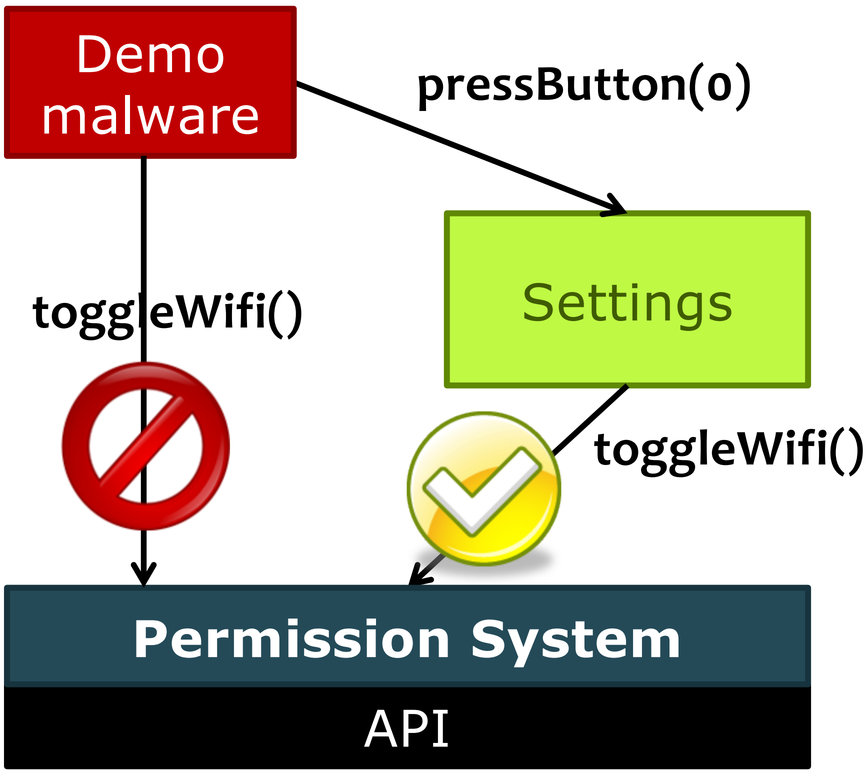
- Buggy apps might accidentally:
  - Expose their component-to-component messages publicly → eavesdropping
  - Act on unauthorized messages they receive → spoofing

[Felt et al.]

Permission Re-Delegation

- An application without a permission gains additional privileges through another application.

- Settings application is deputy: has permissions, and accidentally exposes APIs that use those permissions.



Aside: Incomplete Isolation

Embedded UIs and libraries always run with the host application's permissions! (No same-origin policy here…)

WIRED

Thousands of Android apps have old security flaws lurking inside

Apps with millions of downloads are using code libraries with vulnerabilities in them, including some created by Facebook, Alibaba and Yahoo

Other Android Security Features

- Secure hardware
- Full disk encryption
- Modern memory protections (e.g., ASLR, non-executable stack)
- Application signing
- App store review

Android Fragmentation

- Many different variants of Android (unlike iOS)
  - Motorola, HTC, Samsung, …
- Less secure ecosystem
  - Inconsistent or incorrect implementations
  - Slow to propagate kernel updates and new versions
  - (Working to address, e.g., **Project Treble**)

[https://developer.android.com/about/dashboards/index.html]

Version	Codename	API	Distribution
2.3.3 - 2.3.7	Gingerbread	10	1.0%
4.0.3 - 4.0.4	Ice Cream Sandwich	15	0.8%
4.1.x	Jelly Bean	16	3.2%
4.2.x		17	4.6%
4.3		18	1.3%
4.4	KitKat	19	18.8%
5.0	Lollipop	21	8.7%
5.1		22	23.3%
6.0	Marshmallow	23	31.2%
7.0	Nougat	24	6.6%
7.1		25	0.5%

Data collected during a 7-day period ending on May 2, 2017.
Any versions with less than 0.1% distribution are not shown.

What about iOS?

- Apps are sandboxed
- Encrypted user data
  - Often in the news…
- App Store review process is (was? maybe?) stricter
  - But not infallible: e.g., see Wang et al. “Jekyll on iOS: When Benign Apps Become Evil” (USENIX Security 2013)
- No “sideloading” apps
  - Unless you jailbreak

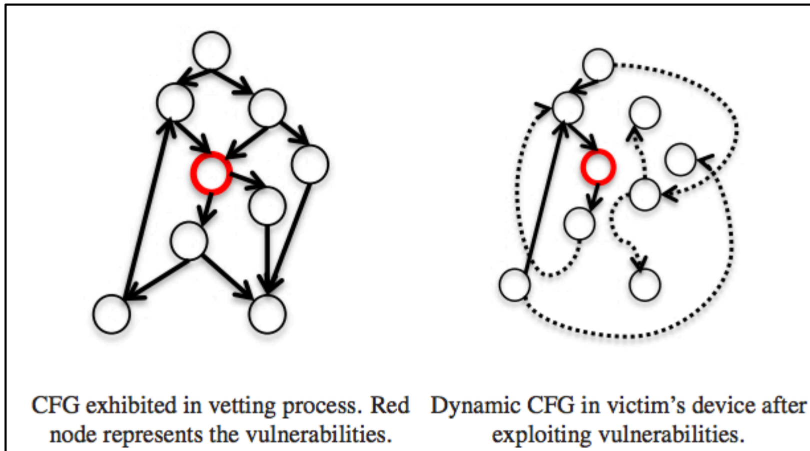


Figure 1: High Level Intuition