CSE 484 / CSE M 584: Computer Security and Privacy

Mobile Platform Security [finish]

Spring 2017

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Thanks to Dan Boneh, Dieter Gollmann, Dan Halperin, Yoshi Kohno, Ada Lerner, John Manferdelli, John Mitchell, Vitaly Shmatikov, Bennet Yee, and many others for sample slides and materials ...

Admin

- Feedback on project checkpoints
- Lab 3 is out **(due June 2, 8pm)**
  - Android security
  - 3 parts
  - You should not need to write a lot of code
  - Don't procrastinate on getting an Android development environment set up!
    - (Took us ~15 minutes, but **just in case…**)

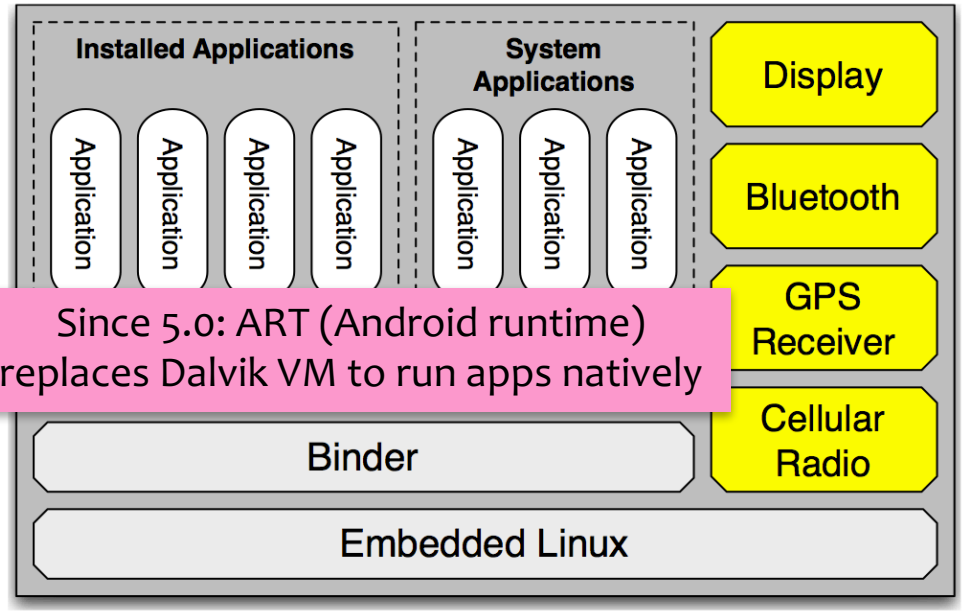
What's Different about Mobile Platforms?

- 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.]



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

- 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

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.

Android Applications

- Activities provide user interfaces.
- Services run in the background.
- BroadcastReceivers receive messages sent to multiple applications (e.g., BOOT_COMPLETED).
- ContentProviders are databases addressable by their application-defined URIs.

- AndroidManifest.xml
  - Specifies application components
  - Specifies required permissions

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:

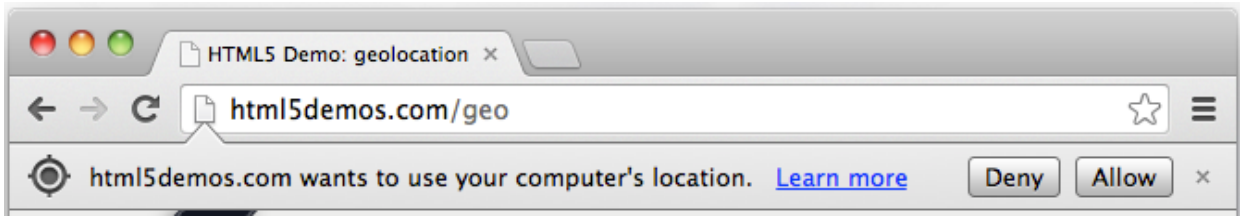
- System Resources (clipboard, file system).
- Devices (camera, GPS, phone, …).

How should operating system grant permissions to applications?

Standard approach: Ask the user.

State of the Art

Prompts (time-of-use)



State of the Art

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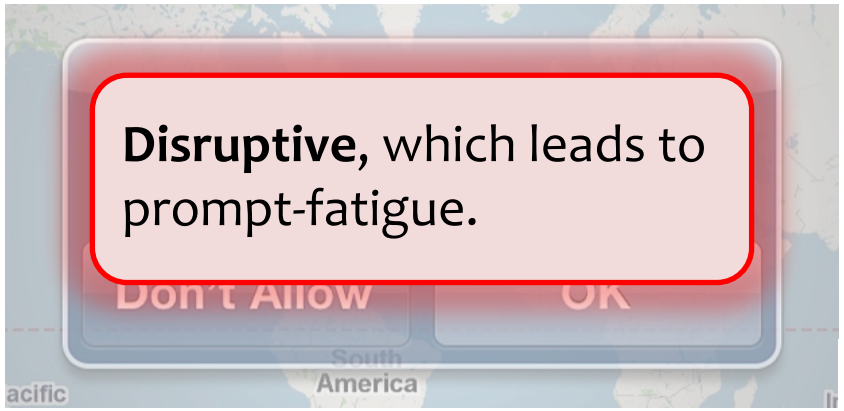
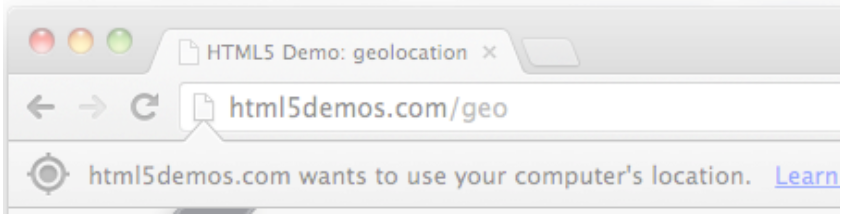
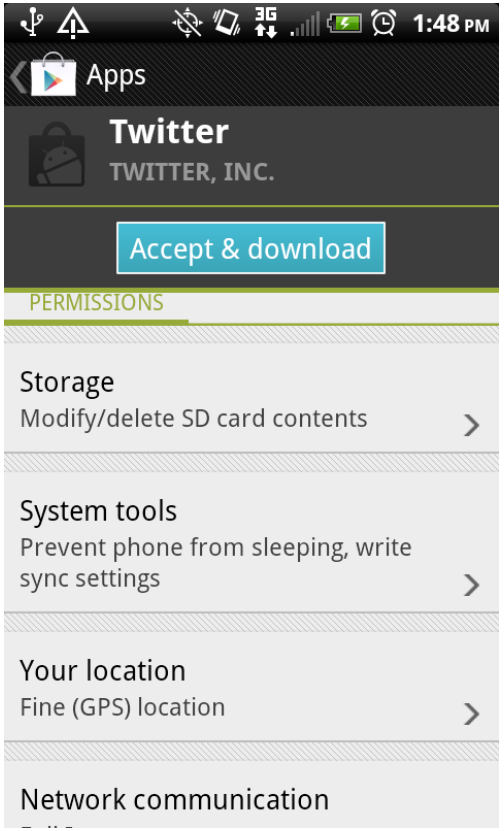


Disruptive, which leads to prompt-fatigue.



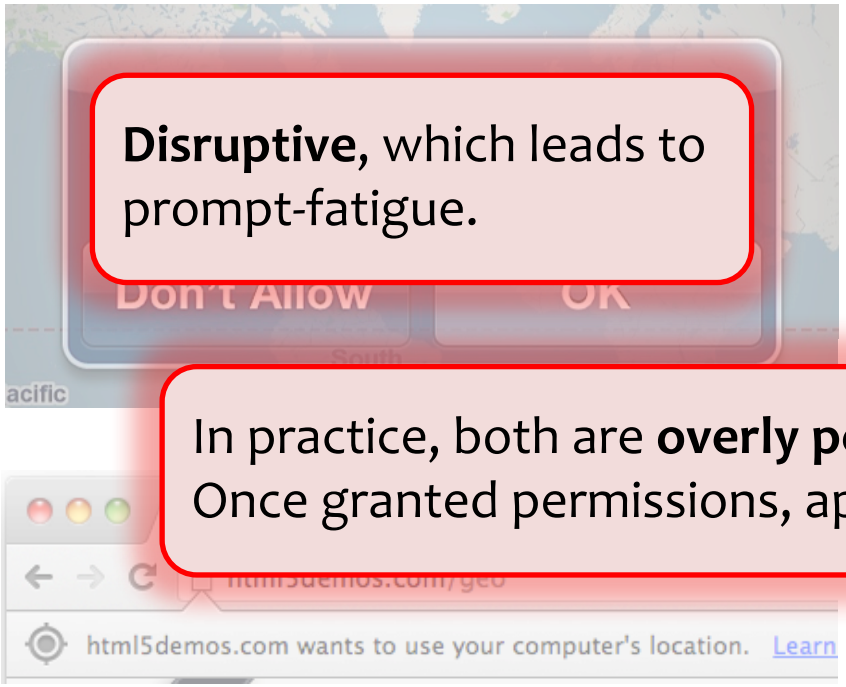
Manifests (install-time)

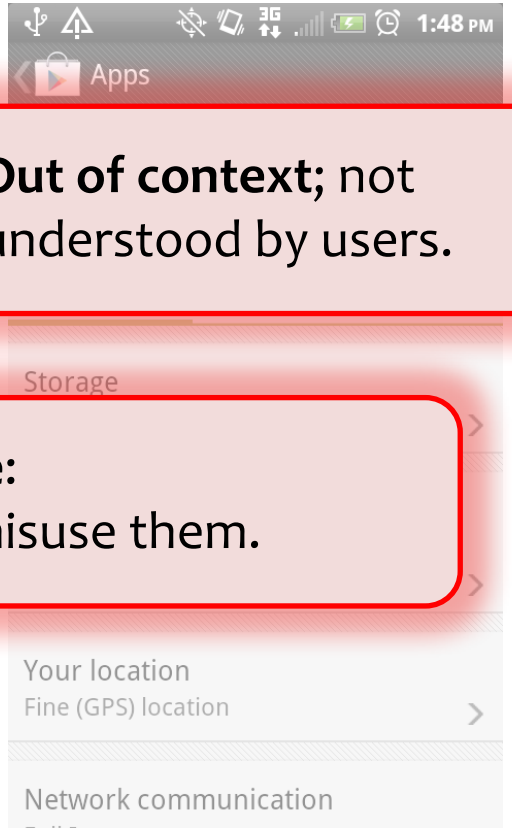


State of the Art

Prompts (time-of-use)

Manifests (install-time)





Disruptive, which leads to prompt-fatigue.

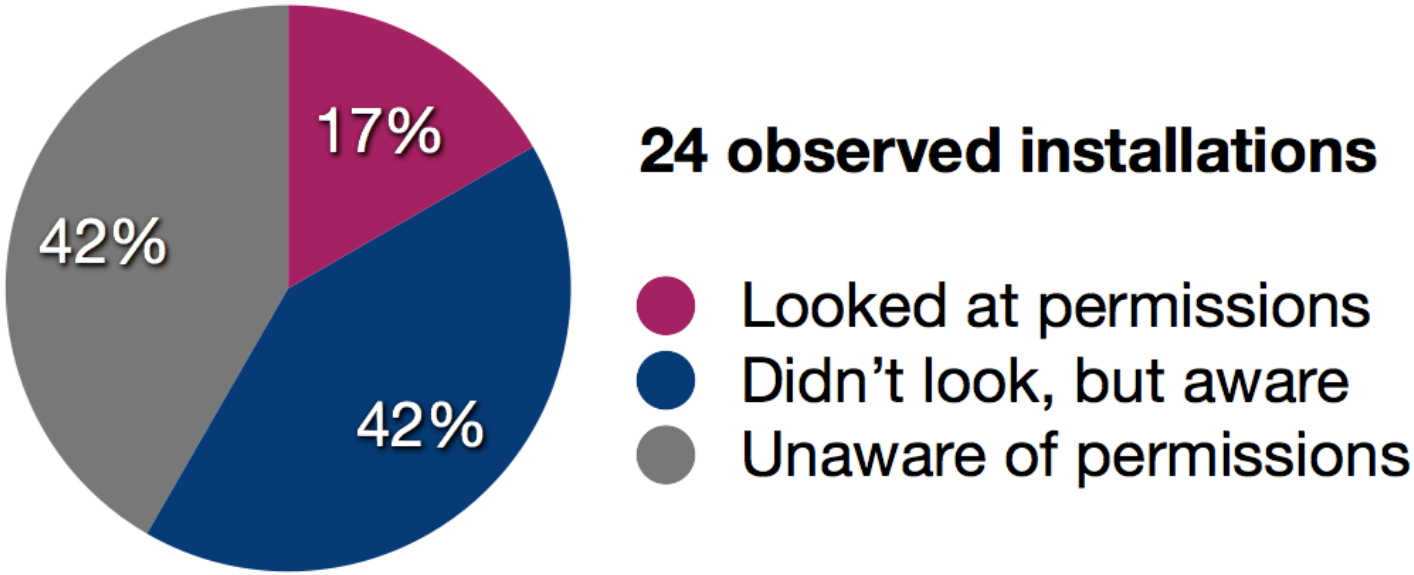
Out of context; not understood by users.

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%

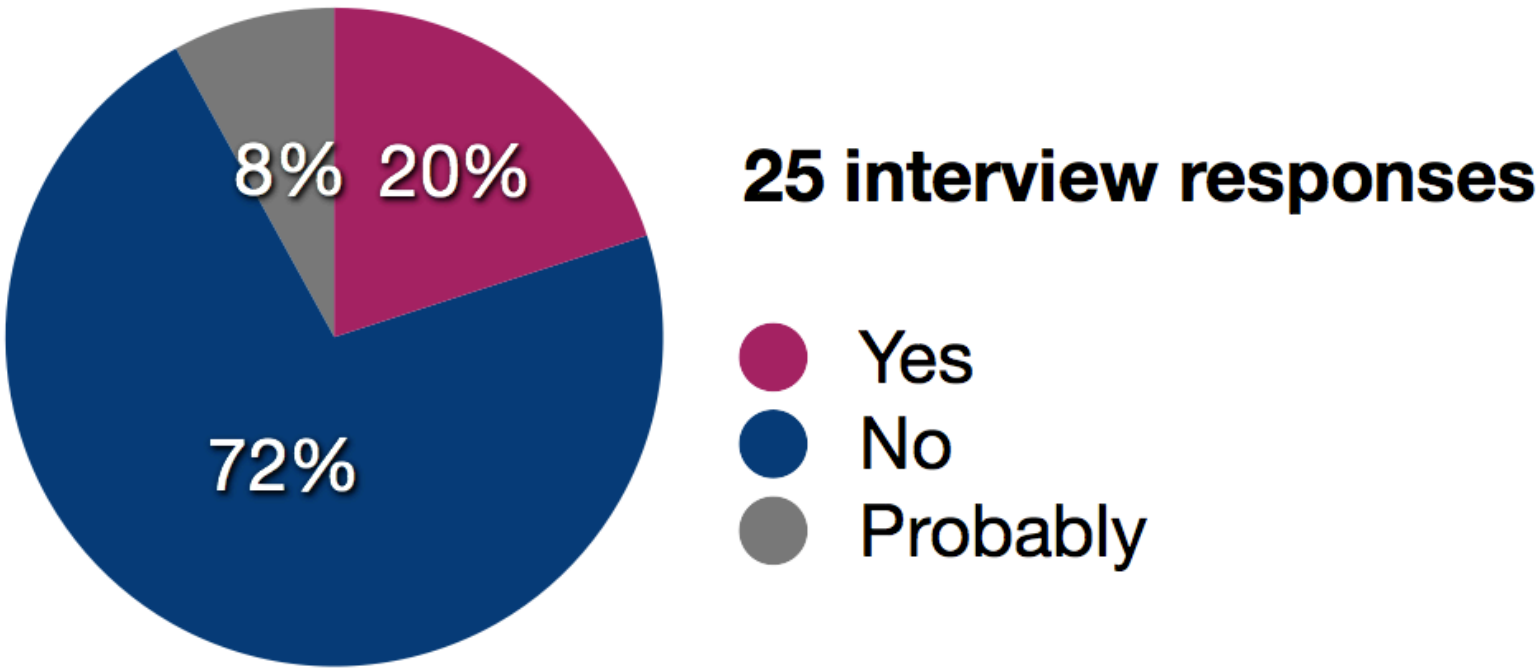
Table 4: The number of people who correctly answered a question. Questions are grouped by the number of correct choices. n is the number of respondents. (Internet Survey, $n = 302$)

[Felt et al.]

Are Manifests Usable?

Do users act on permission information?

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

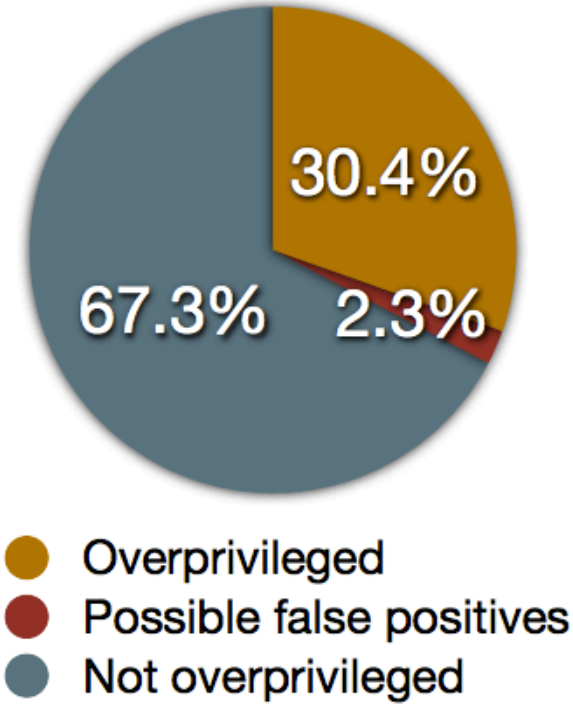


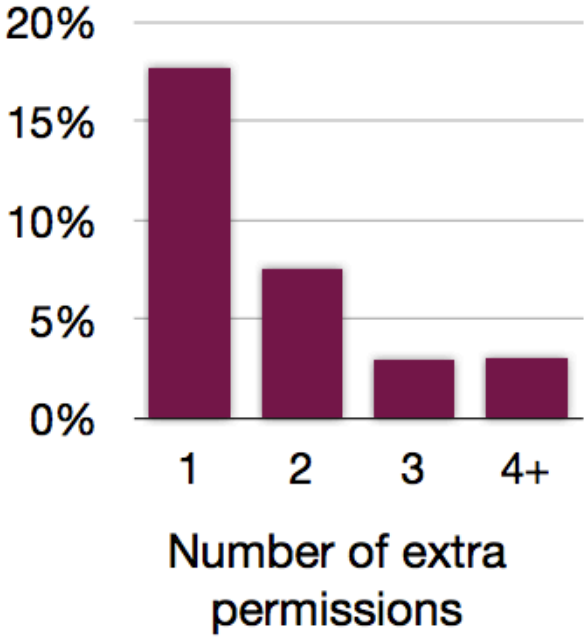
[Felt et al.]

Over-Permissioning

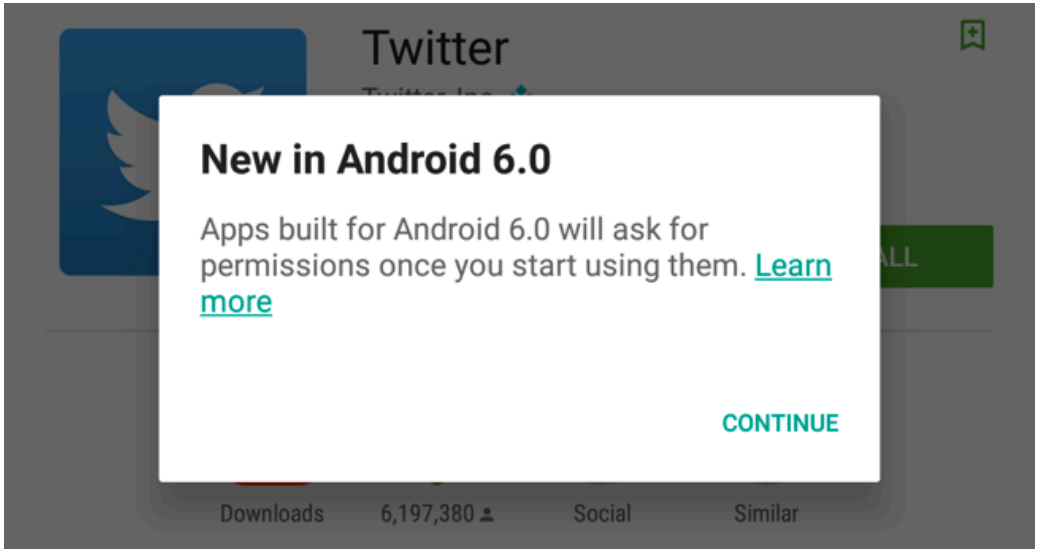
- Android permissions are badly documented.
- Researchers have mapped APIs → permissions.

www.android-permissions.org (Felt et al.), http://pscout.csl.toronto.edu (Au et al.)





Android 6.0: Prompts!

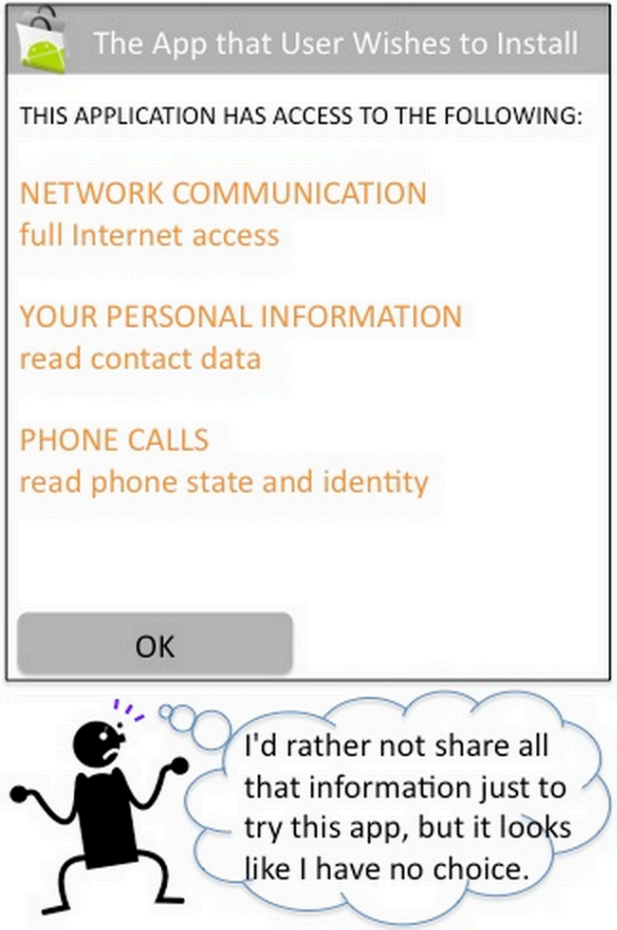


- First-use prompts for sensitive permission (like iOS).
- Big change! Now app developers need to check for permissions or catch exceptions.

[Hornyack et al.]

Improving Permissions: AppFence

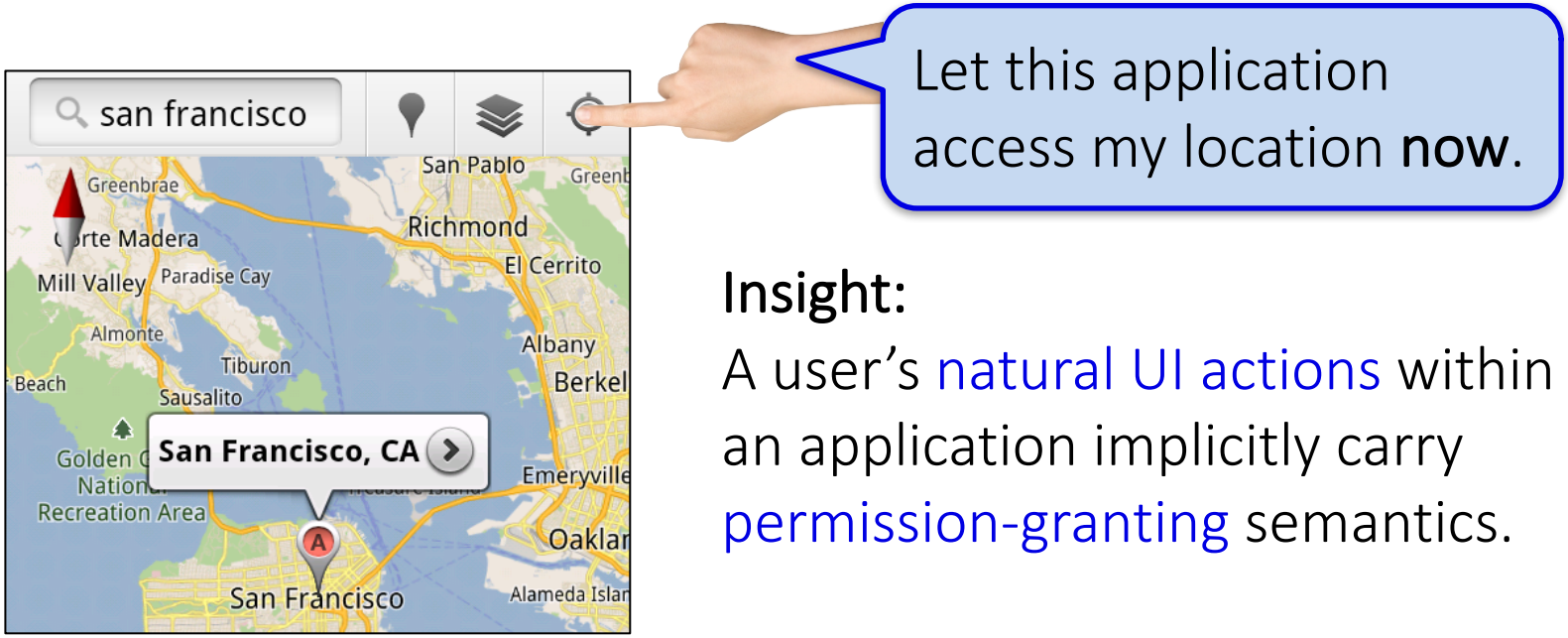
Today, ultimatums give app developers an unfair edge in obtaining permissions.



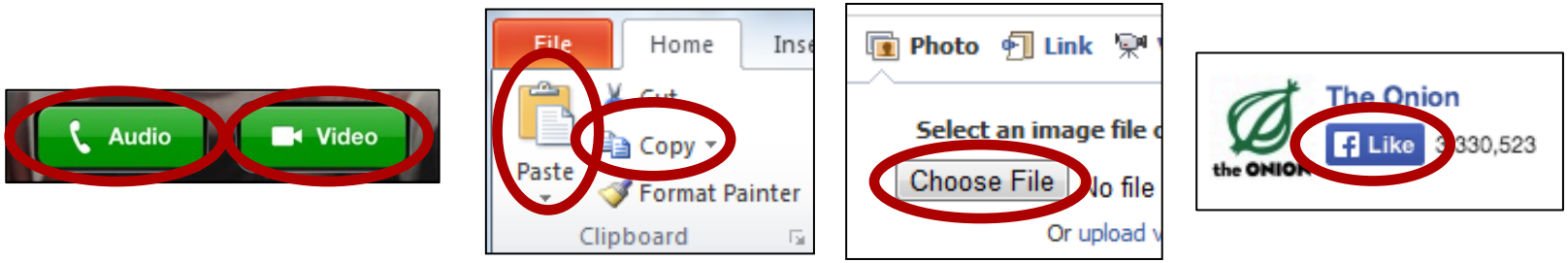
AppFence can enable new interfaces that give users control over the use of their info.

[our work]

Improving Permissions: User-Driven Access Control



Insight:
A user's natural UI actions within an application implicitly carry permission-granting semantics.



[our work]

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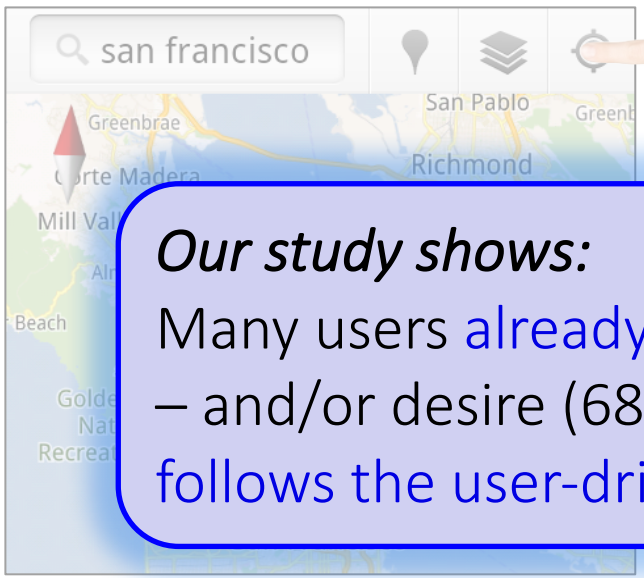
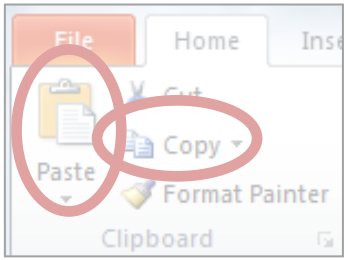
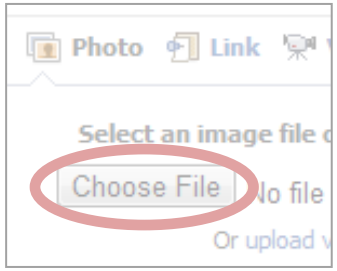


Let this application access my location **now**.

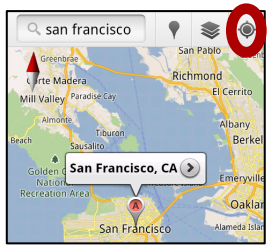
Our study shows:
Many users already believe (52% of 186) – and/or desire (68%) – that resource access follows the user-driven access control model.

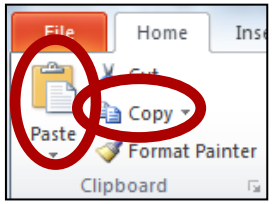
ns within
carry
antics.

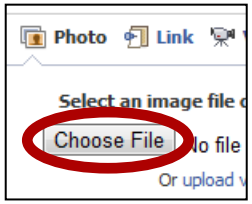




New OS Primitive: Access Control Gadgets (ACGs)







Approach: Make resource-related UI elements first-class operating system objects (access control gadgets).

- To receive resource access, applications must embed a system-provided ACG.
- ACGs allow the OS to capture the user's permission granting intent in application-agnostic way.

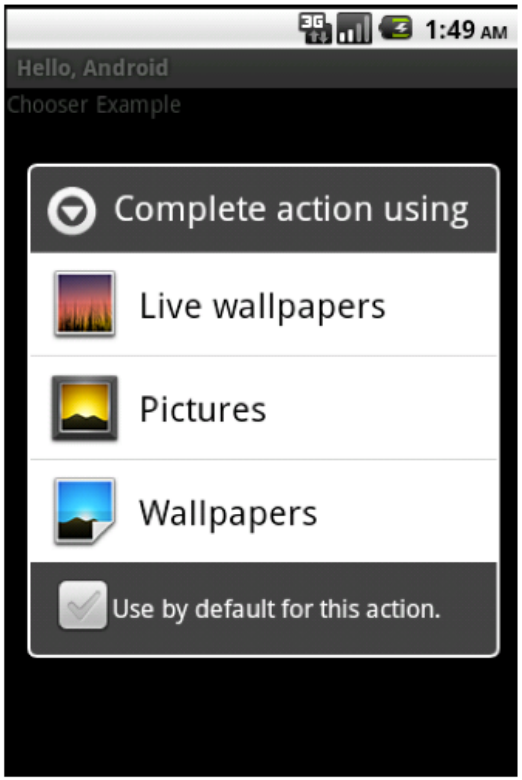
(2) Inter-Process Communication

- 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.]

Unauthorized Intent Receipt

- Attack #1: Eavesdropping / Broadcast Thefts
  - Implicit intents make intra-app messages public.
- Attack #2: Activity Hijacking
  - May not always work:
- Attack #3: Service Hijacking
  - Android picks one at random upon conflict!



[Chin et al.]

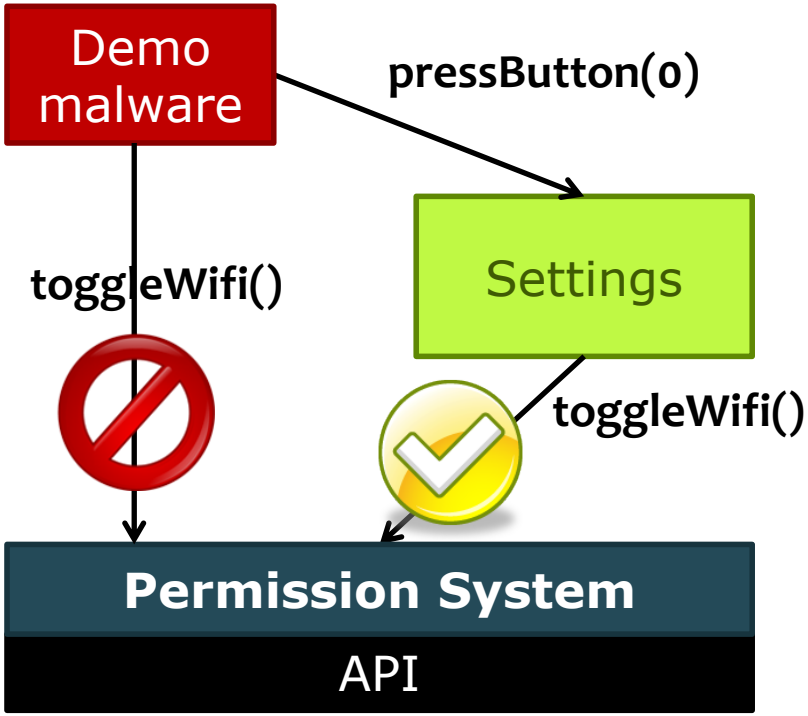
Intent Spoofing

- Attack #1: General intent spoofing
  - Receiving implicit intents makes component public.
  - Allows data injection.
- Attack #2: System intent spoofing
  - Can't directly spoof, but victim apps often don't check specific "action" in intent.

[Felt et al.]

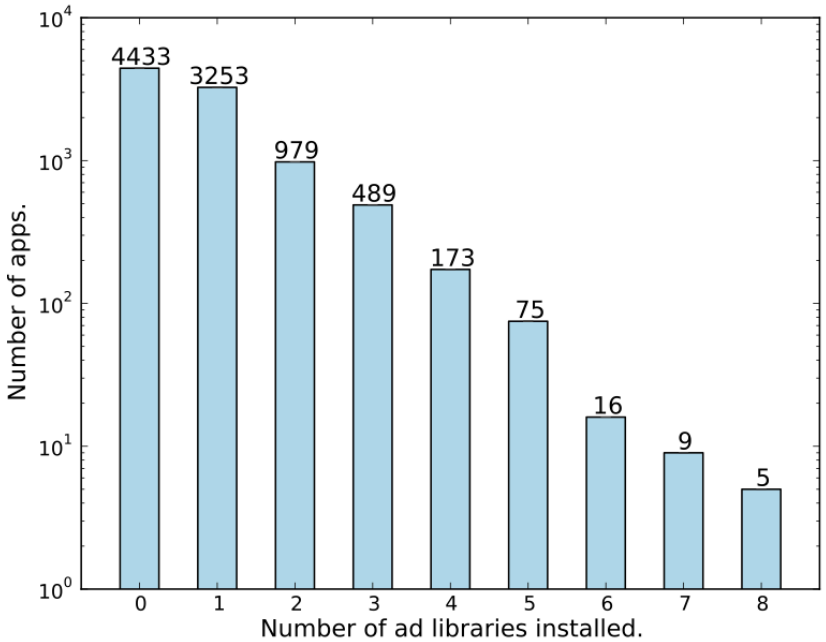
Permission Re-Delegation

- An application without a permission gains additional privileges through another application.
- Demo video
- 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…)



[Shekhar et al.]

Ad from ad library

Map from Google library

Social button from Facebook library

More on Android…

Android Application Signing

- Apps are signed
  - Often with self-signed certificates
  - Signed application certificate defines which user ID is associated with which applications
  - Different apps run under different UIDs
- Shared UID feature
  - Shared Application Sandbox possible, where two or more apps signed with same developer key can declare a shared UID in their manifest

Shared UIDs

- App 1: Requests GPS / camera access
- App 2: Requests Network capabilities

- Generally:
  - First app can't exfiltrate information
  - Second app can't exfiltrate anything interesting
- With Shared UIDs (signed with same private key)
  - Permissions are a superset of permissions for each app
  - App 1 can now exfiltrate; App 2 can now access GPS / camera

File Permissions

- Files written by one application cannot be read by other applications
  - Previously, this wasn't true for files stored on the SD card (world readable!) – Android cracked down on this
- It is possible to do full file system encryption
  - Key = Password/PIN combined with salt, hashed

Memory Management

- Address Space Layout Randomization to randomize addresses on stack
- Hardware-based No eXecute (NX) to prevent code execution on stack/heap
- Stack guard derivative
- Some defenses against double free bugs (based on OpenBSD's dmalloc() function)
- etc.

[See http://source.android.com/tech/security/index.html]

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

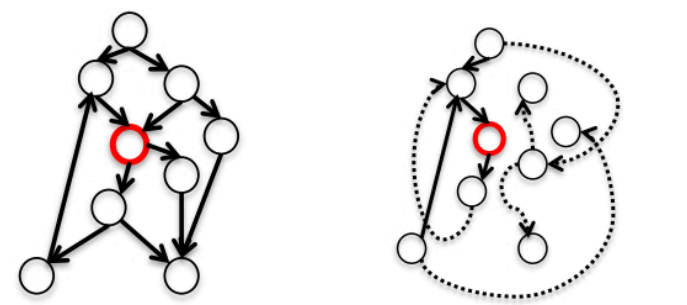
[https://developer.android.com/about/dashboards/index.html]

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
  - See recent news…
- App Store review process is (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



CFG exhibited in vetting process. Red node represents the vulnerabilities.

Dynamic CFG in victim's device after exploiting vulnerabilities.

Figure 1: High Level Intuition