CSE 484: Computer Security and Privacy

Mobile Devices

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Logistics

- FP Part A due today
  - We'll get feedback to you quickly on FP parts
  - Prioritizing these over other things

- We've seen a couple of different heap bugs people are running in to
  - Some of these are _existing_ bugs in tinyserv, you don't need to fix these
  - Buggy code tends to be buggy :/

Mobile devices

What is the difference?

- Mobile devices (smartphones)
- Tablets
- Laptops
- Desktops
- Servers

A surprising difference

Mobile security is *really really good*

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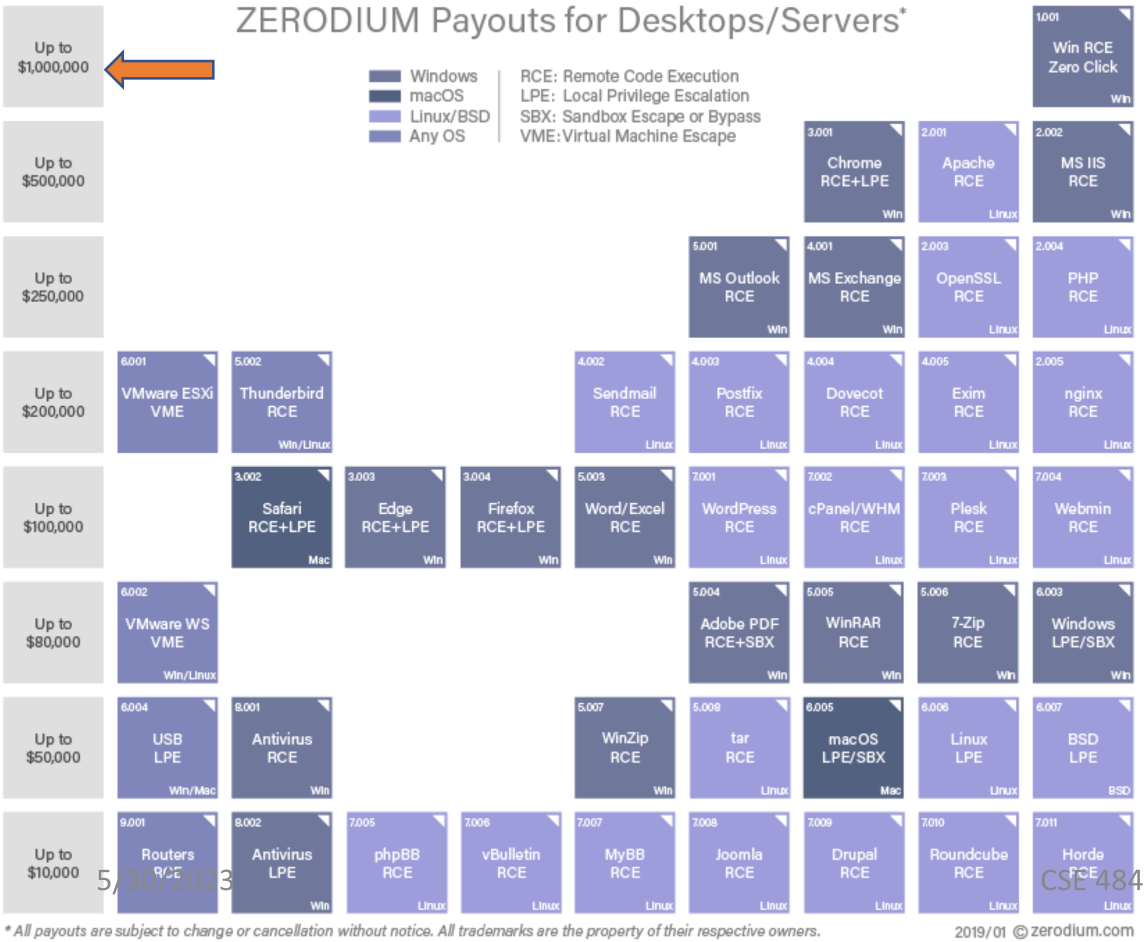

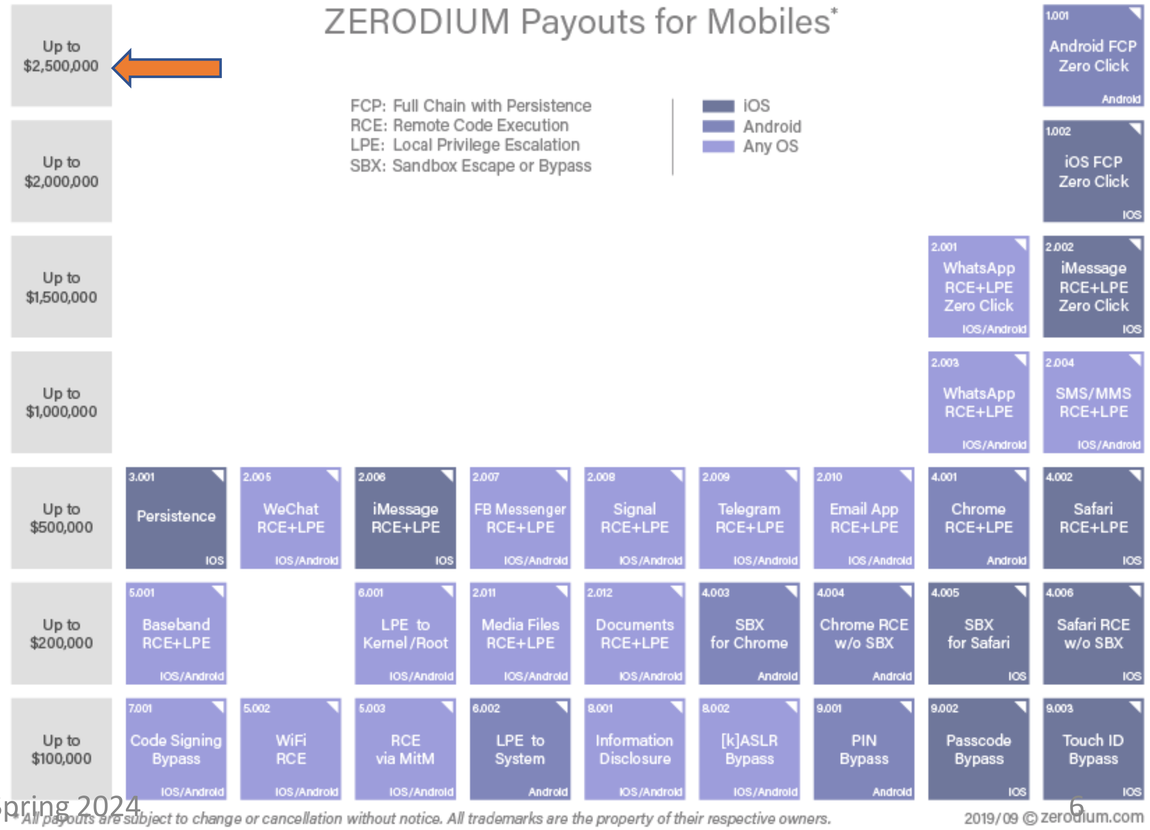

Why?

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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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

Why isolate on mobile devices and not PCs?

- Application isolation is *great!*

- Phones drew lessons from desktops
- Desktops draw lessons from phones
- Browsers learning too

- App Isolation sometimes available for PCs
  - Windows 10 Sandbox (May 2019)

- Browsers: Site Isolation

More Details: Android

- 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

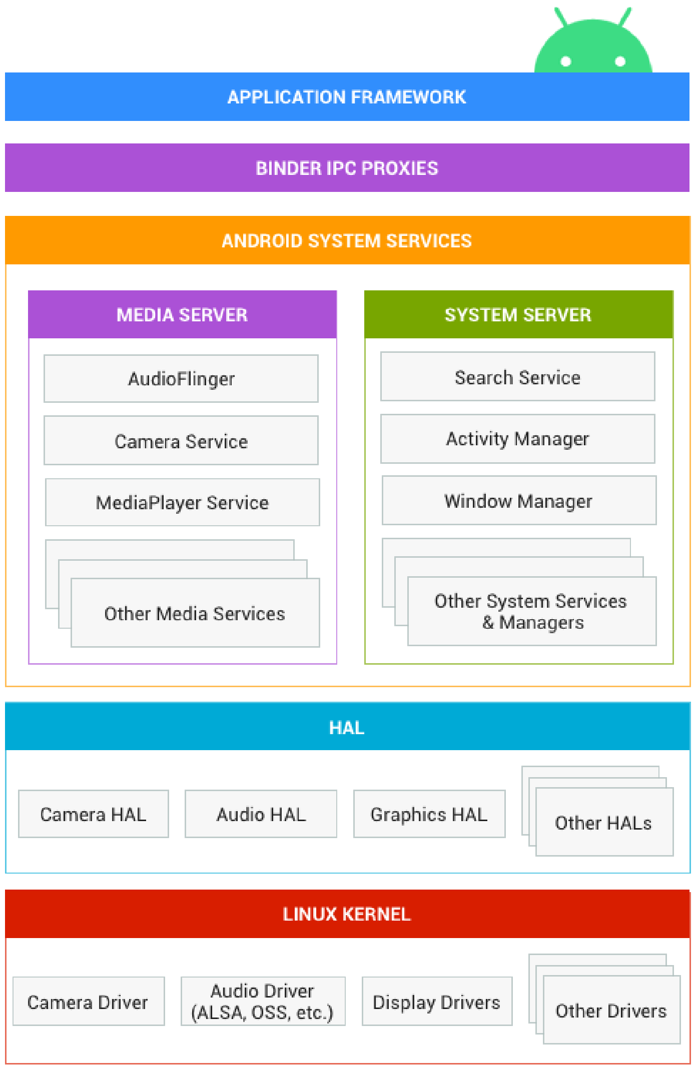


Figure 1. Android system architecture

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?

What can go wrong?

“Threat Model” 1: Malicious applications

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

(1) Permission Granting Problem

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

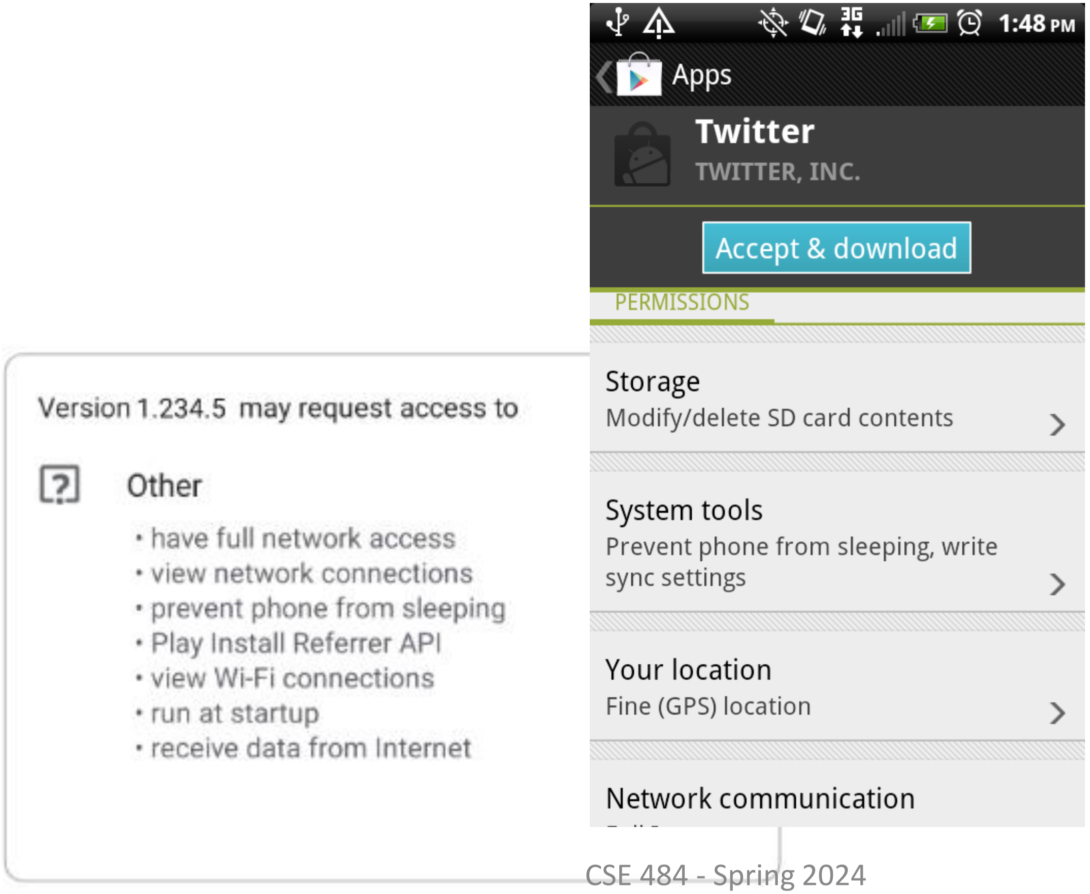
- System Resources (clipboard, file system).
- Devices (camera, GPS, phone, …).

How should operating system grant permissions to applications?

Standard approach: Ask the user.

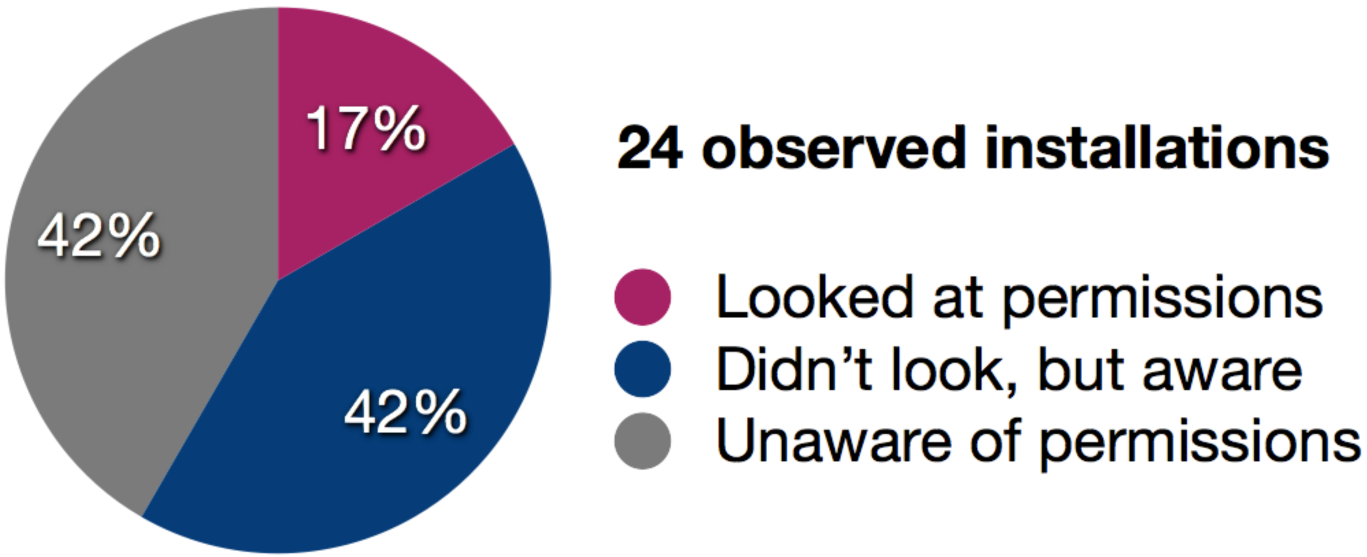
Android’s old approach: Manifests

- Big list of things the app wants at install time



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?

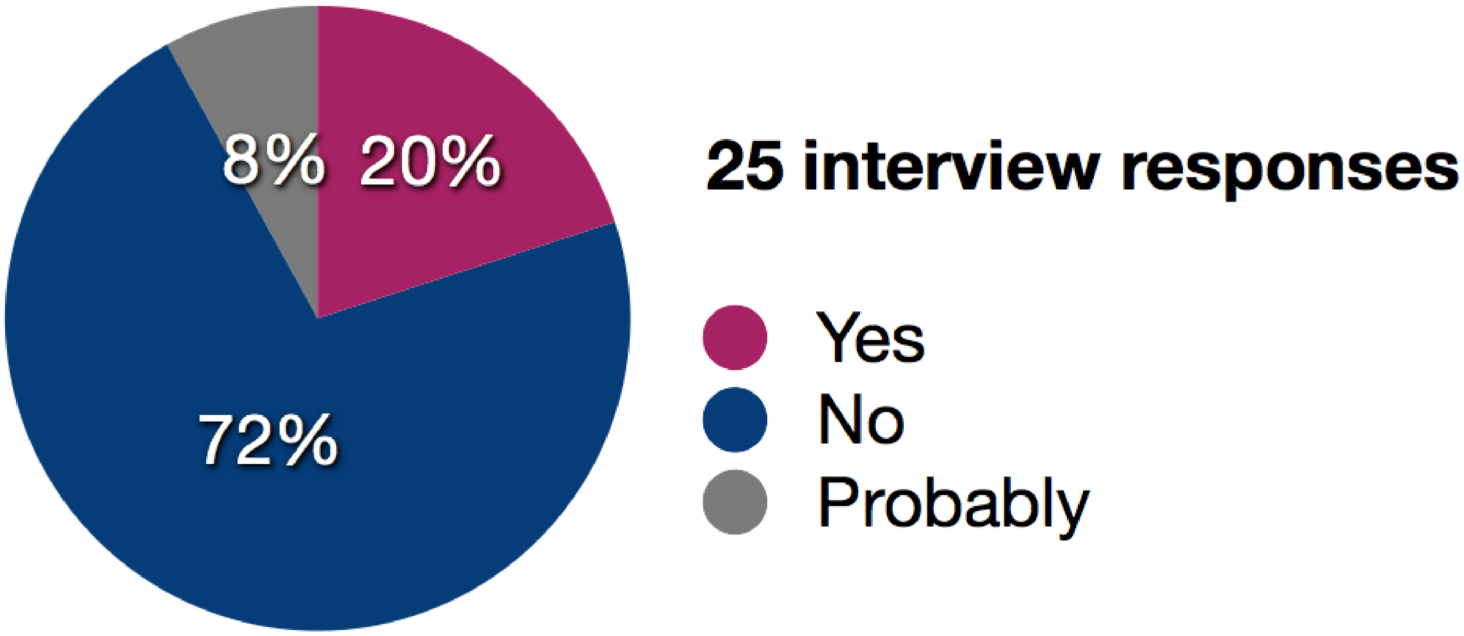
	Permission	n	Correct Answers	
1 Choice	READ_CALENDAR	101	46	45.5%
	CHANGE_NETWORK_STATE	66	26	39.4%
	$READ\_SMS_1$	77	24	31.2%
	CALL_PHONE	83	16	19.3%
2 Choices	WAKE_LOCK	81	27	33.3%
	WRITE_EXTERNAL_STORAGE	92	14	15.2%
	READ_CONTACTS	86	11	12.8%
	INTERNET	109	12	11.0%
	READ_PHONE_STATE	85	4	4.7%
	$READ\_SMS_2$	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, $n = 302$)

Are Manifests Usable?

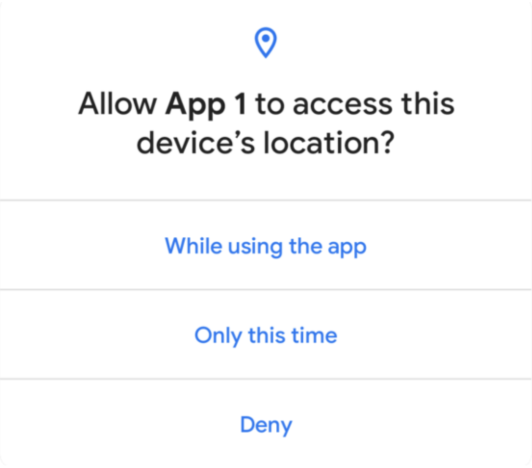
Do users act on permission information?

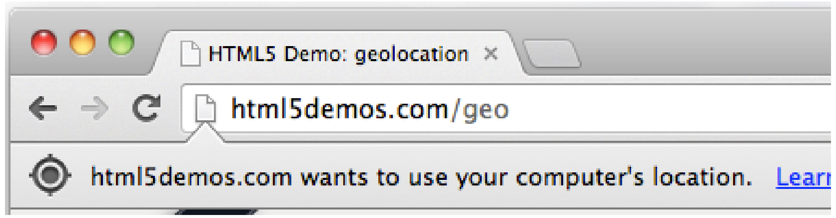
"Have you ever not installed an app because of permissions?"



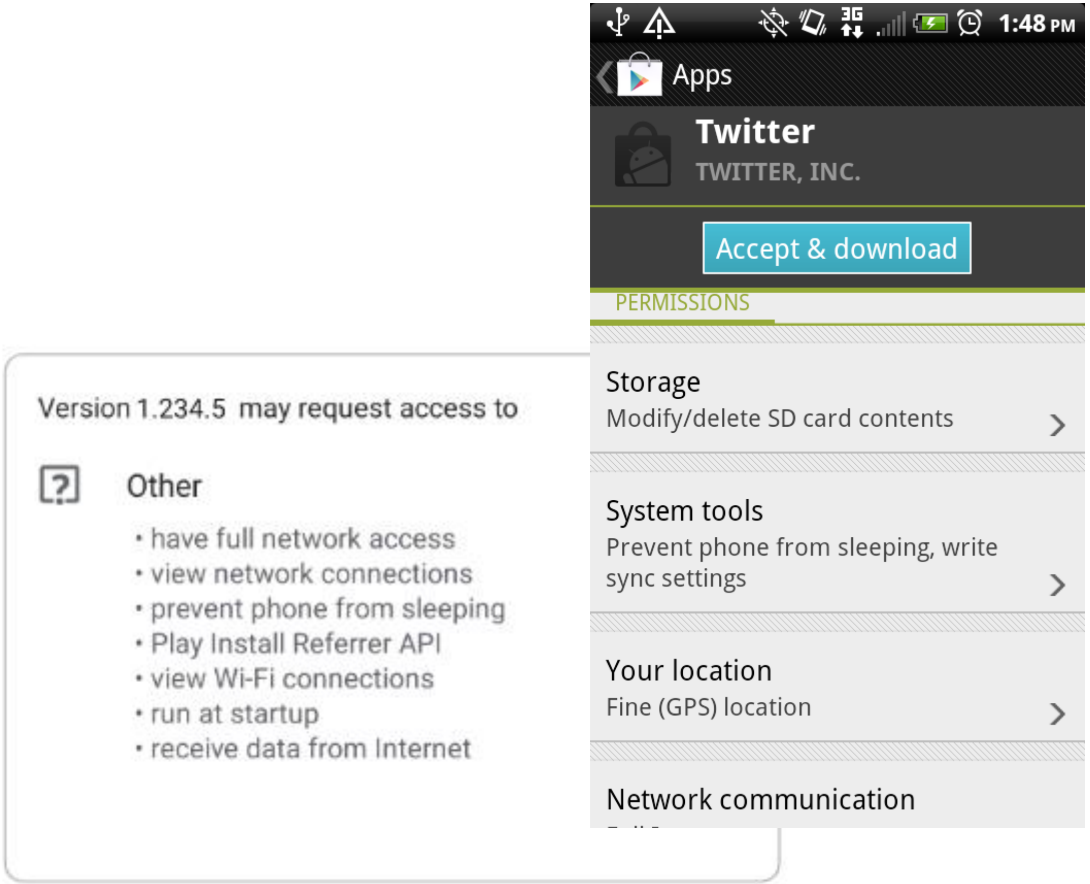
State of the Art

Prompts (time-of-use)

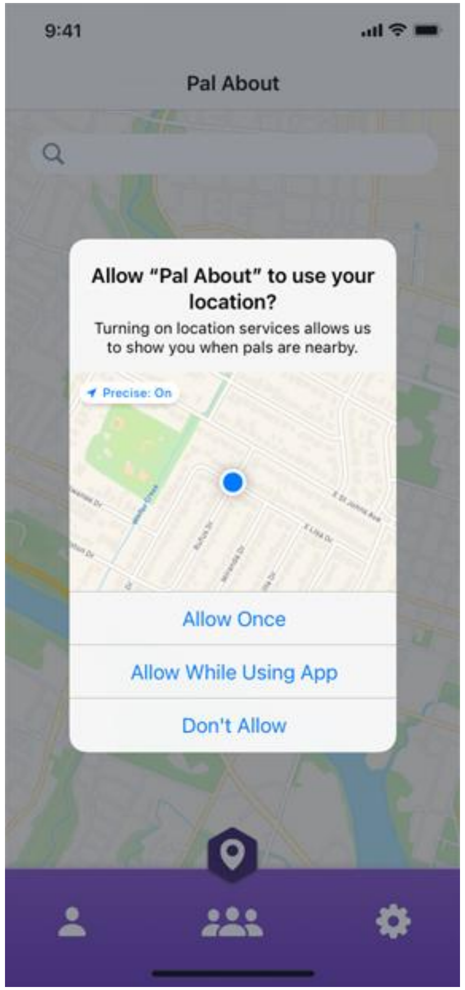


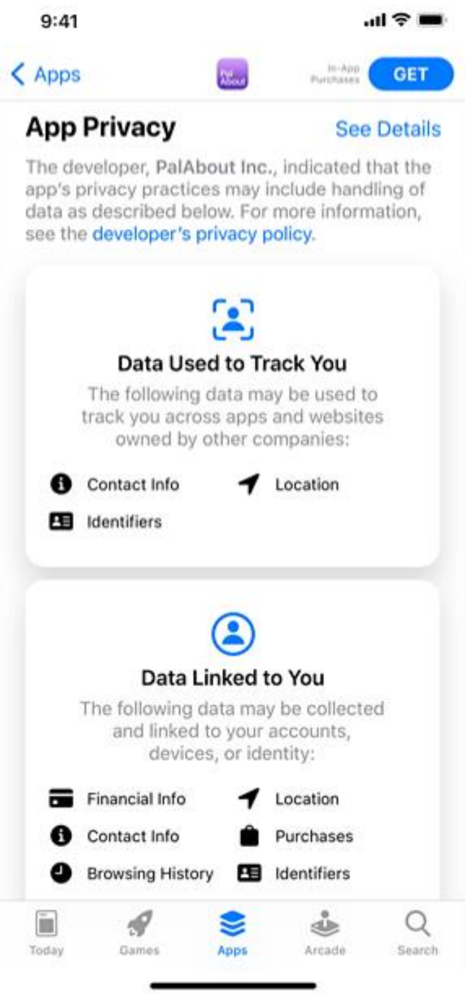


Manifests (install-time, old model)



State of the Art (iOS)





https://developer.apple.com/design/human-interface-guidelines/ios/app-architecture/accessing-user-data/

(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.

Eavesdropping and Spoofing

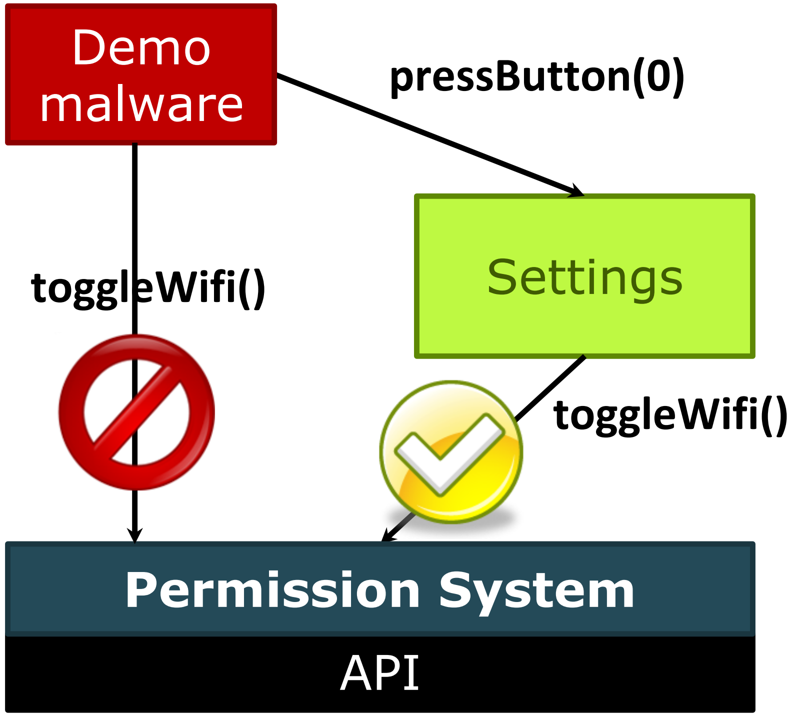
- Buggy apps might accidentally:
  - Expose their component-to-component messages publicly → eavesdropping
  - Act on unauthorized messages they receive → spoofing

[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.



Other Android Security Features

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

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
  - Many changes made in past few years (e.g. Project Treble)

Android Platform Version (API Level)	Distribution (as of April 10, 2020)
Android 4.0 "Ice Cream Sandwich" (15)	0.2%
Android 4.1 "Jelly Bean" (16)	0.6%
Android 4.2 "Jelly Bean" (17)	0.8%
Android 4.3 "Jelly Bean" (18)	0.3%
Android 4.4 "KitKat" (19)	4%
Android 5.0 "Lollipop" (21)	1.8%
Android 5.1 "Lollipop" (22)	7.4%
Android 6.0 "Marshmallow" (23)	11.2%
Android 7.0 "Nougat" (24)	7.5%
Android 7.1 "Nougat" (25)	5.4%
Android 8.0 "Oreo" (26)	7.3%
Android 8.1 "Oreo" (27)	14%
Android 9 "Pie" (28)	31.3%
Android 10 (29)	8.2%

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

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.

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

iOS model vs Android

- Monolithic vs fragmented
- Closed vs open
- Single distributor vs many

Lessons Being Learned from Other Spaces

- Mobile phone platforms built on lessons learned from desktops
- Desktops and Browsers learning from Mobile phones
- Overall, trying to increase security for all platforms