CSE 484 / CSE M 584: Computer Security and Privacy

Mobile Usability

Autumn 2018

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

Admin

- HW 3 due Nov 30
- Lab 3 out today (this afternoon), due Dec 7 (Quiz Section on Nov 29)

- Wednesday evening lecture (tonight): *Extra credit* in-class assignment

- Next Monday: Guest Lecturer: Emily McReynolds, Microsoft
- Next Wednesday: Ivan Evtimov, Adversarial Machine Learning
- Next Friday: No lecture – extra time to work on your projects and labs
  - But there is an *extra credit* in-class assignment, if you would like (2 more Enigma talks)

Admin

- Final Project Proposals: Looked great!
- Final Project Checkpoint: Nov 30 – preliminary outline and references
- Final Project Presentation: Dec 10 – 12-15-minute video – **must** be on time
- Explore something of interest to you, that could hopefully benefit you or your career in some way – technical topics, current events, etc

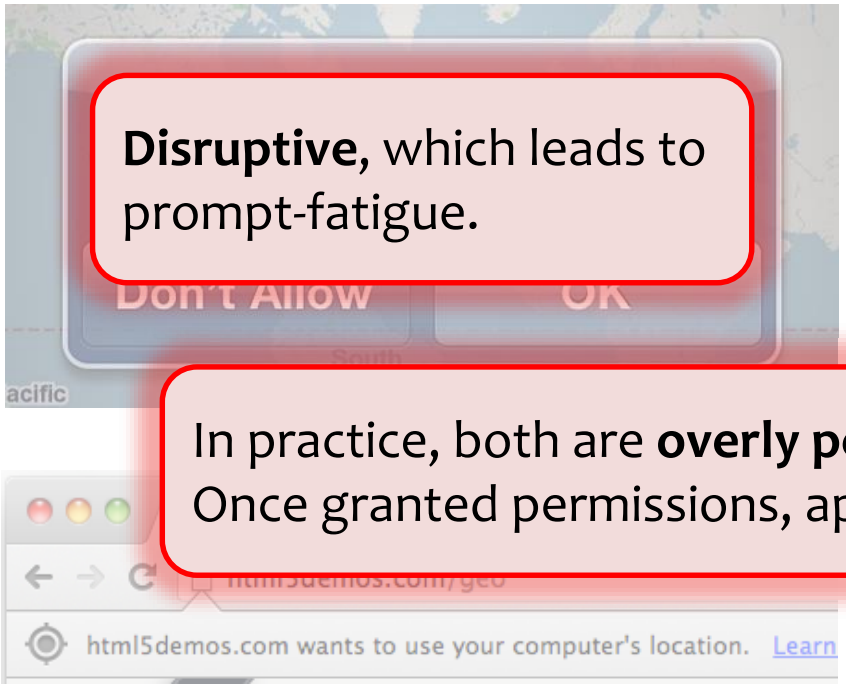
Review: Challenges with Isolated Apps

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?

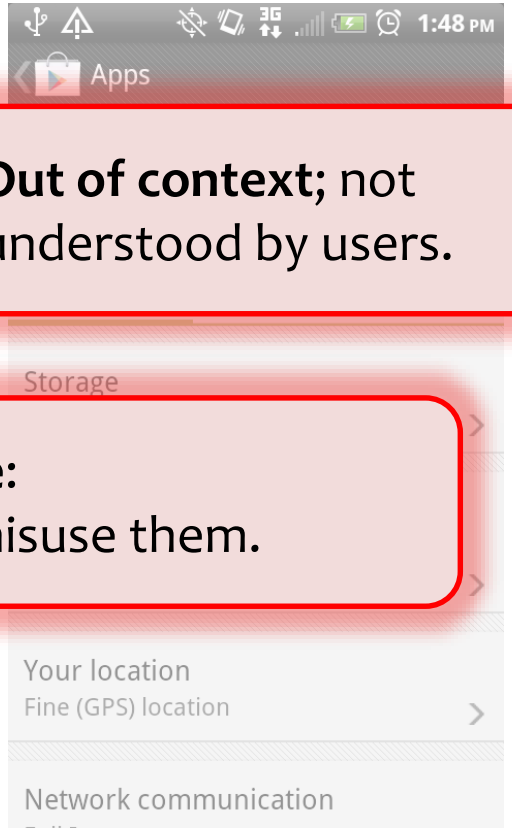
Review: Two Ways to Ask the User

Prompts (time-of-use)



Disruptive, which leads to prompt-fatigue.

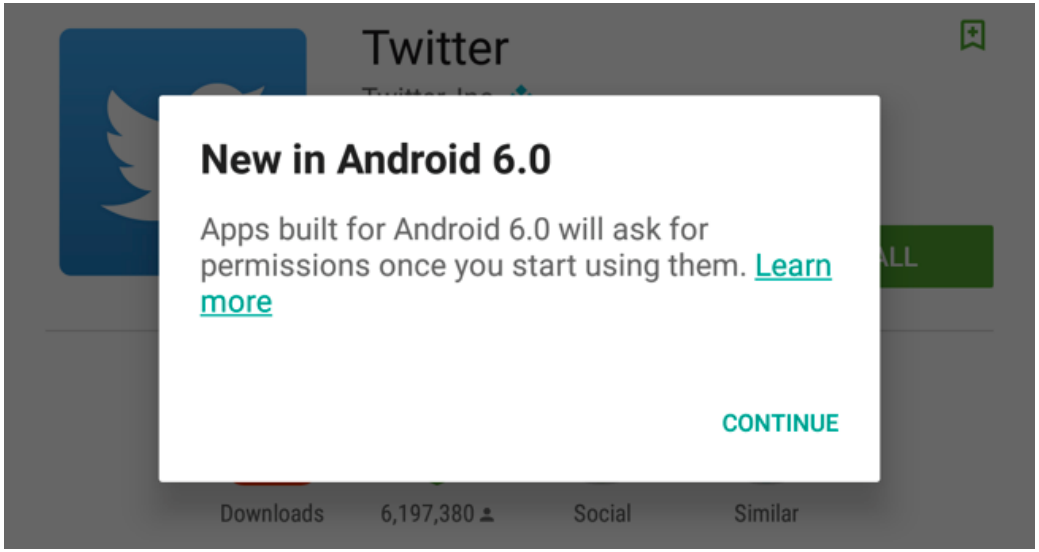
Manifests (install-time)



Out of context; not understood by users.

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

Android 6.0: Prompts!



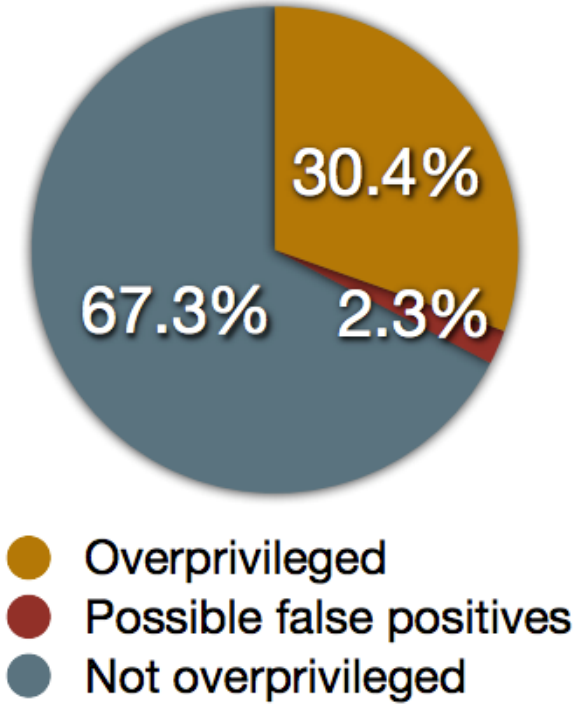
- First-use prompts for sensitive permission (like iOS).
- Big change! Now app developers need to check for permissions or catch exceptions.

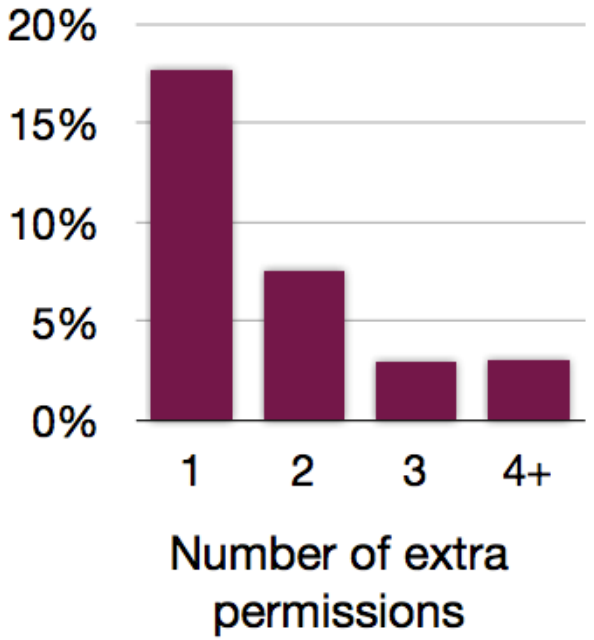
[Felt et al.]

Over-Permissioning

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

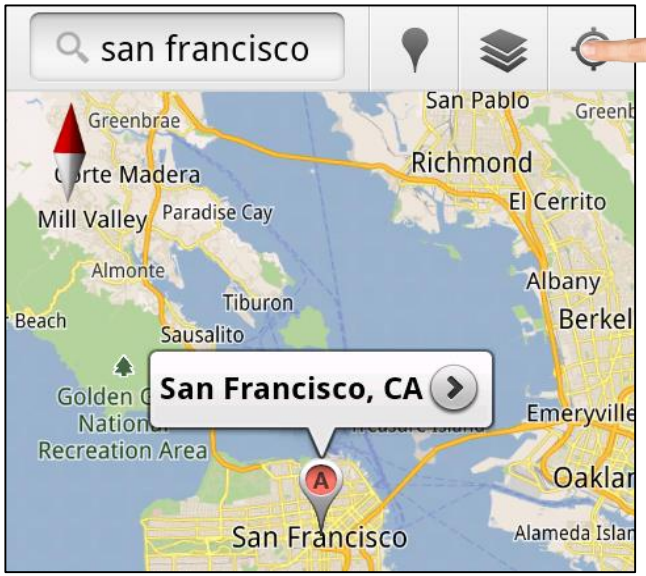
www.android-permissions.org (Felt et al.), http://pscout.csl.toronto.edu (Au et al.)

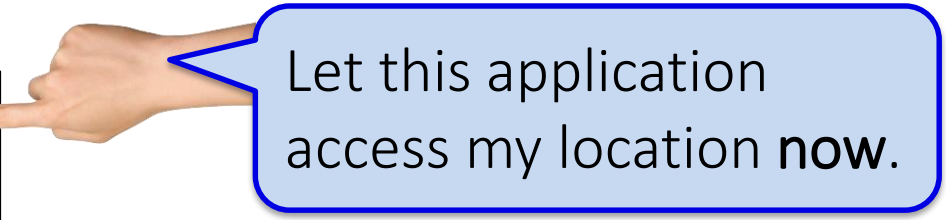




[Roesner et al]

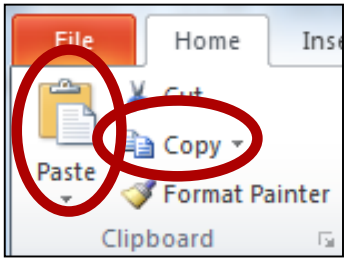
Improving Permissions: User-Driven Access Control

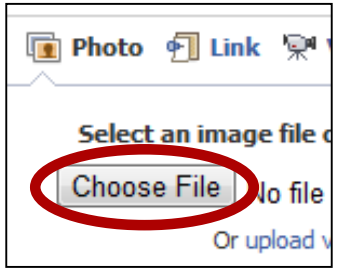




Insight:

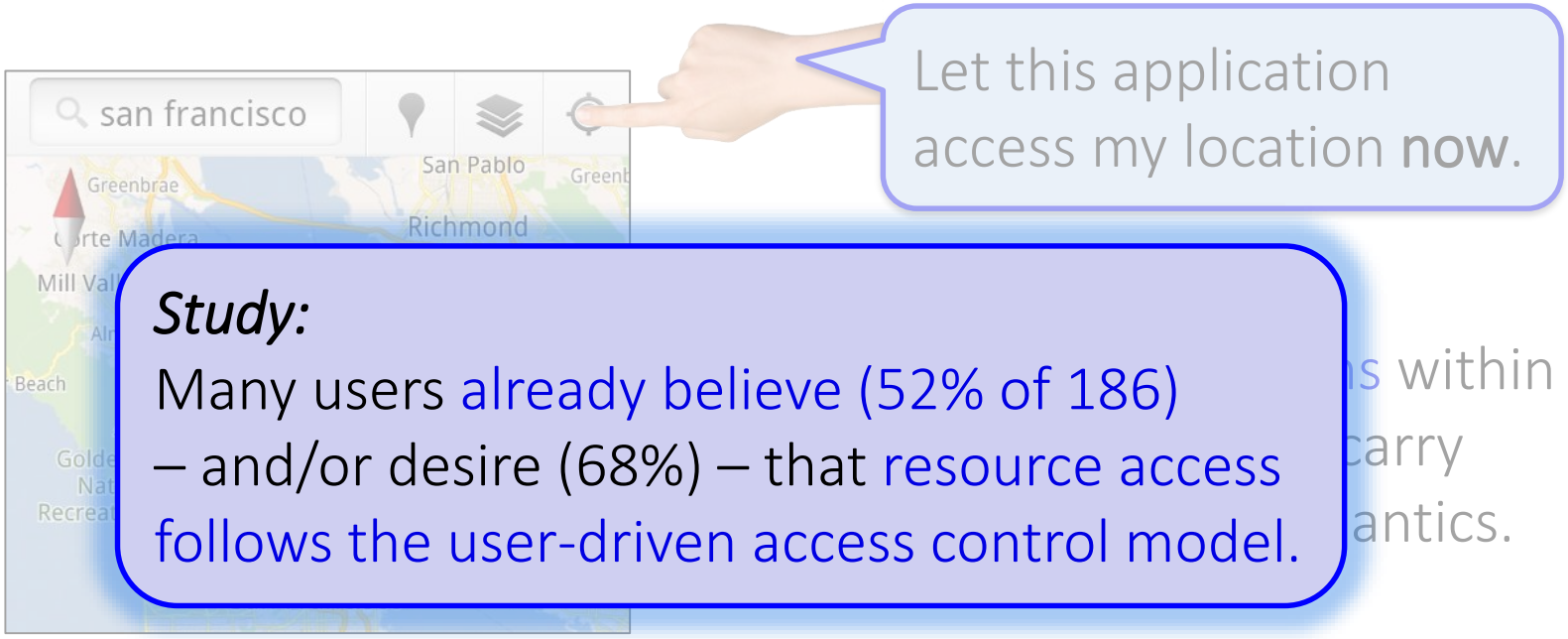
A user's natural UI actions within an application implicitly carry permission-granting semantics.



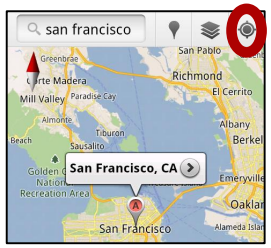


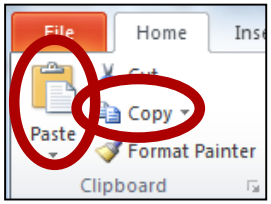
[Roesner et al]

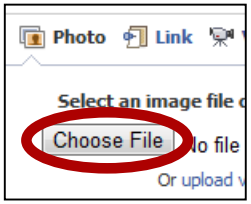
Improving Permissions: User-Driven Access Control



New OS Primitive: Access Control Gadgets (ACGs)







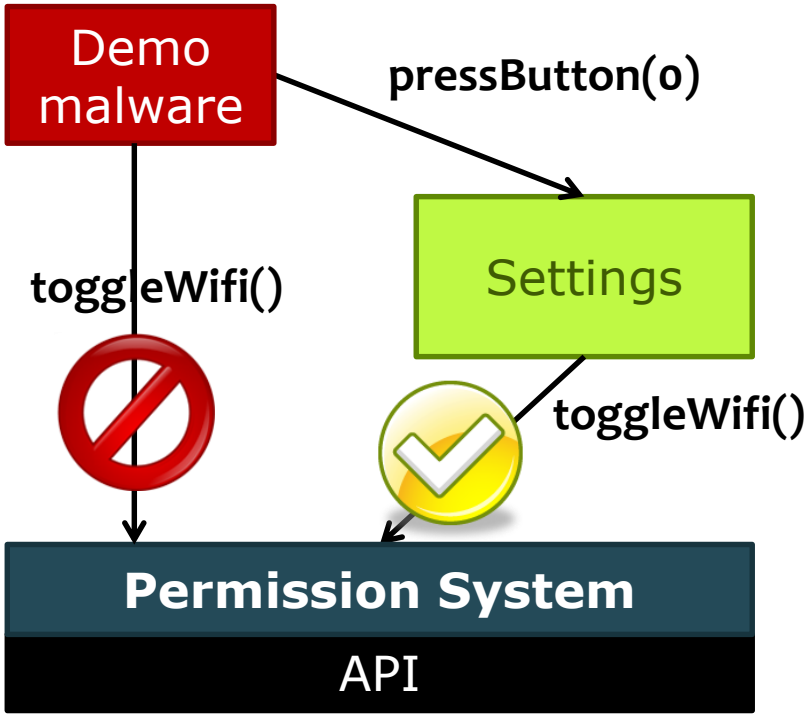
Approach: Make resource-related UI elements first-class operating system objects (access control gadgets).

- 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.

[Felt et al.]

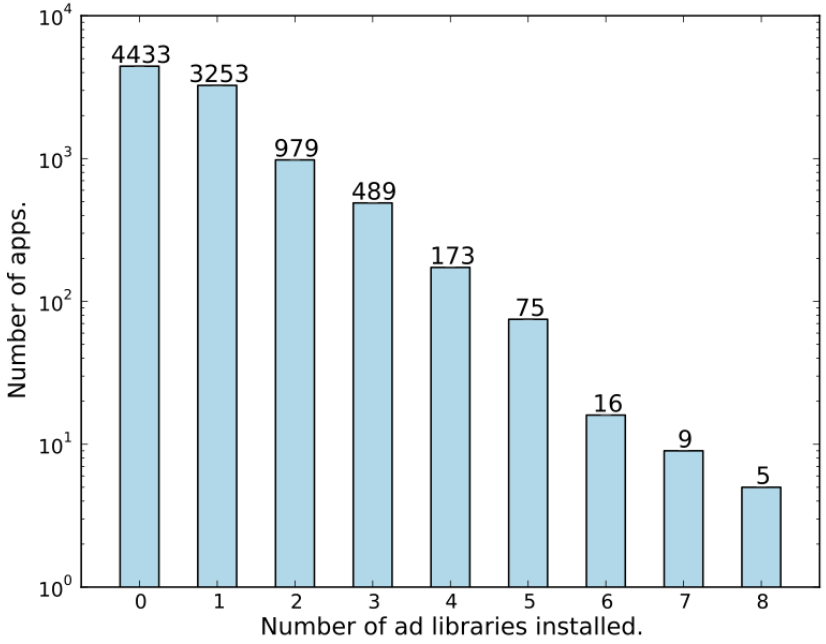
Permission Re-Delegation

- 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…)



[Shekhar et al.]

Ad from ad library

Map from Google library

Social button from Facebook library

Android Application Signing

- Apps are signed
  - 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

Android Permission Recommendations

- Only use the permissions necessary for your app to work
- Pay attention to permissions required by libraries
- Be transparent
- Make system accesses explicit. Providing continuous indications when you access sensitive capabilities (for example, the camera or microphone) …

https://developer.android.com/training/permissions/usage-notes

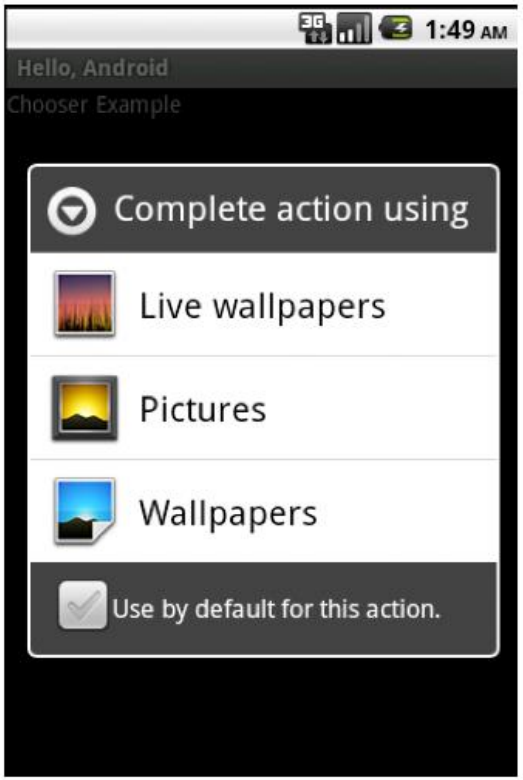
(2) Inter-Process Communication

- 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.

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
- 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)

What's Next?

- This about these issues for the next computing platform
  - Augmented Reality?
  - Cars?
  - Smarthomes?

Usability

On Usability

- Why is usability important?
  - People are the critical element of any computer system
    - People are the real reason computers exist in the first place
  - Even if it is **possible** for a system to protect against an adversary, people may use the system in other, **less secure** ways
  - Usability errors can lead people to think that they are using a secure setting when in fact they are not (e.g., certain password managers)

Root Causes?

- Computer systems are complex; users lack intuition
- Users in charge of managing own devices
  - Unlike other complex systems, like healthcare or cars.
- Hard to gauge risks
  - "It won't happen to me!"
- Annoying, awkward, difficult
- Social issues
  - Send encrypted emails about lunch?...

Question

- What does usable security mean?
- What does it mean for a system to have usable security?

How to Improve?

- Security education and training
- Help users build accurate mental models
- Make security invisible
- Make security the least-resistance path
- …?