CSE 484 / CSE M 584: Computer Security and Privacy

Mobile Platform Security [finish]

Fall 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

- Project checkpoint #2 due tonight
- Keep letting us know of any fuzzing issues with HW3
  - Double check that you followed the instructions
  - Make sure to put things in C: instead of D:
  - It's possible to run into issues on the MS side, so let us know and we'll loop them in if needed (in the meantime you can relax ☺)

This Week: Mac OS X High Sierra Issue

- Given physical access, if root password not set, can login (creating a root account?) without a password
- Manual fix: set root password

Security Update 2017-001

Released November 29, 2017

Directory Utility

Available for: macOS High Sierra 10.13 and macOS High Sierra 10.13.1

Not impacted: macOS Sierra 10.12.6 and earlier

Impact: An attacker may be able to bypass administrator authentication without supplying the administrator's password

Description: A logic error existed in the validation of credentials. This was addressed with improved credential validation.

CVE-2017-13872

Entry updated November 29, 2017

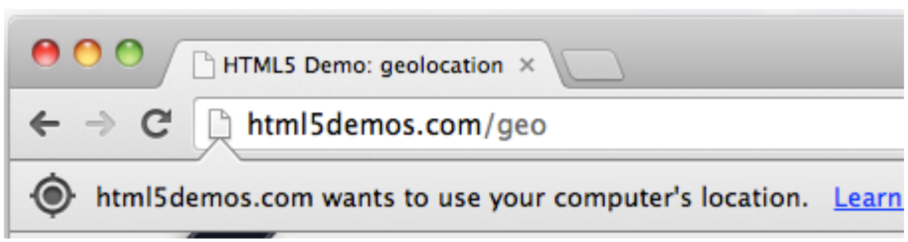
Back to Mobile Security: Challenges with Isolated Apps

So mobile platforms isolate applications for security, but…

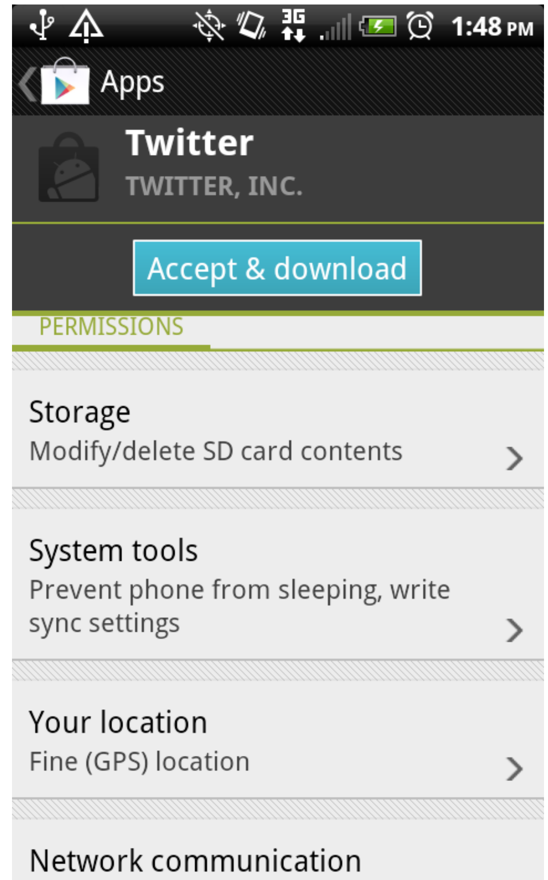
1. Permissions: How can applications access sensitive resources?
2. Communication: How can applications communicate with each other?

State of the Art

Prompts (time-of-use)



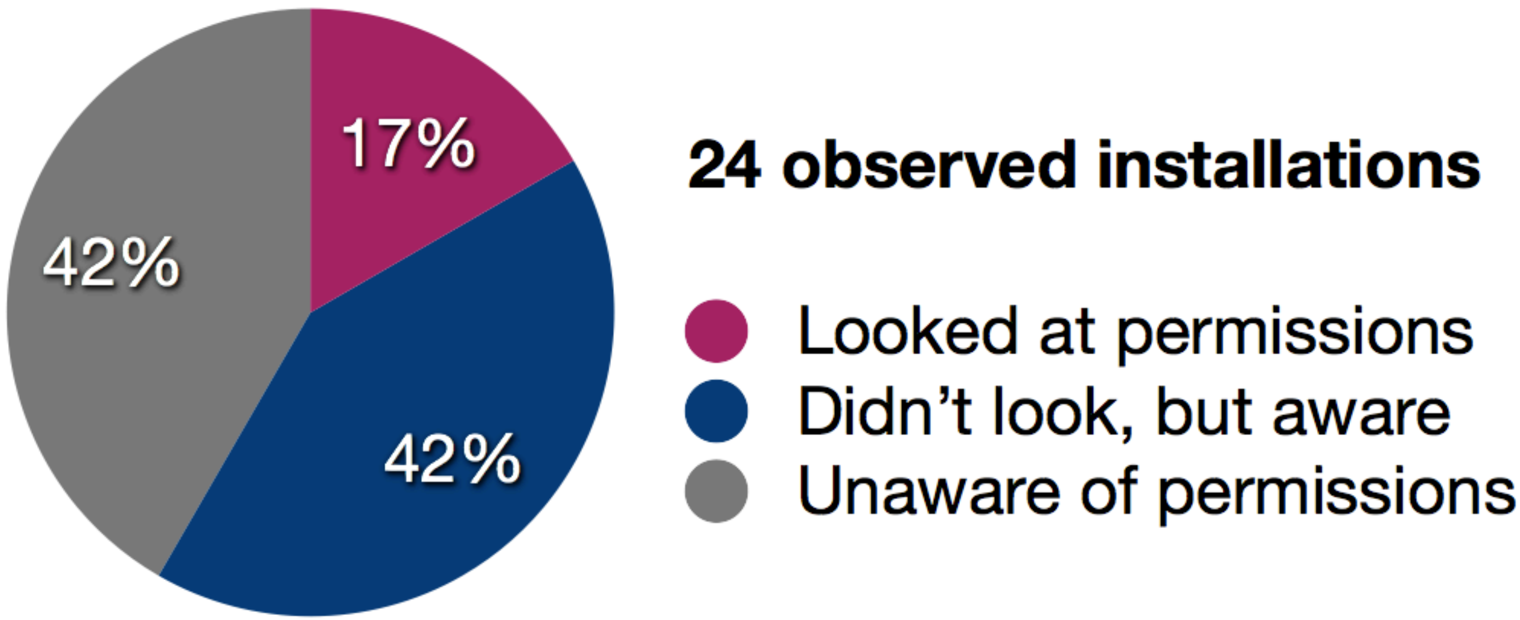
Manifests (install-time)



[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%

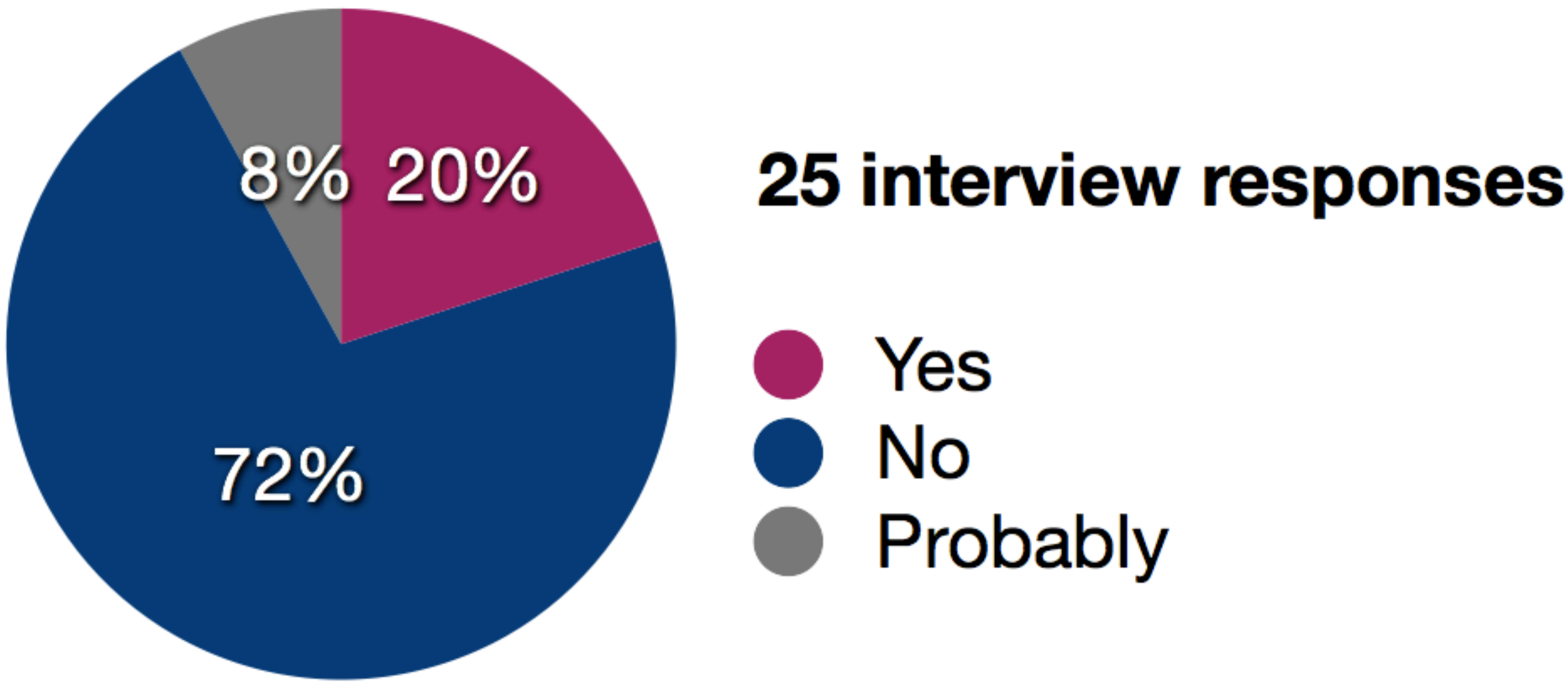
Table 4: The number of people who correctly answered a question. Questions are grouped by the number of correct choices. n is the number of respondents. (Internet Survey, $n = 302$)

[Felt et al.]

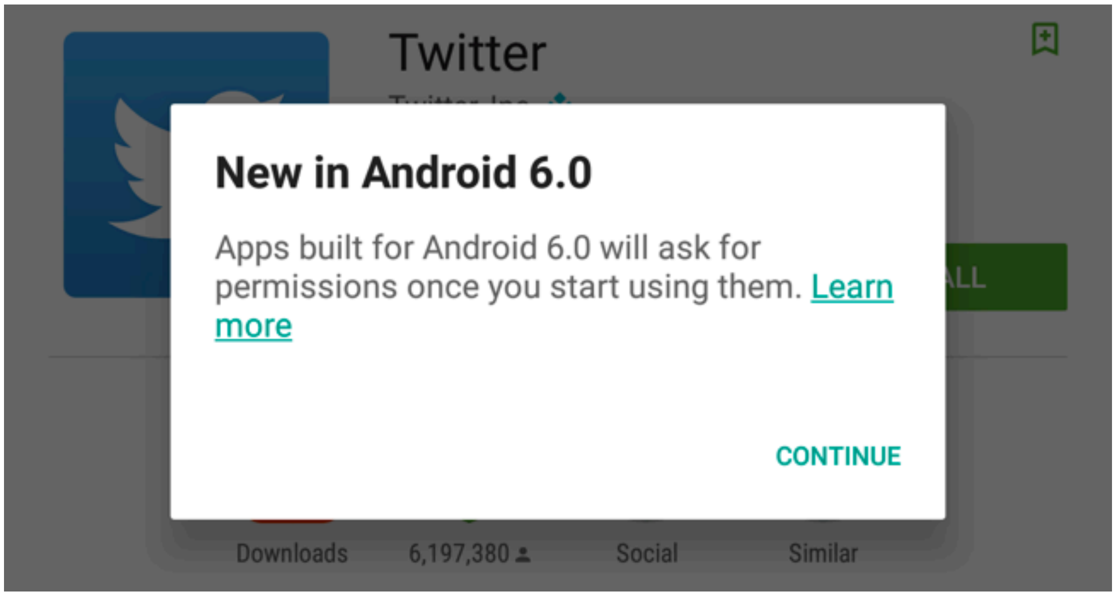
Are Manifests Usable?

Do users act on permission information?

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



Android 6.0: Prompts!

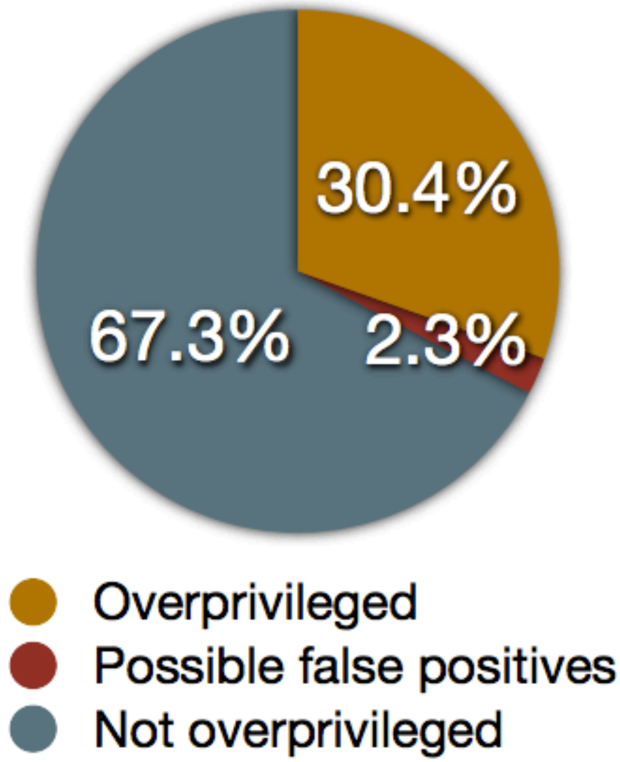


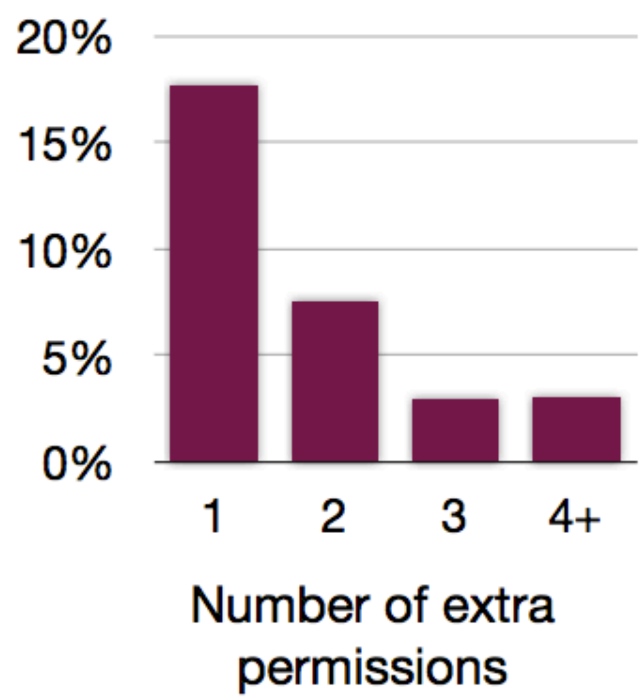
- First-use prompts for sensitive permission (like iOS).
- Big change! Now app developers need to check for permissions or catch exceptions.

Over-Permissioning

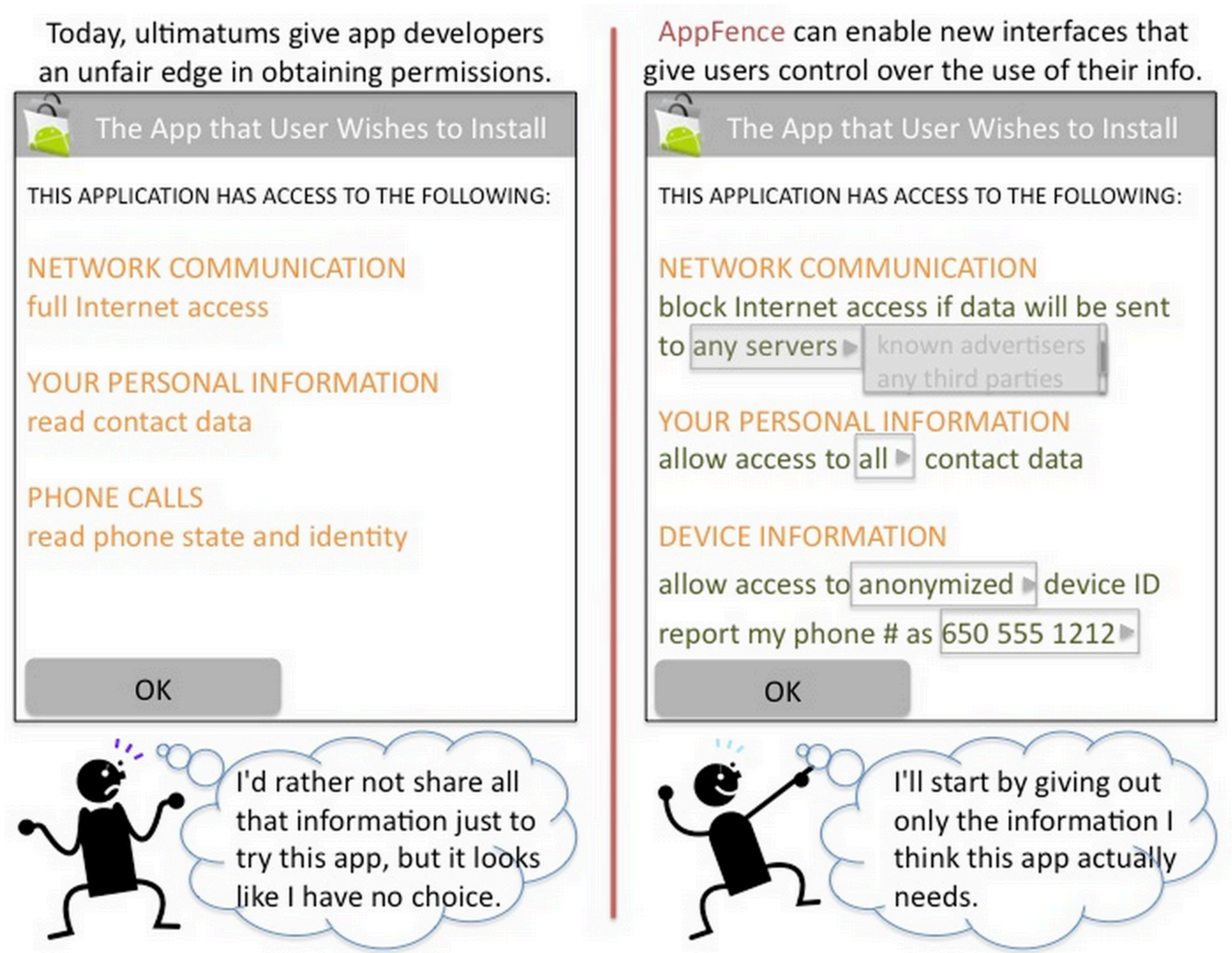
- Android permissions are badly documented.
- Researchers have mapped APIs → permissions.

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



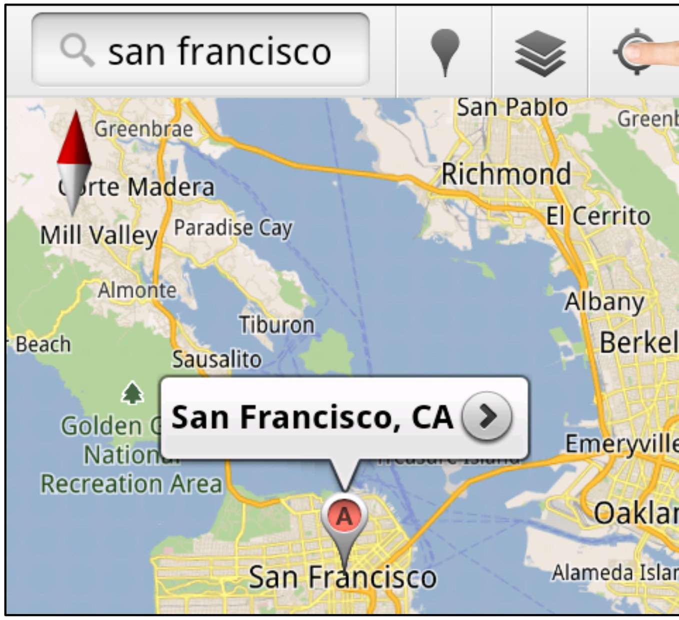


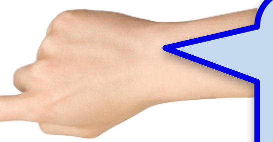
Improving Permissions: AppFence



[our work]

Improving Permissions: User-Driven Access Control

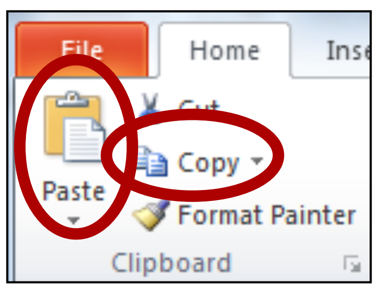


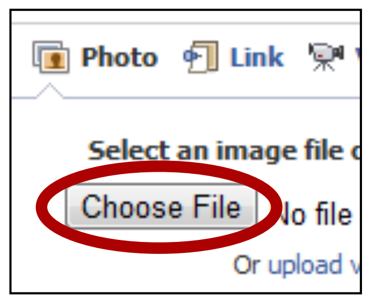


Let this application access my location **now**.

Insight:

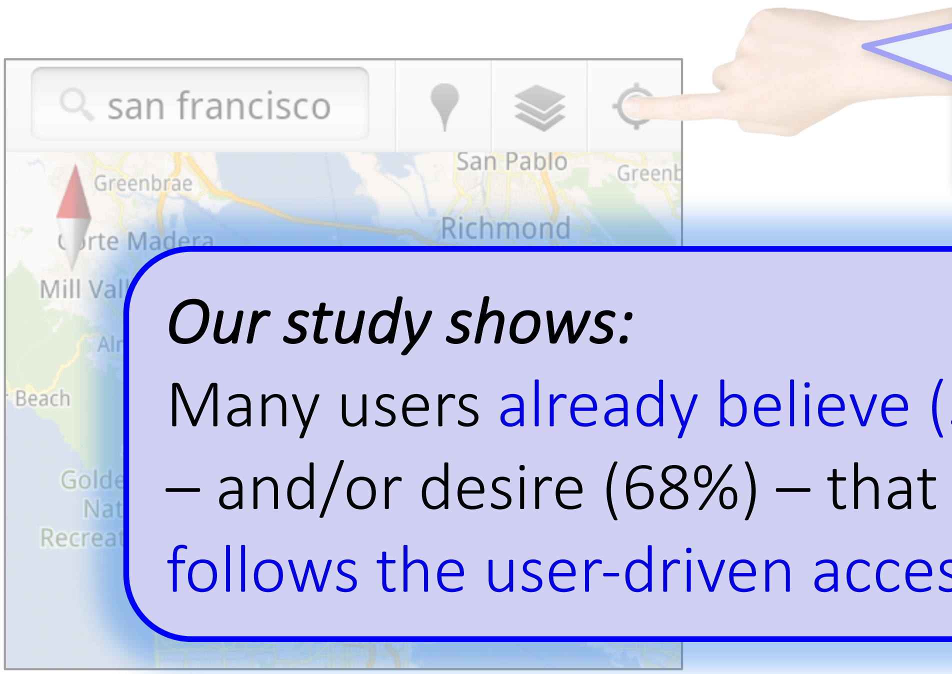
A user's natural UI actions within an application implicitly carry permission-granting semantics.





[our work]

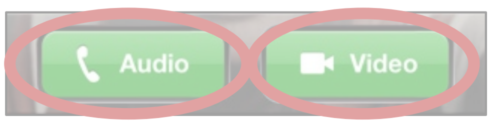
Improving Permissions: User-Driven Access Control

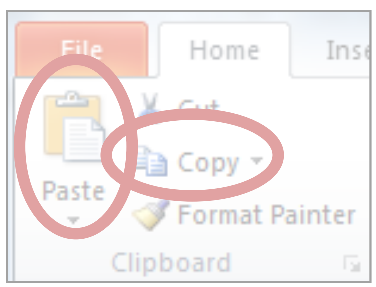


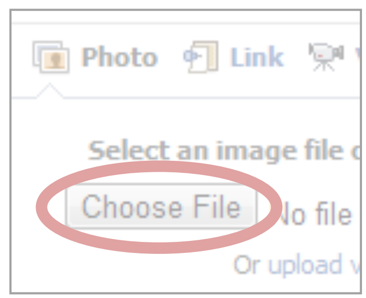
Let this application access my location **now**.

s within
carry
antics.

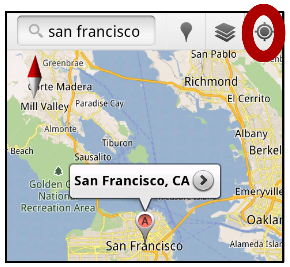
Our study shows:
Many users already believe (52% of 186) – and/or desire (68%) – that resource access follows the user-driven access control model.

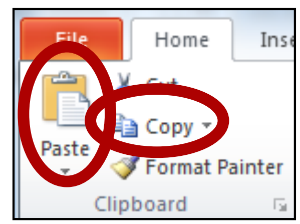


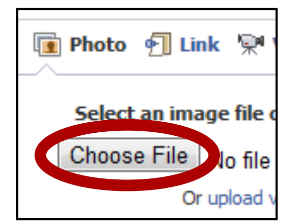




New OS Primitive:
Access Control Gadgets (ACGs)







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

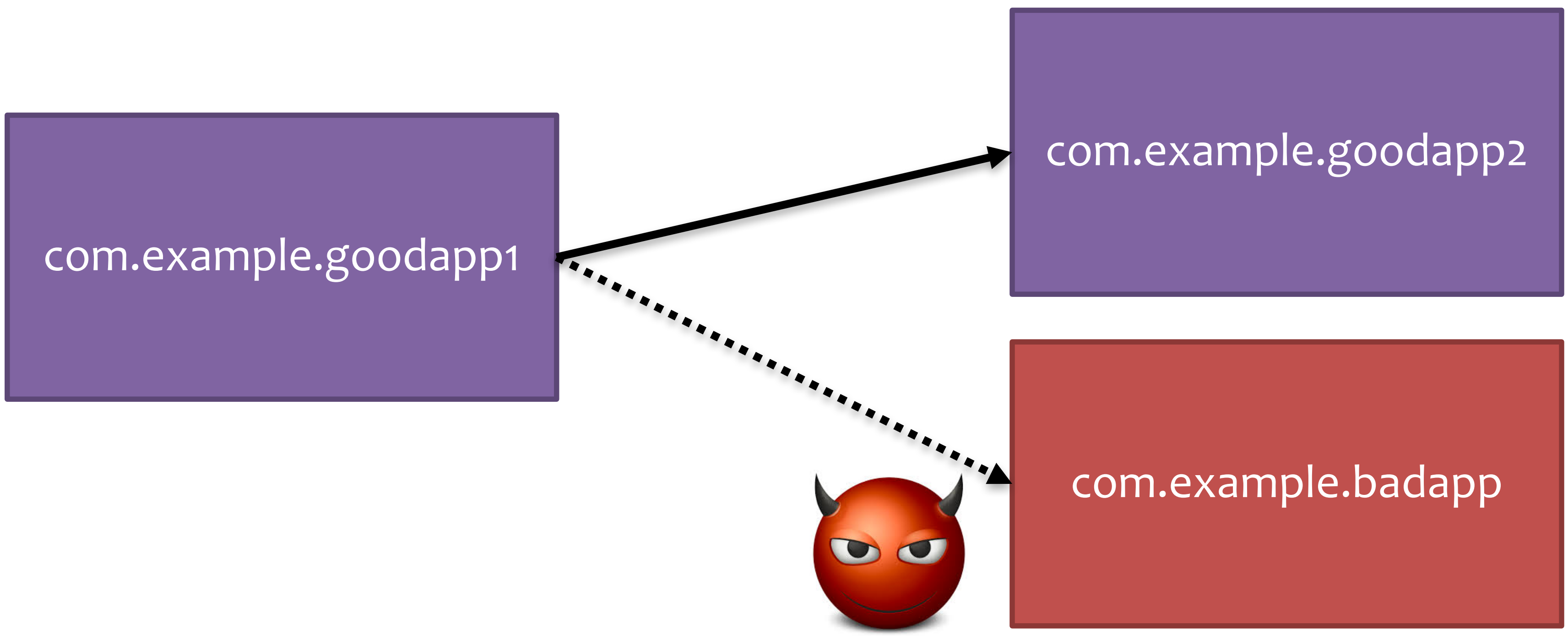
- To receive resource access, applications must embed a system-provided ACG.
- ACGs allow the OS to capture the user's permission granting intent in application-agnostic way.

(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.

Unauthorized Intent Receipt

Attack #1: Eavesdropping / Broadcast Theft



Unauthorized Intent Receipt

Attack #2: Service/Activity Hijacking

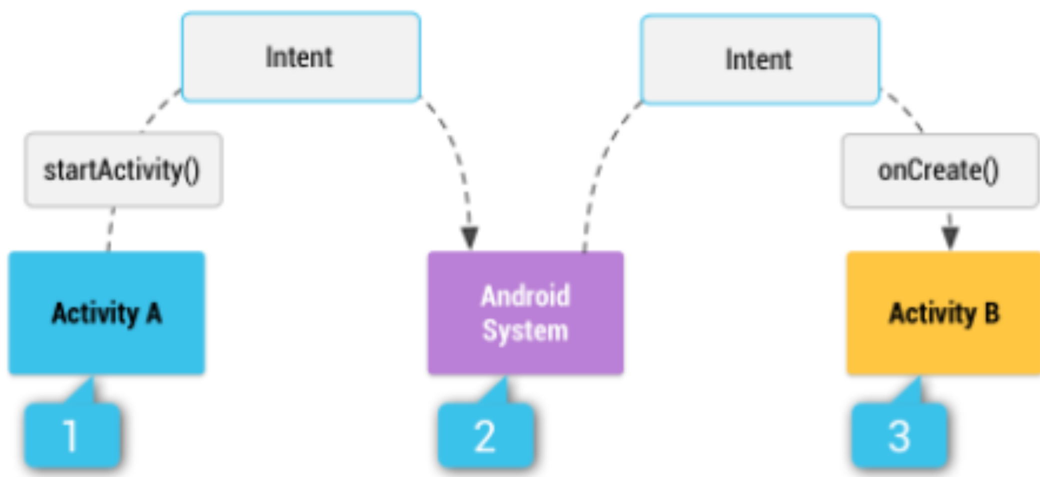


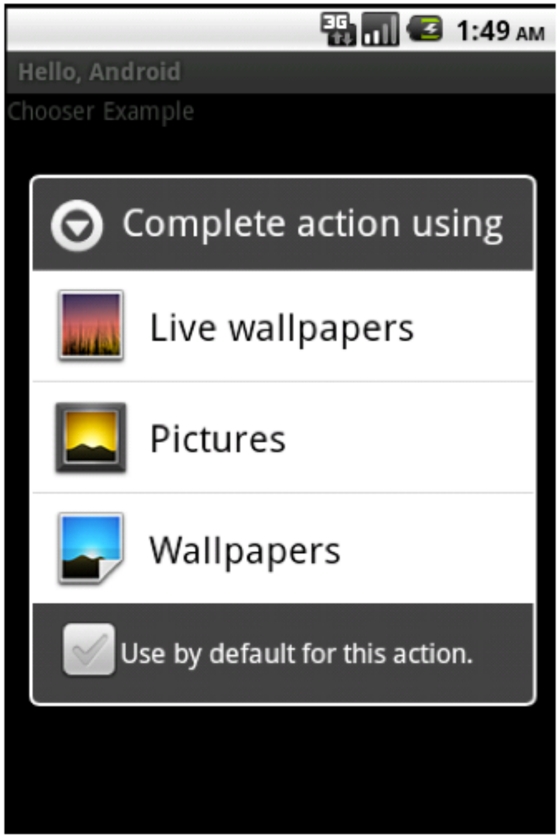
Figure 1. How an implicit intent is delivered through the system to start another activity: **[1]** *Activity A* creates an `Intent` with an action description and passes it to `startActivity()`. **[2]** The Android System searches all apps for an intent filter that matches the intent. When a match is found, **[3]** the system starts the matching activity (*Activity B*) by invoking its `onCreate()` method and passing it the `Intent`.

"**Caution:** To ensure that your app is secure, always use an explicit intent when starting a Servier. Using an implicit intent to start a service is a security hazard because you can't be certain what service will respond to the intent, and the user can't see which service starts."

[Chin et al.]

Unauthorized Intent Receipt

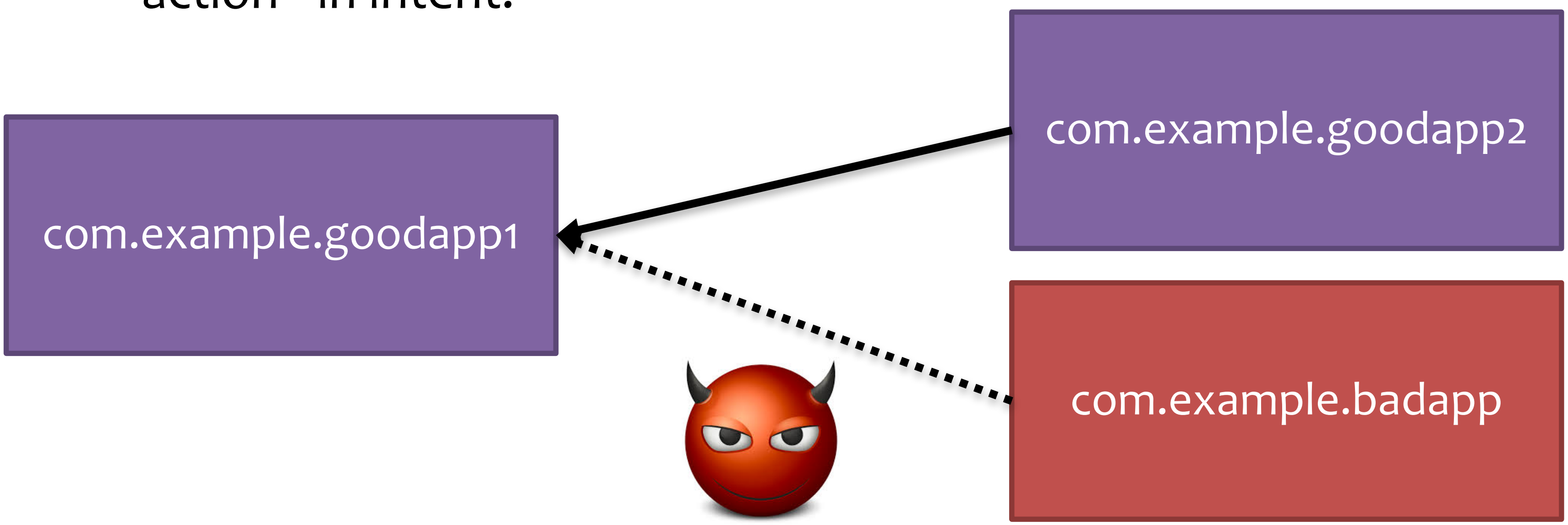
- Attack #1: Eavesdropping / Broadcast Thefts
  - Implicit intents make intra-app messages public.
- Attack #2: Activity Hijacking
  - May not always work:
- Attack #3: Service Hijacking
  - Android picks one at random upon conflict!



[Chin et al.]

Intent Spoofing

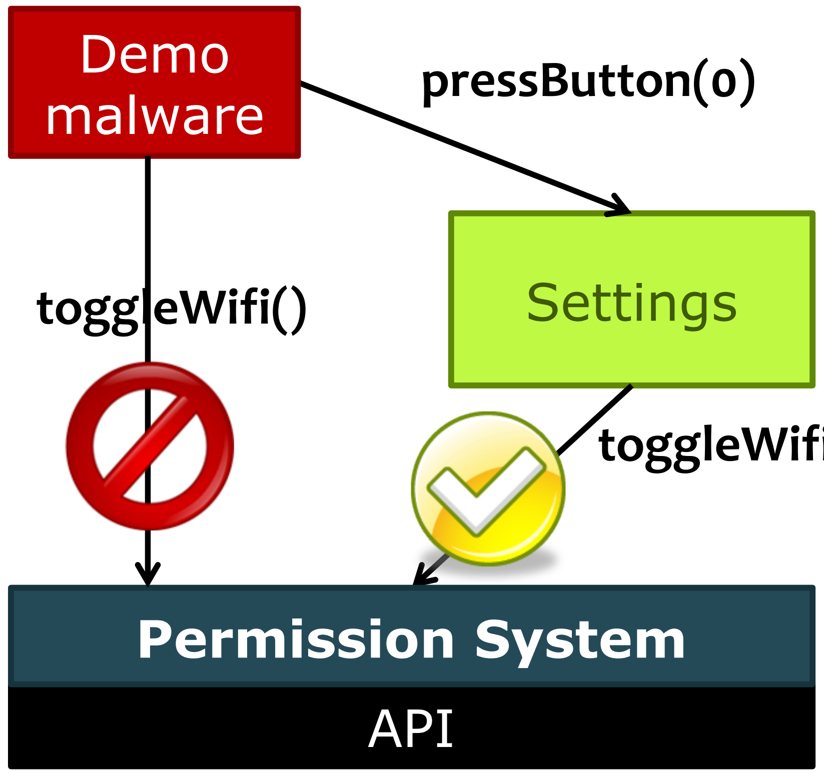
- Attack #1: General intent spoofing
  - Receiving implicit intents makes component public.
  - Allows data injection.
- Attack #2: System intent spoofing
  - Can’t directly spoof, but victim apps often don’t check specific “action” in intent.



[Felt et al.]

Permission Re-Delegation

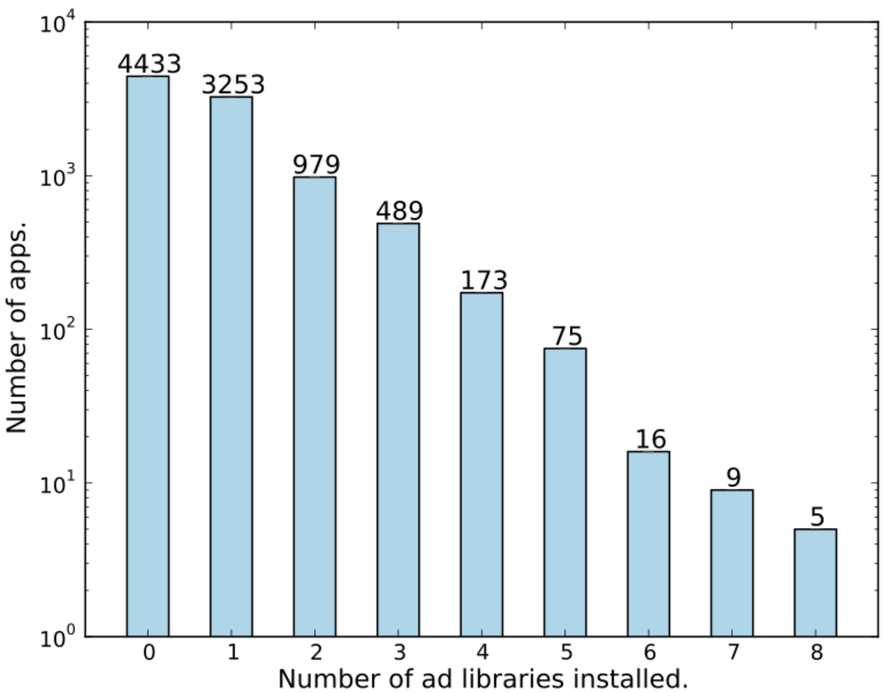
- An application without a permission gains additional privileges through another application.
- Demo video
- Settings application is deputy: has permissions, and accidentally exposes APIs that use those permissions.



More on Android…

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
  - 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

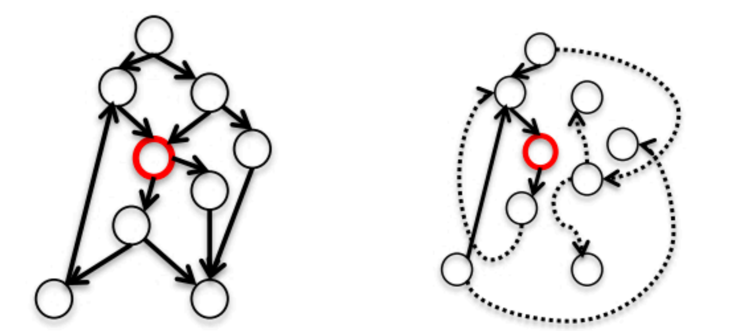
[https://developer.android.com/about/dashboards/index.html]

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

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Usable Security [start]

Fall 2017

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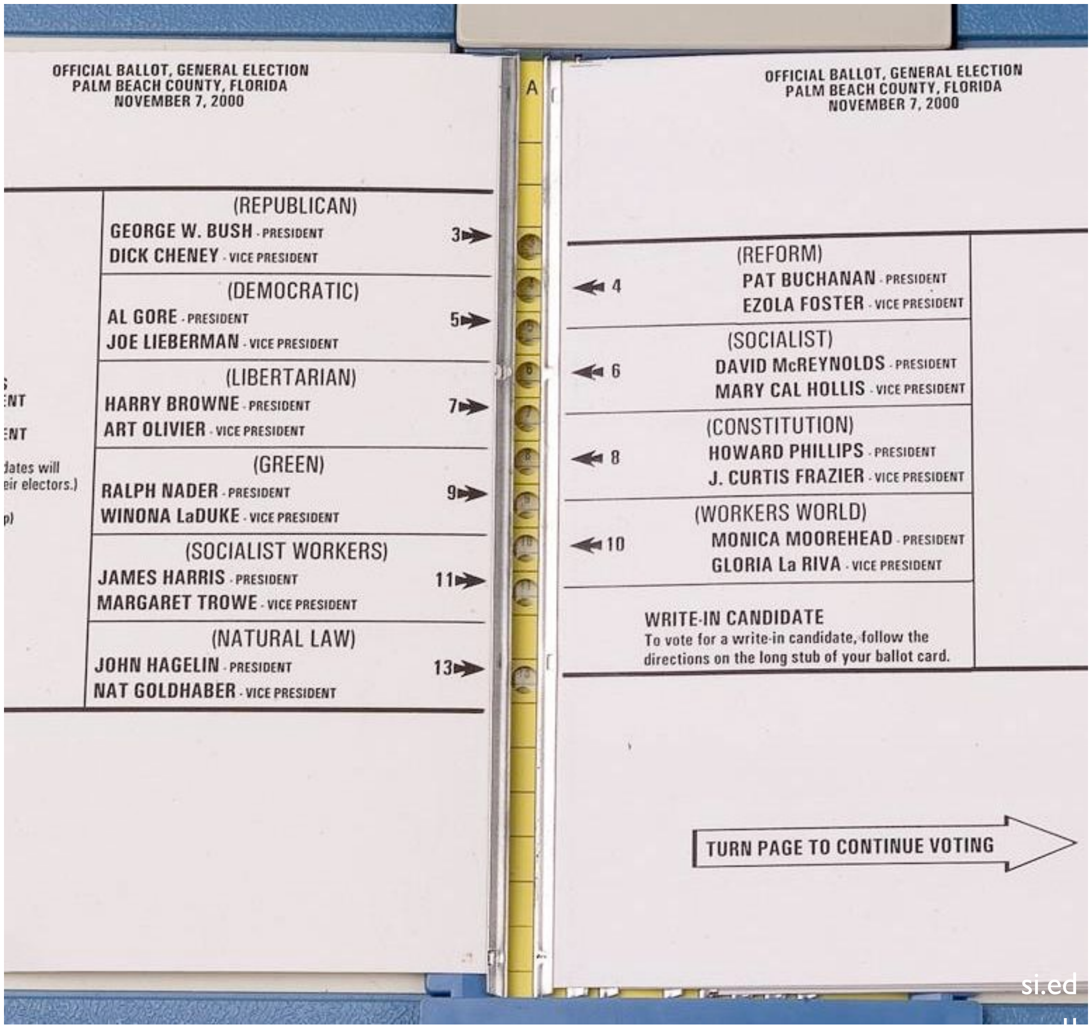
Poor Usability Causes Problems



AP

Importance in Security

- 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

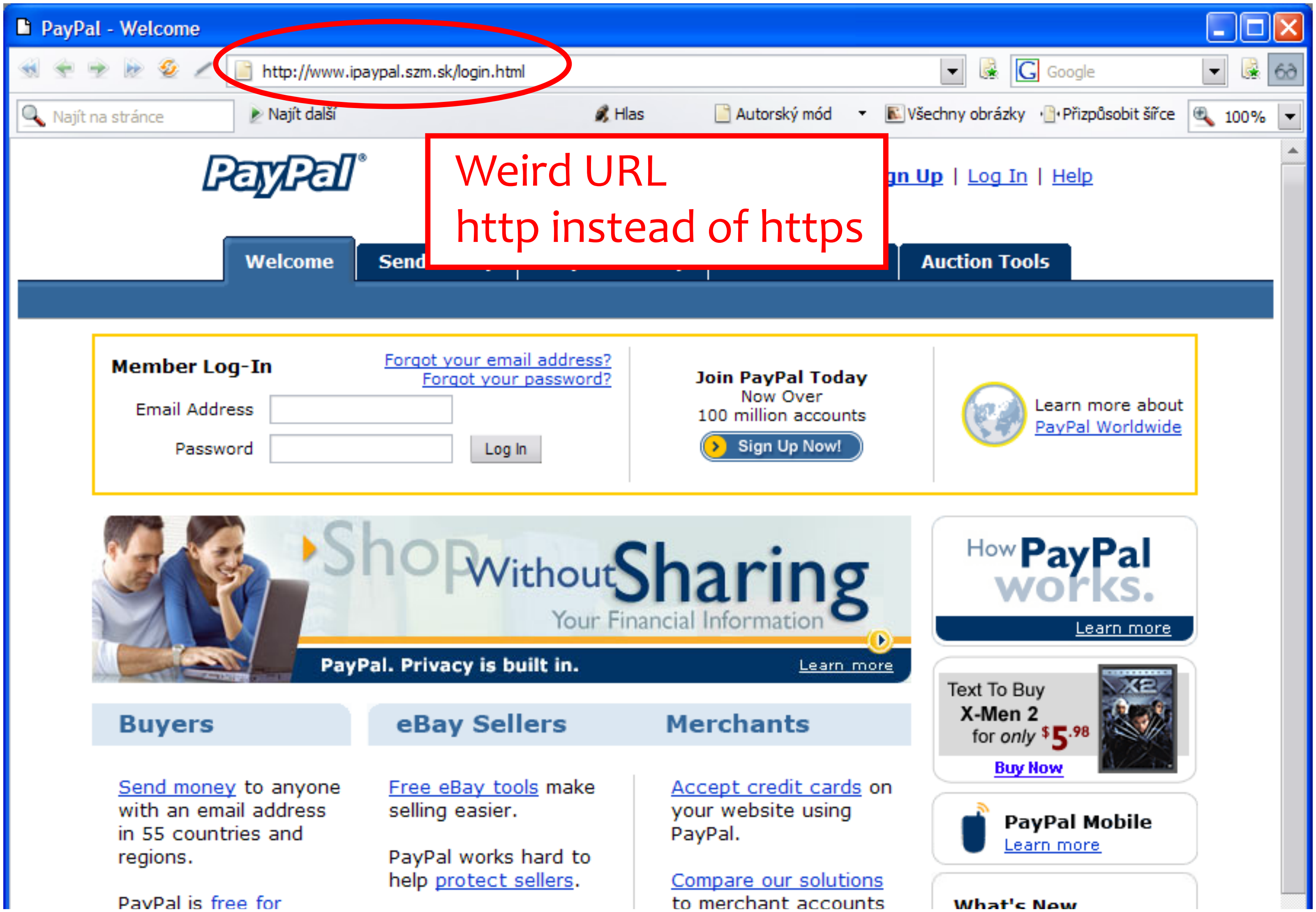
Usable Security Roadmap

- 2 case studies
  - Phishing
  - SSL warnings
- Step back: root causes of usability problems, and how to address

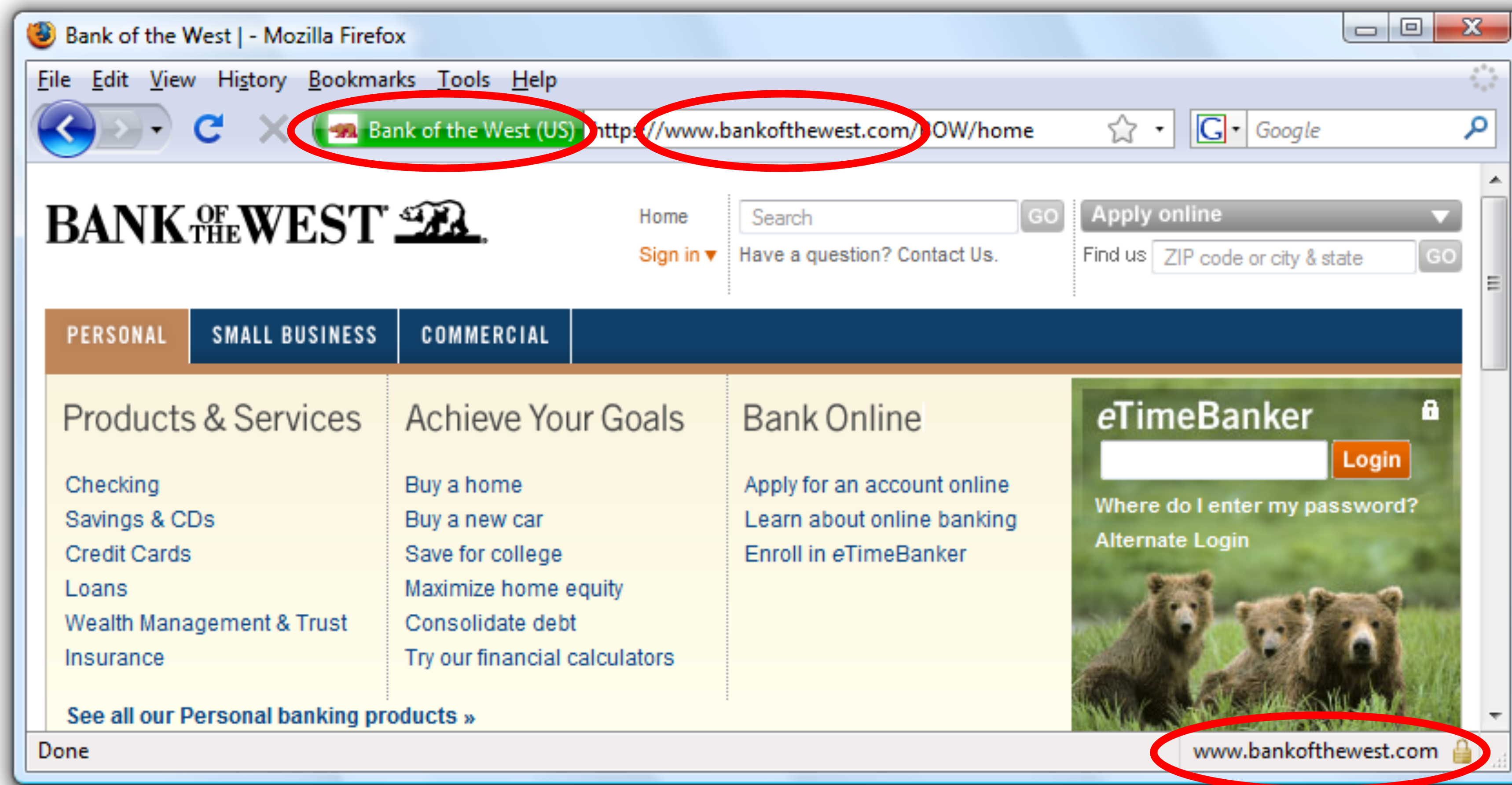
Case Study #1: Phishing

- Design question: How do you help users avoid falling for phishing sites?

A Typical Phishing Page



Safe to Type Your Password?



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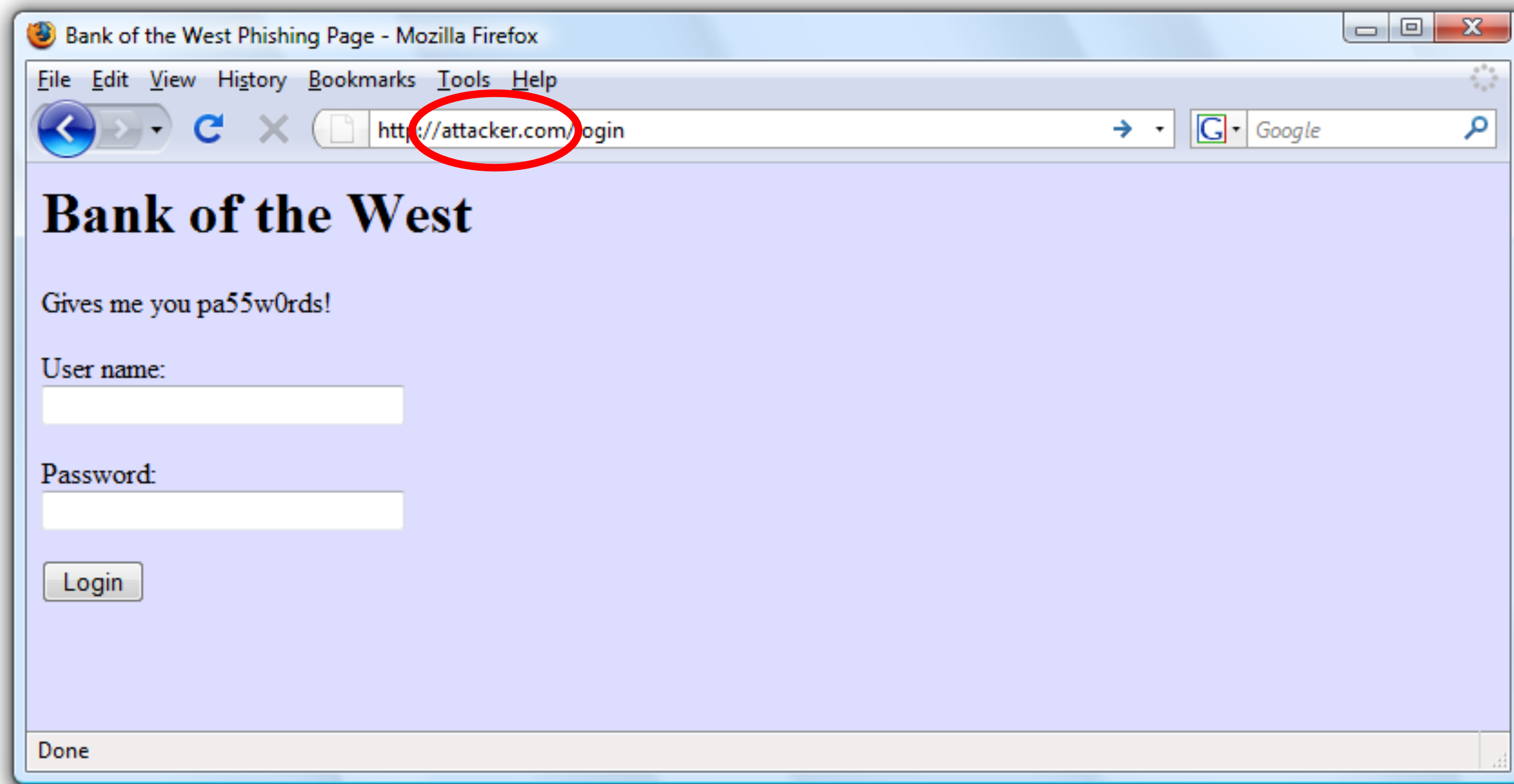

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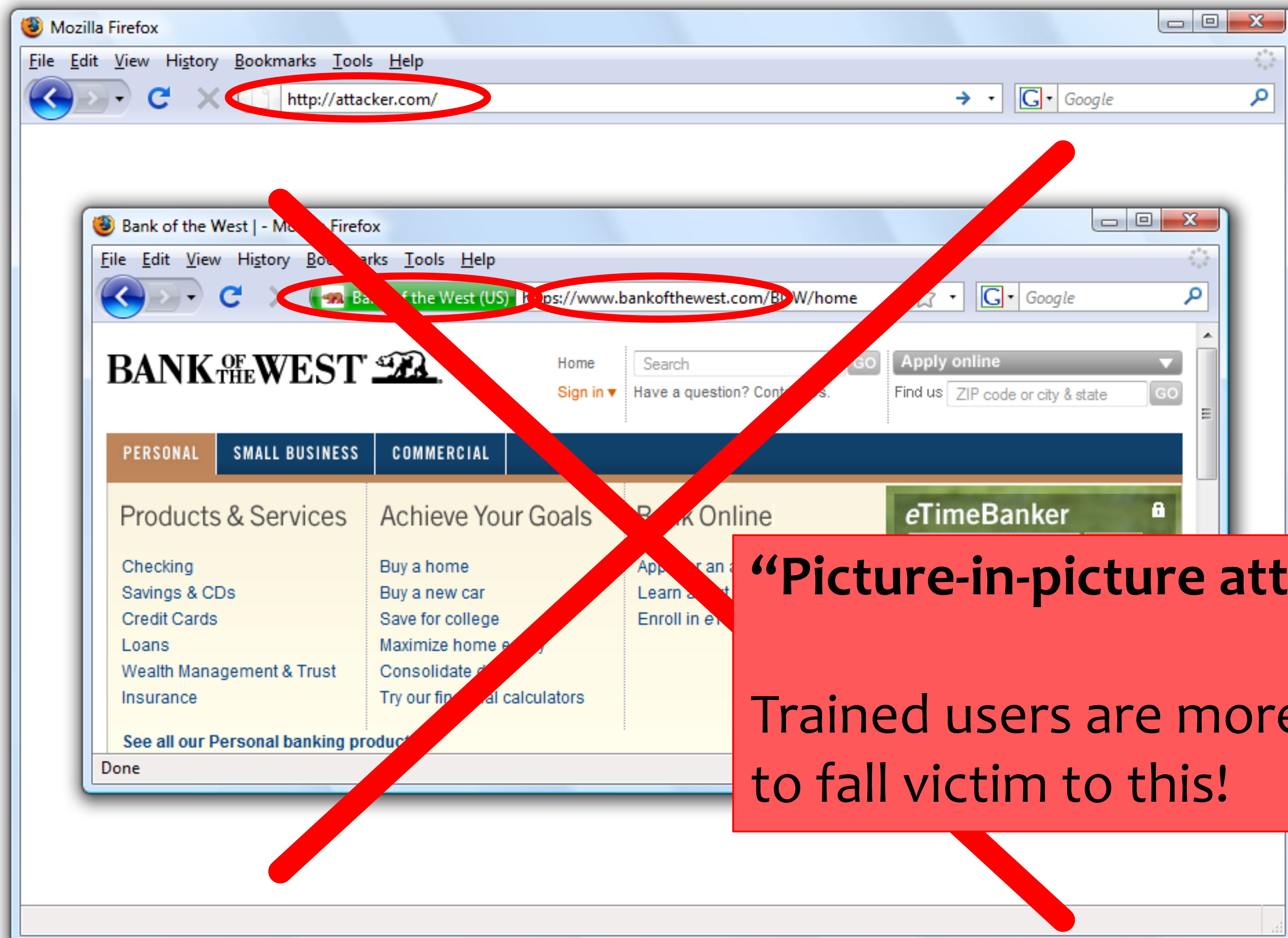


"Picture-in-picture attacks"

Trained users are more likely to fall victim to this!

Experiments at Indiana University

- Reconstructed the social network by crawling sites like Facebook, MySpace, LinkedIn and Friendster
- Sent 921 Indiana University students a spoofed email that appeared to come from their friend
- Email redirected to a spoofed site inviting the user to enter his/her secure university credentials
  - Domain name clearly distinct from indiana.edu
- 72% of students entered their real credentials into the spoofed site

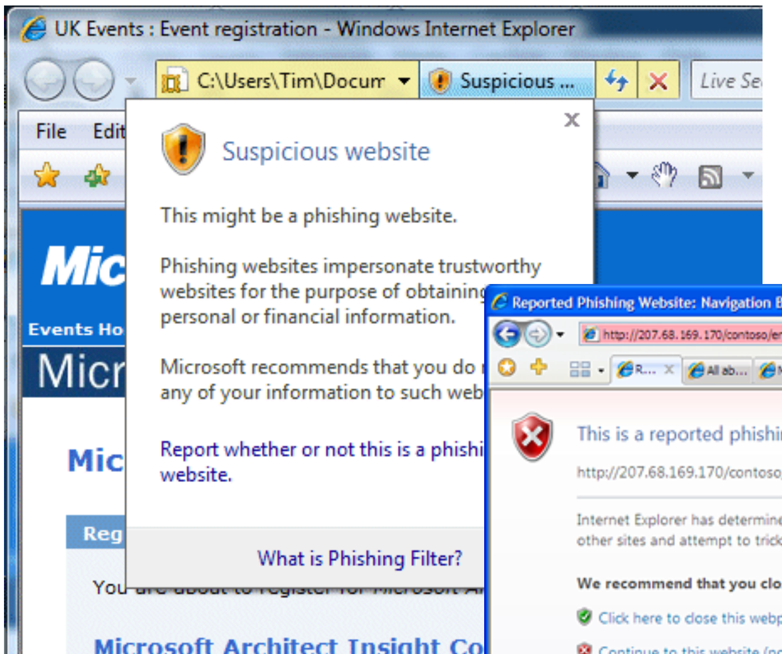
More Details

- Control group: 15 of 94 (16%) entered personal information
- Social group: 349 of 487 (72%) entered personal information

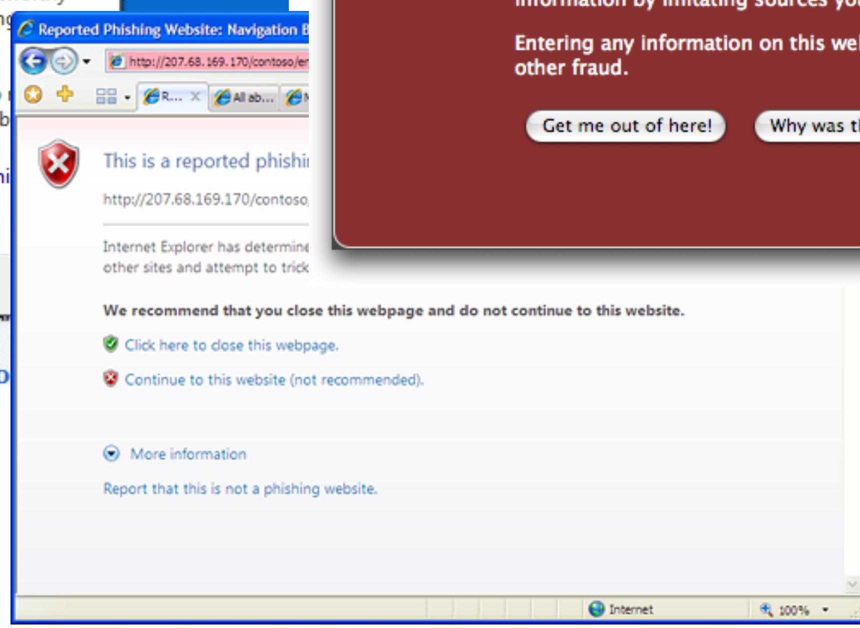
- 70% of responses within first 12 hours
- Adversary wins by gaining users' trust

- Also: If a site looks "professional", people likely to believe that it is legitimate

Phishing Warnings



Passive (IE)



Active (IE)

Active (Firefox)

[Egelman et al.]

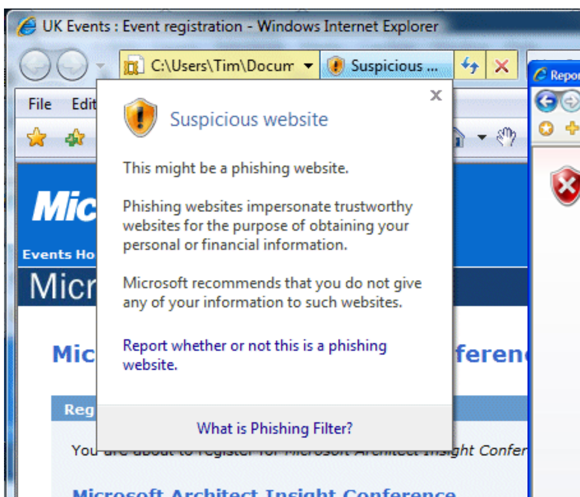
Are Phishing Warnings Effective?

- CMU study of 60 users
- Asked to make eBay and Amazon purchases
- All were sent phishing messages in addition to the real purchase confirmations
- Goal: compare active and passive warnings

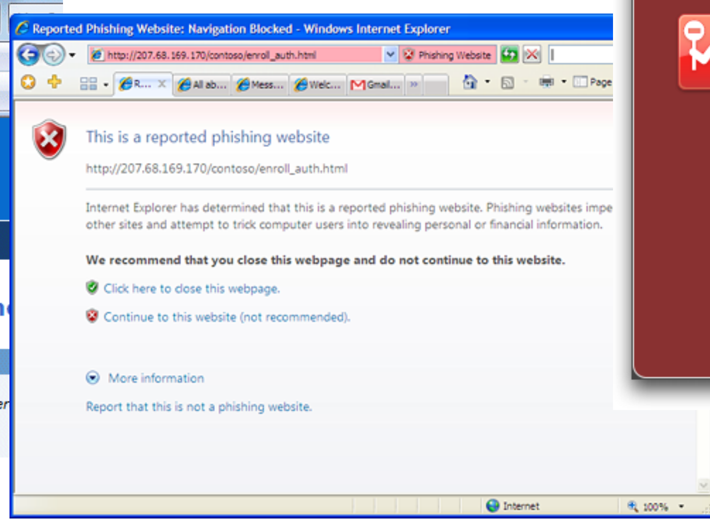
[Egelman et al.]

Active vs. Passive Warnings

- Active warnings significantly more effective
  - Passive (IE): 100% clicked, 90% phished
  - Active (IE): 95% clicked, 45% phished
  - Active (Firefox): 100% clicked, 0% phished



Passive (IE)



Active (IE)

Active (Firefox)

[Egelman et al.]

User Response to Warnings

- Some fail to notice warnings entirely
  - Passive warning takes a couple of seconds to appear; if user starts typing, his keystrokes dismiss the warning
- Some saw the warning, closed the window, went back to email, clicked links again, were presented with the same warnings… repeated 4-5 times
  - Conclusion: "website is not working"
  - Users never bothered to read the warnings, but were still prevented from visiting the phishing site
  - Active warnings work!

[Egelman et al.]

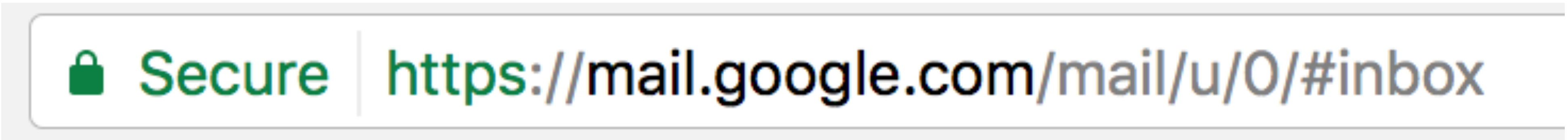
Why Do Users Ignore Warnings?

- Don't trust the warning
  - "Since it gave me the option of still proceeding to the website, I figured it couldn't be that bad"
- Ignore warning because it's familiar (IE users)
  - "Oh, I always ignore those"
  - "Looked like warnings I see at work which I know to ignore"
  - "I thought that the warnings were some usual ones displayed by IE"
  - "My own PC constantly bombards me with similar messages"

Case Study #2: Browser SSL Warnings

- **Design question 1:** How to indicate encrypted connections to users?
- **Design question 2:** How to alert the user if a site's SSL certificate is untrusted?

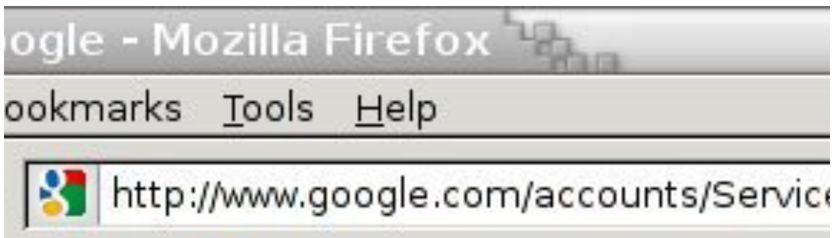
The Lock Icon



- Goal: identify secure connection
  - SSL/TLS is being used between client and server to protect against active network attacker
- Lock icon should only be shown when the page is secure against network attacker
  - Semantics subtle and not widely understood by users
  - Whose certificate is it??
  - Problem in user interface design

[Moxie Marlinspike]

Will You Notice?



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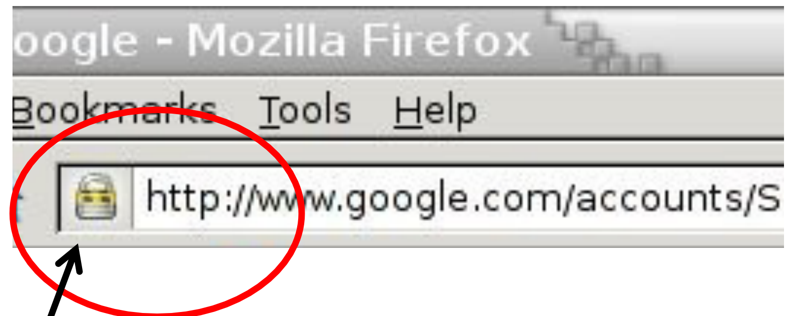


Clever favicon inserted by network attacker

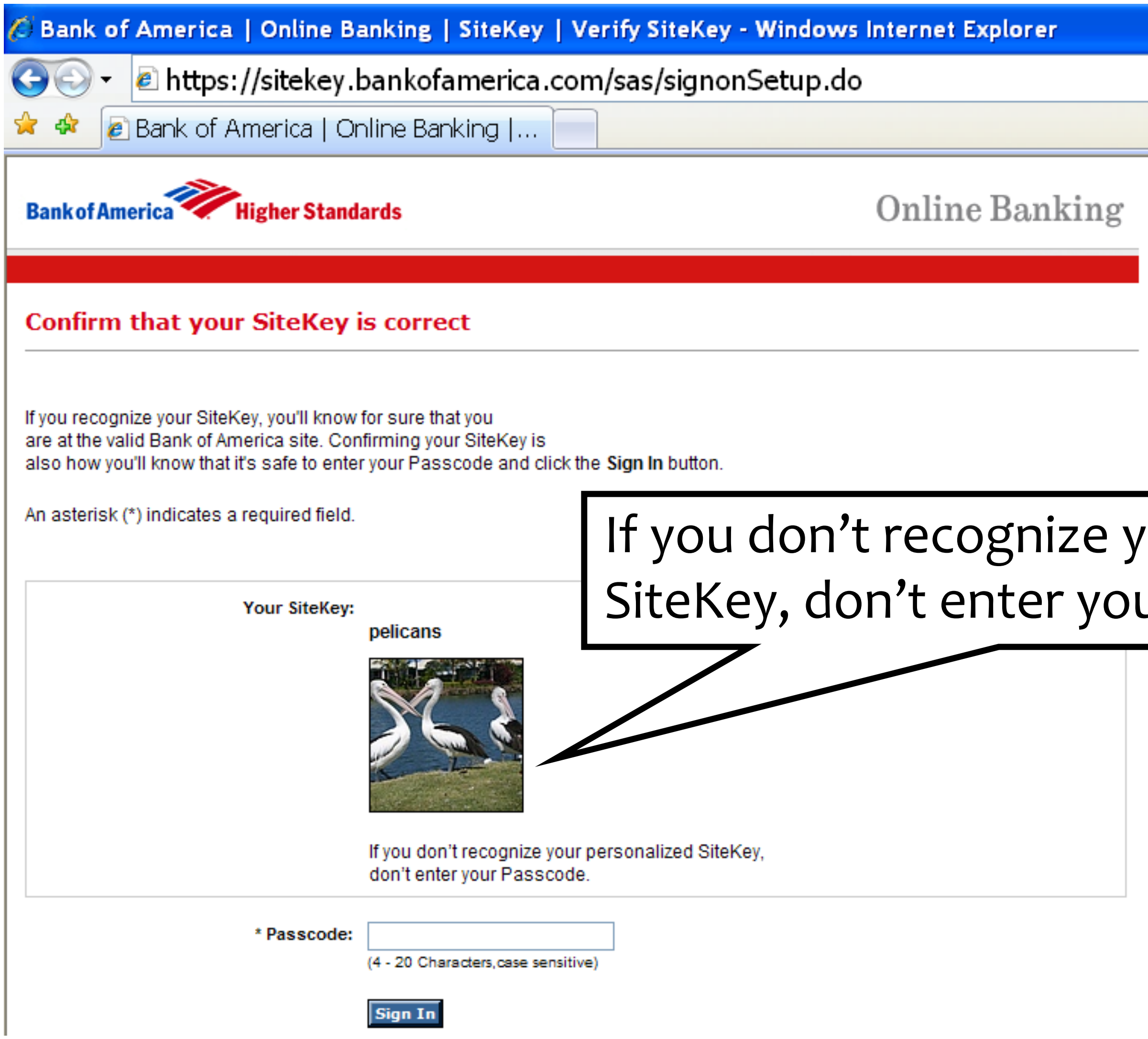
Do These Indicators Help?

- "The Emperor's New Security Indicators"
  - http://www.usablesecurity.org/emperor/emperor.pdf

		Group									
Score	*First chose* not *to enter password...*	*1*		*2*		*3*		*1* ∪ 2		*Total*	
0	upon noticing HTTPS absent	0	0%	0	0%	0	0%	0	0%	0	0%
1	after site-authentication image removed	0	0%	0	0%	2	9%	0	0%	2	4%
2	after warning page	8	47%	5	29%	12	55%	13	37%	25	44%
3	never (always logged in)	10	53%	12	71%	8	36%	22	63%	30	53%
	Total	18		17		22		35		57	

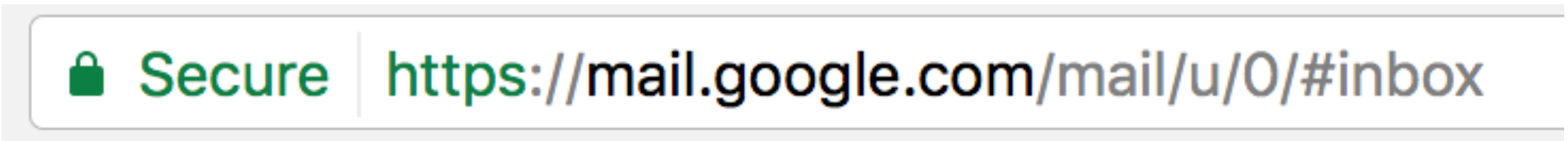
Users don't notice the **absence** of indicators!

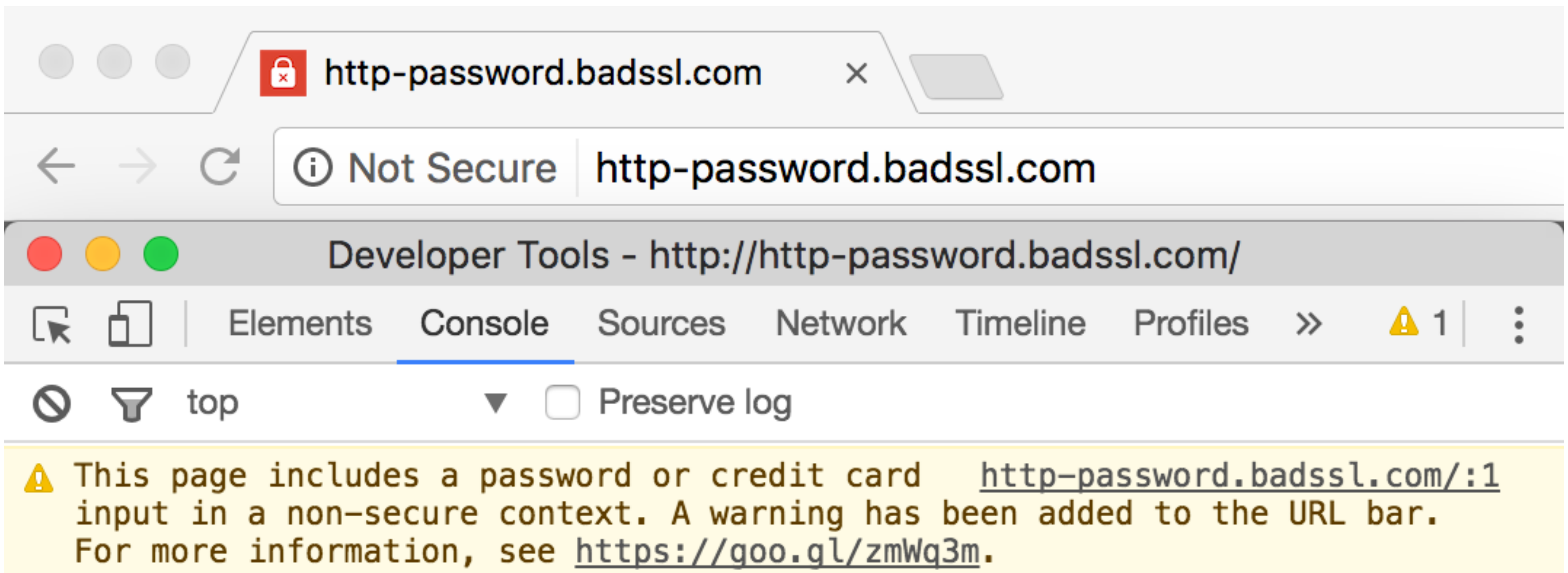
Aside (re: Phishing): Site Authentication Image (SiteKey)



If you don’t recognize your personalized SiteKey, don’t enter your Passcode

Latest Design in Chrome

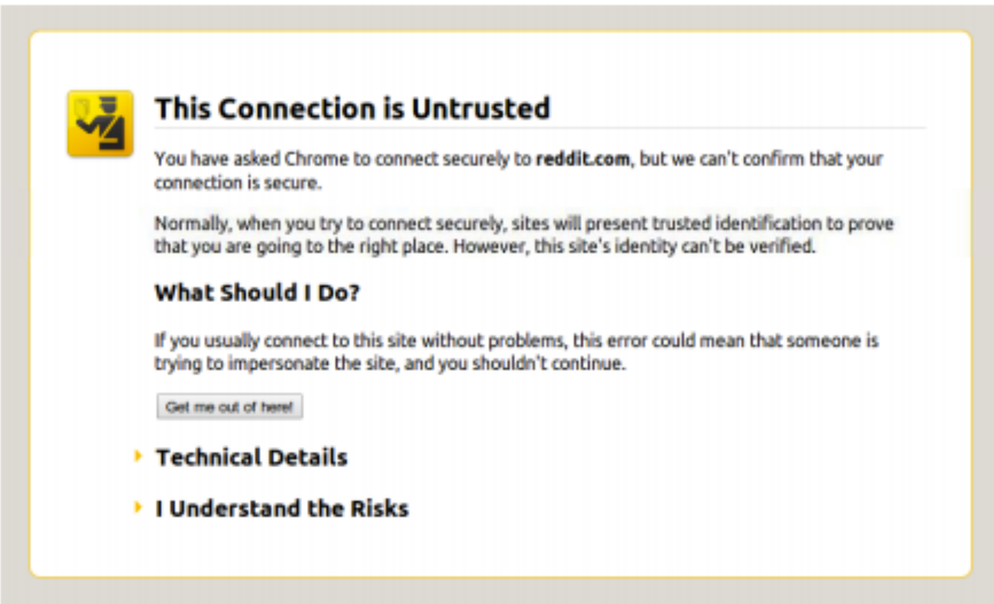


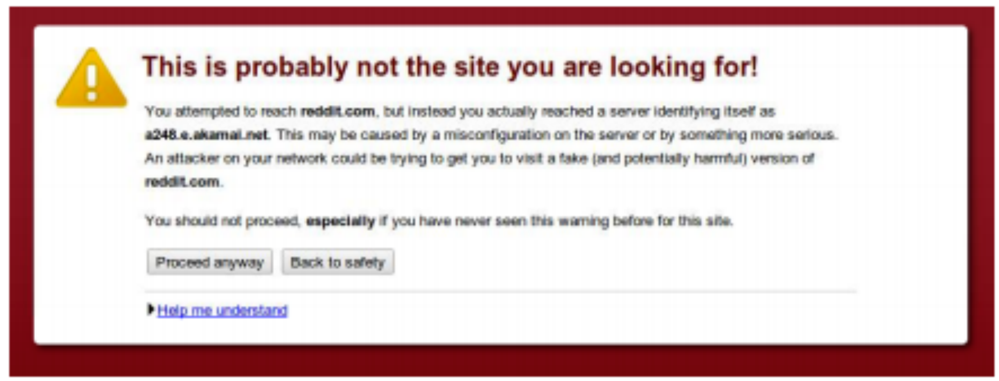


[Felt et al.]

Firefox vs. Chrome Warning

33% vs. 70% clickthrough rate





[Felt et al.]

Experimenting w/ Warning Design

#	Condition	CTR	N
1	Control (default Chrome warning)		
2	Chrome warning with policeman		
3	Chrome warning with criminal		
4	Chrome warning with traffic light		
5	Mock Firefox		
6	Mock Firefox, no image		
7	Mock Firefox with corporate styling		

Table 1. Click-through rates and sample size for conditions.

Experimenting w/ Warning Design

#	Condition	CTR	N
1	Control (default Chrome warning)	67.9%	17,479
2	Chrome warning with policeman		
3	Chrome warning with criminal		
4	Chrome warning with traffic light		
5	Mock Firefox		
6	Mock Firefox, no image		
7	Mock Firefox with corporate styling		

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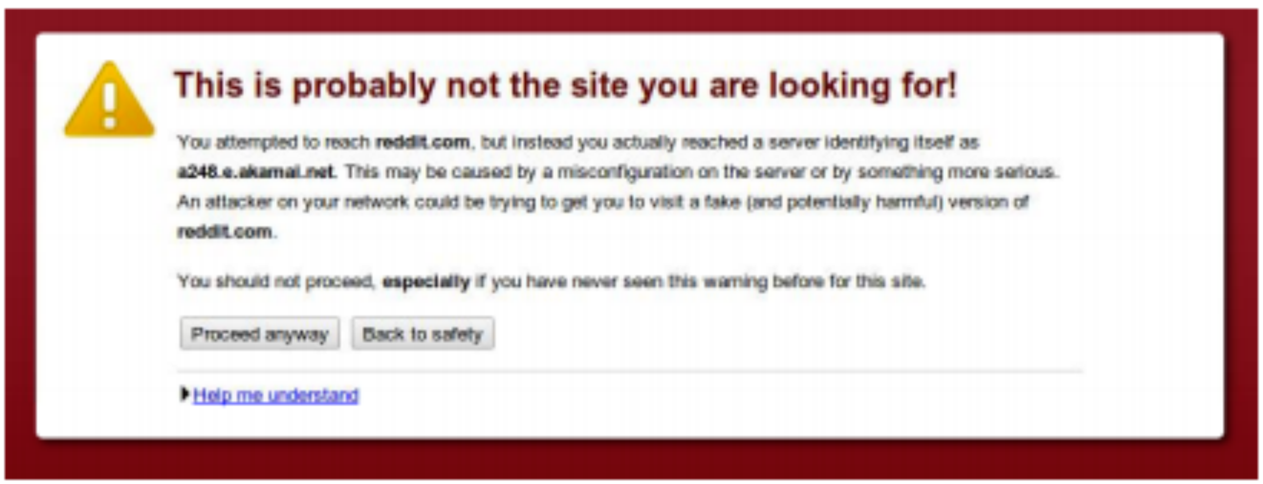

Figure 1. The default Chrome SSL warning (Condition 1).

Experimenting w/ Warning Design

#	Condition	CTR	N
1	Control (default Chrome warning)	67.9%	17,479
2	Chrome warning with policeman	68.9%	17,977
3	Chrome warning with criminal	66.5%	18,049
4	Chrome warning with traffic light	68.8%	18,084
5	Mock Firefox		
6	Mock Firefox, no image		
7	Mock Firefox with corporate styling		

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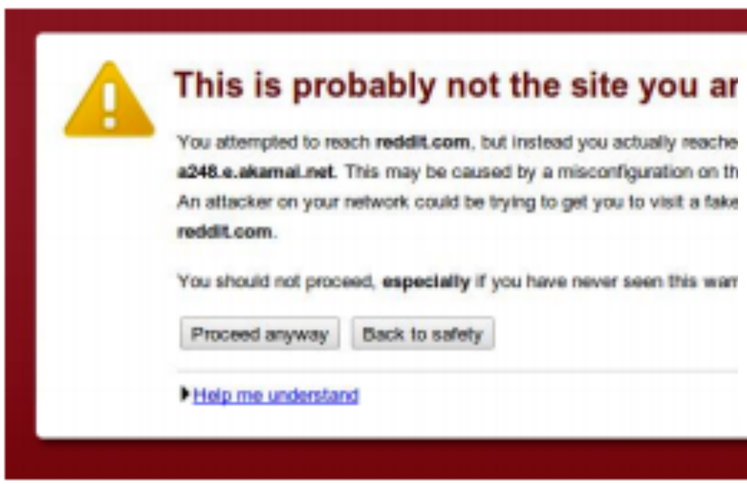

Figure 4. The three images used in Conditions 2-4.

Figure 1. The default Chrome SSL warning (Condition 1).

[Felt et al.]

Experimenting w/ Warning Design

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4	Chrome warning with traffic light	68.8%	18,084
5	Mock Firefox	56.1%	20,023
6	Mock Firefox, no image	55.9%	19.297
7	Mock Firefox with corporate styling		

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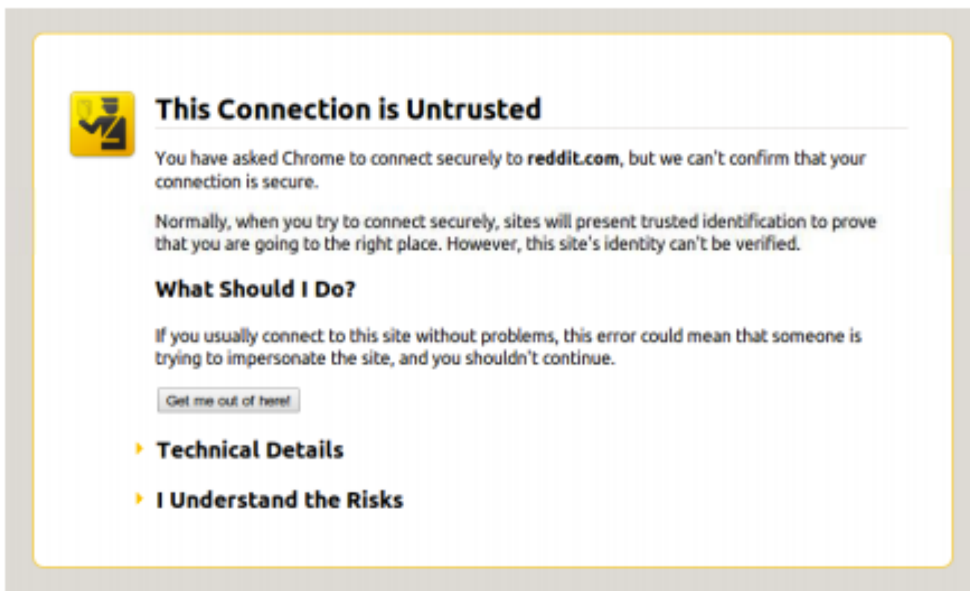

Figure 2. The mock Firefox SSL warning (Condition 5).

[Felt et al.]

Experimenting w/ Warning Design

#	Condition	CTR	N
1	Control (default Chrome warning)	67.9%	17,479
2	Chrome warning with policeman	68.9%	17,977
3	Chrome warning with criminal	66.5%	18,049
4	Chrome warning with traffic light	68.8%	18,084
5	Mock Firefox	56.1%	20,023
6	Mock Firefox, no image	55.9%	19,297
7	Mock Firefox with corporate styling	55.8%	19,845

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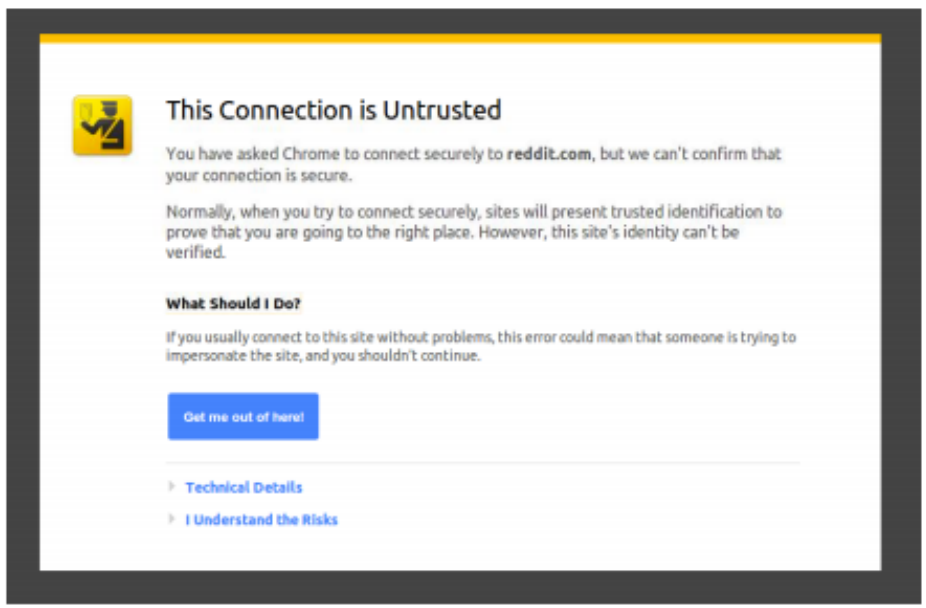
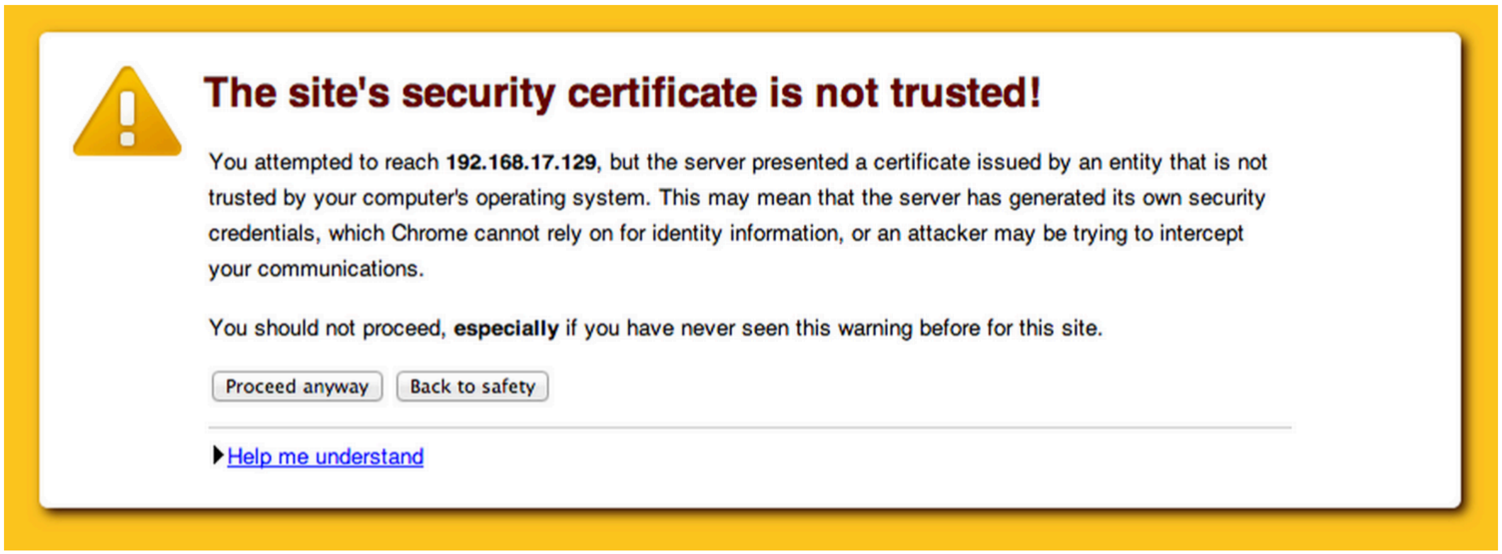


Figure 3. The Firefox SSL warning with Google styling (Condition 7).

[Felt et al.]

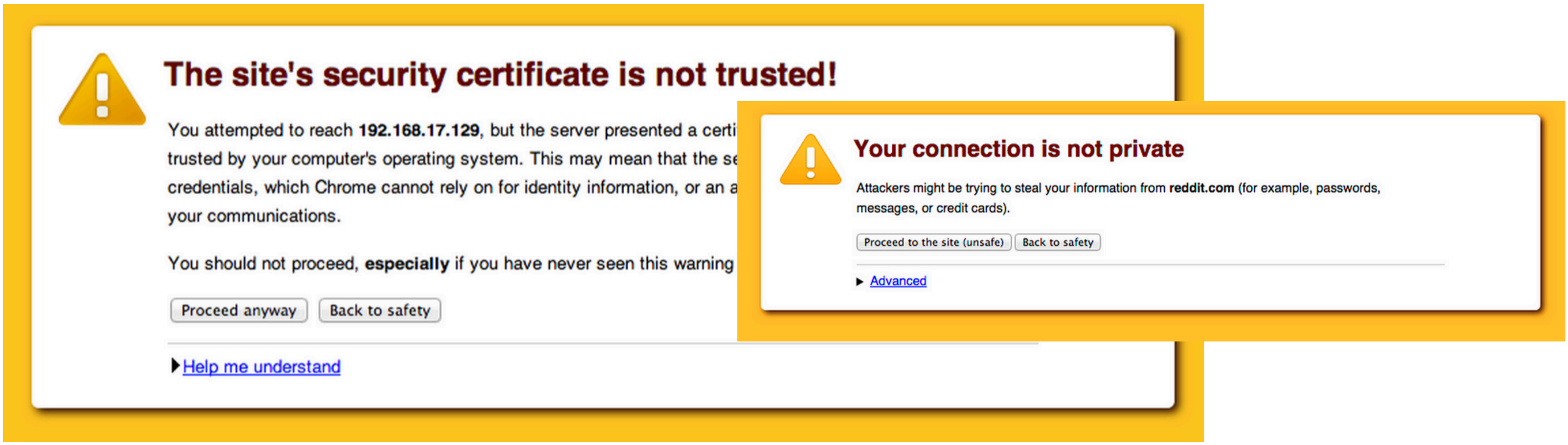
Opinionated Design Helps!

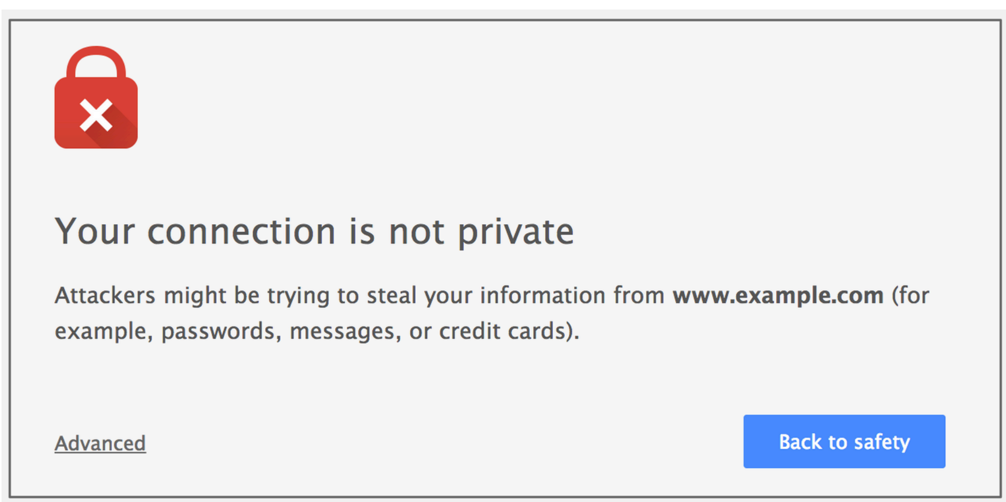


Adherence	N
30.9%	4,551

[Felt et al.]

Opinionated Design Helps!

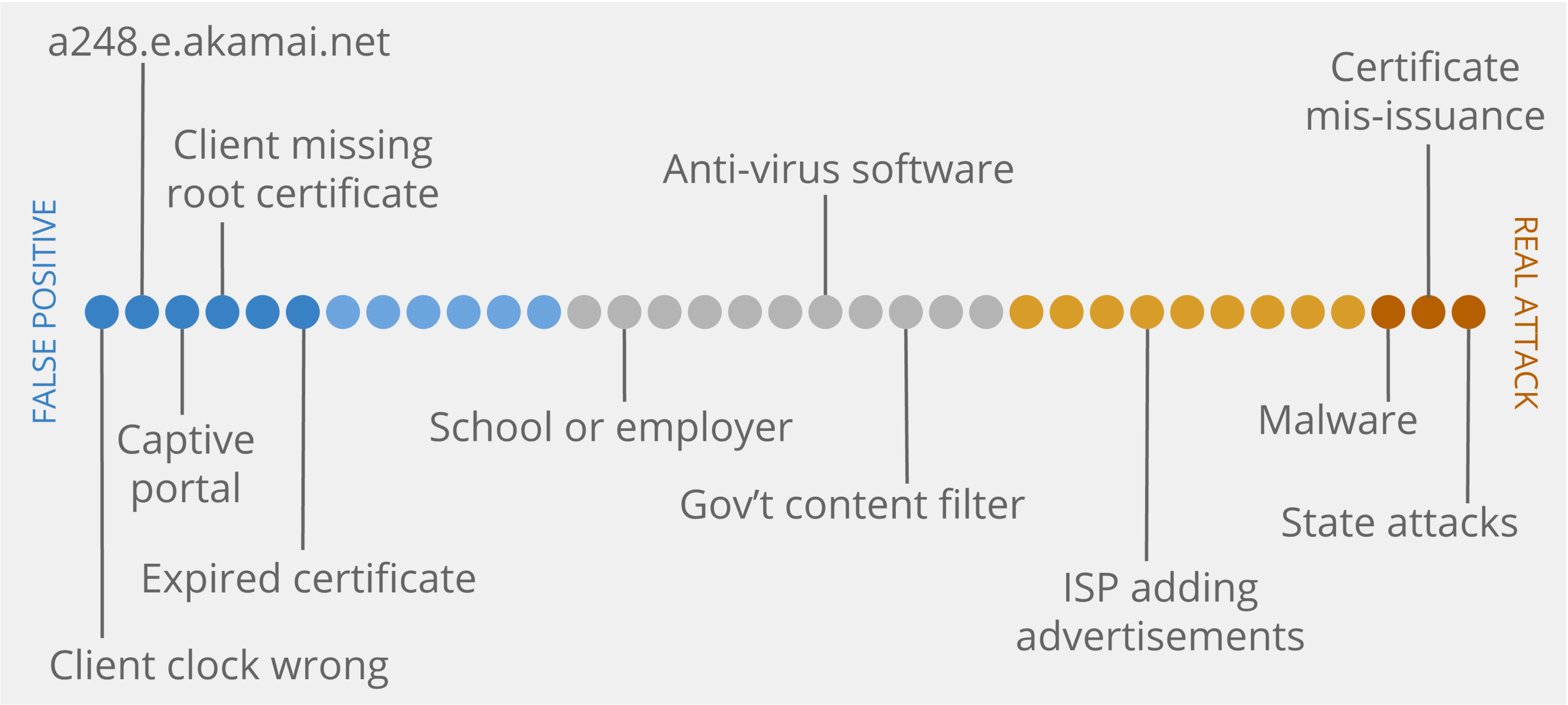




Adherence	N
30.9%	4,551
32.1%	4,075
58.3%	4,644

[Felt et al.]

Challenge: Meaningful Warnings



Stepping Back: 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?...

How to Improve?

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