CSE 484 / CSE M 584: Computer Security and Privacy

Mobile Platform Security [finish], Usable Security [start]

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

- Monday is a holiday!
- Project checkpoint #2 due Wed, 5/31, 11:59pm
- Lab 3 due Fri June 2, 8pm
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?
(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 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!
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.
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...
Aside: Incomplete Isolation

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

[Shekhar et al.]
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]

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<th>Codename</th>
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<th>Distribution</th>
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<tr>
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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
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Poor Usability Causes Problems

<table>
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<th>PARTY</th>
<th>PRESIDENT</th>
<th>VICE PRESIDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( REPUBLICAN )</td>
<td>GEORGE W. BUSH</td>
<td>DICK CHENEY</td>
</tr>
<tr>
<td></td>
<td>( DEMOCRATIC )</td>
<td>AL GORE, JOE LIEBERMAN</td>
</tr>
<tr>
<td></td>
<td>( LIBERTARIAN )</td>
<td>HARRY BROWNE, ART OLIVIER</td>
</tr>
<tr>
<td></td>
<td>( Green )</td>
<td>RALPH NADER, WINONA LA DUKA</td>
</tr>
<tr>
<td></td>
<td>( SOCIALIST WORKERS )</td>
<td>JAMES HARRIS, MARGARET TROWE</td>
</tr>
<tr>
<td></td>
<td>( NATURAL LAW )</td>
<td>JOHN HAGELIN, NAT GOLDHABER</td>
</tr>
</tbody>
</table>

**WRITE-IN CANDIDATE**
To vote for a write-in candidate, follow the directions on the long stub of your ballot card.

**TURN PAGE TO CONTINUE VOTING**
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
A Typical Phishing Page

Weird URL
http instead of https
Safe to Type Your Password?
Safe to Type Your Password?

Bank of the West

Gives me you pa55w0rds!

User name: 

Password: 

Login
Safe to Type Your Password?
Safe to Type Your Password?

“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)
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
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
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!
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”
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
Will You Notice?

Clever favicon inserted by network attacker
If you don’t recognize your personalized SiteKey, don’t enter your Passcode.
Do These Indicators Help?

• “The Emperor’s New Security Indicators”

Users don’t notice the absence of indicators!
Case Study #2: Browser SSL Warnings

• Design question: How to alert the user if a site’s SSL certificate is untrusted?
Firefox vs. Chrome Warning

33% vs. 70% clickthrough rate
Experimenting w/ Warning Design

<table>
<thead>
<tr>
<th>#</th>
<th>Condition</th>
<th>CTR</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control (default Chrome warning)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Chrome warning with policeman</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Chrome warning with criminal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Chrome warning with traffic light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Mock Firefox</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mock Firefox, no image</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mock Firefox with corporate styling</td>
<td></td>
<td></td>
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Table 1. Click-through rates and sample size for conditions.
Experimenting w/ Warning Design

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<td>17,479</td>
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Table 1. Click-through rates and sample size for conditions.

![Warning Design](image)

Figure 1. The default Chrome SSL warning (Condition 1).
# Experimenting w/ Warning Design

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<td>Chrome warning with criminal</td>
<td>66.5%</td>
<td>18,049</td>
</tr>
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<td>68.8%</td>
<td>18,084</td>
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Table 1. Click-through rates and sample size for conditions.

![Figure 1. The default Chrome SSL warning (Condition 1).](image1)

![Figure 4. The three images used in Conditions 2-4.](image2)
# Experimenting w/ Warning Design

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<td>56.1%</td>
<td>20,023</td>
</tr>
<tr>
<td>6</td>
<td>Mock Firefox, no image</td>
<td>55.9%</td>
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<td>Mock Firefox with corporate styling</td>
<td></td>
<td></td>
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</tbody>
</table>

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

![Mock Firefox SSL warning](image)

Figure 2. The mock Firefox SSL warning (Condition 5).
Experimenting w/ Warning Design

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

Figure 3. The Firefox SSL warning with Google styling (Condition 7).
Opinionated Design Helps!

Adherence | N
---|---
30.9% | 4,551
Opinionated Design Helps!

<table>
<thead>
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<th>Adherence</th>
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<td>30.9%</td>
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<tr>
<td>58.3%</td>
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Challenge: Meaningful Warnings

FALSE POSITIVE
- a248.e.akamai.net
- Client missing root certificate
- Captive portal
- Expired certificate
- Client clock wrong

REAL ATTACK
- Certificate mis-issuance
- Malware
- State attacks
- ISP adding advertisements
- Gov’t content filter
- School or employer
- Anti-virus software
- [Felt et al.]
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
- ...?