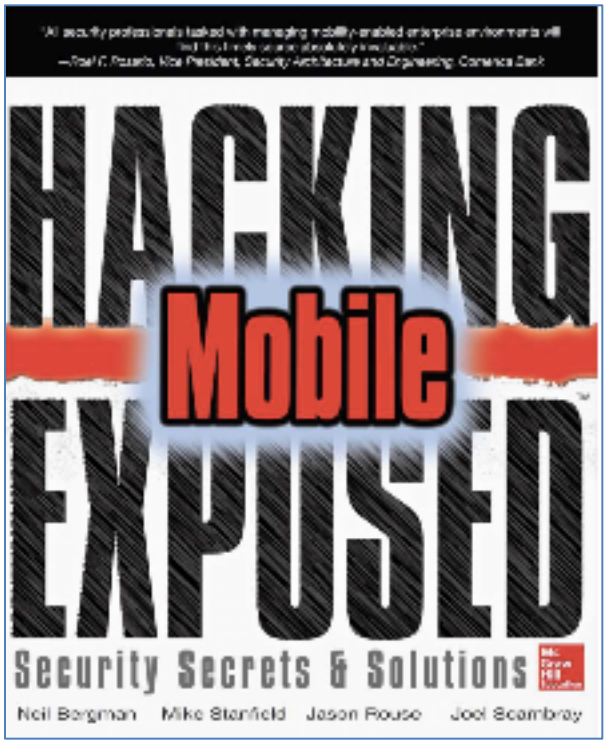
Ch 8: Mobile Development Security



CNIT 128: Hacking Mobile Devices

Revised 4-12-17

App Security Constraints

- Built-in security features of the mobile platform
- Possibility of device theft

Mobile App Threat Modeling

Threat Modeling

- A pencil-and-paper exercise
- Identifying security risks
- Helps developer identify most critical risks
- Focus on features and/or controls to mitigate those risks
- The alternative is endless, aimless, bug-squashing

Threat Modeling Technologies

- Microsoft Threat Modeling
  - From 1999 (link Ch 8a)
- Trike
  - Open-source, began in 2006 (link Ch 8b)
  - More traditional risk management philosophy

Threat Modeling Technologies

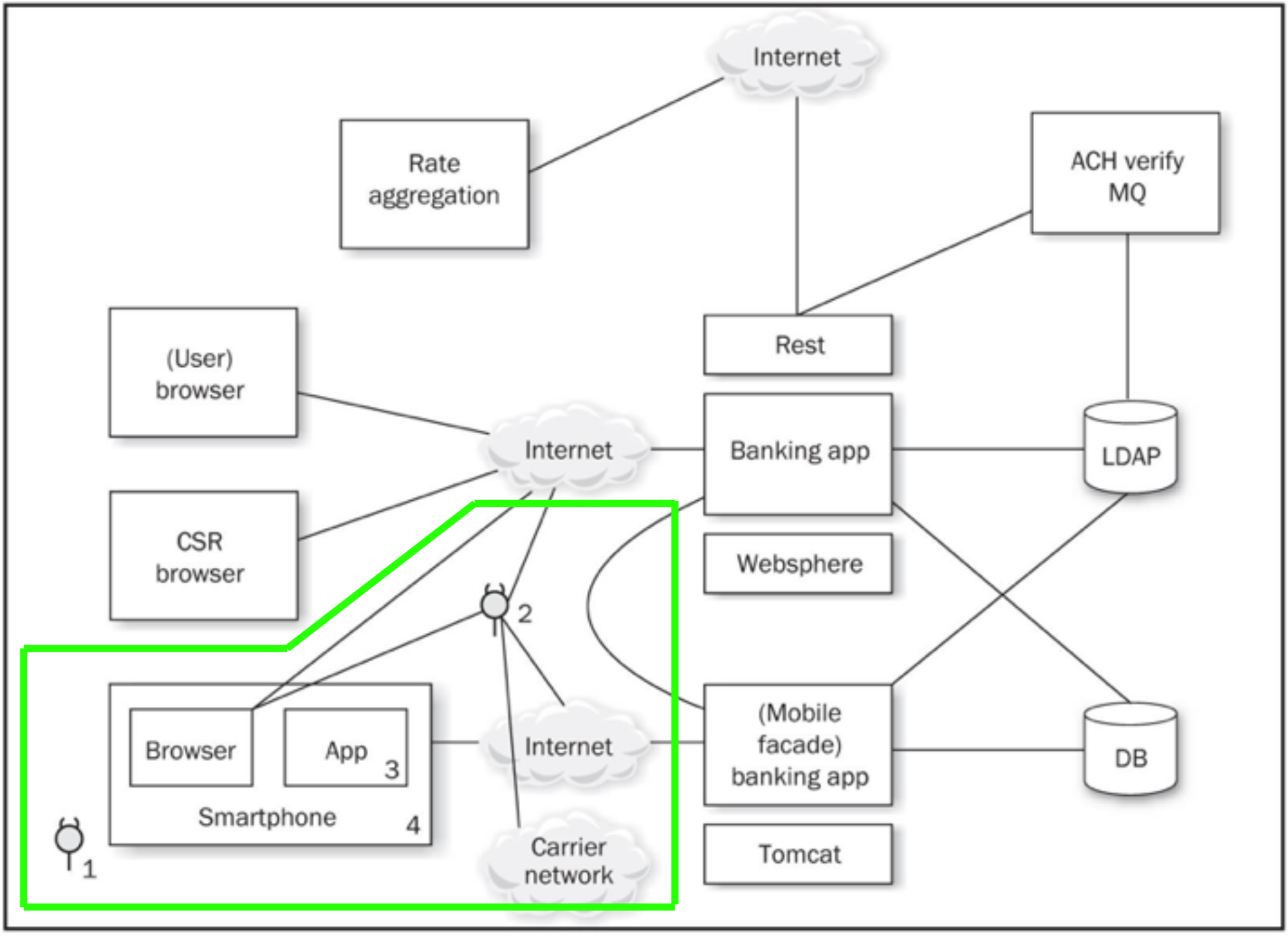
- OCTAVE (Operationally Critical Threat, Asset, and Vulnerability Evaluation)
  - From CERT (link Ch 8c)
- Cigital Threat Modeling
  - Based on software architecture (link Ch 8d)
- P.A.S.T.A. (Process for Attack Simulation and Threat Analysis)

Similar Approach

- Diagram the app
- Understand where information assets flow
- Document risks to the assets and security controls
- Rank the risks by probability and impact
- Remediate and verify highest-scored risks

Example: Adding a Mobile Client to an Existing Web App

- New client will support end users and Customer Support Representatives (CSRs)
- How do existing threats change when a mobile app is added?
  - Enumerate threats
  - Outline assets mobile devices possess
  - Discuss how the mobile tech stacks create opportunities for threats


Internet
Rate aggregation
ACH verify MQ
(User) browser
Rest
Internet
Banking app
LDAP
CSR browser
Websphere
2
Browser
App
3
Smartphone
4
Internet
(Mobile facade) banking app
DB
1
Carrier network
Tomcat

Threats

- Web app hacking tools
- Bluetooth and 802.11 attacks
- Injecting code into a mobile browser
  - Man-in-The-Browser (MiTB)
- Malicious apps
  - Malware and Trojans
- Femtocells
  - Observe all traffic

Threats from Phone's User

- Download your app and reverse-engineer it
- Jailbreak the device, subverting controls you depend on
- Thieves may steal the device and gain access to the UI and physical interfaces such as USB

1. Users as Threats

- What evil or insidious things could a user do?
  - Steal encryption keys or credentials from apps
  - Reverse-engineer apps
- What obnoxious or stupid things could a user do to cause trouble?

Other Device "Owners" as Threats

- Other stakeholders
  - App store account owner
  - App publisher, who provides the user experience and access to mobile services
  - Mobile carrier, e.g. AT&T
  - Device manufacturer: Samsung, etc.
  - App store curator: Apple, Google, Amazon, etc.
  - Company's IT dept. that administers the device

Importance of Other Stakeholders

- Operate apps and underlying software
- Control credentials
- Operate services
- Carriers and handset manufacturers place apps on the device
  - May customize the OS
  - May place code beneath the OS in firmware

Importance of Other Stakeholders

- App store curators control a large portion of the app lifecycle
  - Packaging and deployment
  - Update and removal
- When stakeholder goals differ
  - Opportunity for one "owner" to do something that another stakeholder considers a violation of security or privacy
  - Like collecting and storing personal information

Assets

- Each stakeholder protects its assets
- End-users may value privacy
- App publisher and carrier want to collect and use personal and usage information

Types of Data

- Offline access
  - Available when phone is not connected to a network
- Personal data
  - Contacts, voicemails
- Sensor-based data
  - Location data (GPS and tower telemetry)
  - Camera and microphone data

Identity Data

- App publishers are reluctant to force users to authenticate using small virtual keyboards
- Identity data includes
  - Persistent credentials
  - Bearer tokens (such as OAuth)
  - Usernames
  - Device-, user-, or application-specific UUIDs

Usernames

- If a web-based service uses a mobile device for "out-of-band" password reset
- And a user has an app for that service
- Attacker with a stolen phone can reset the password

Threat Modeling

- Derive the attack surface and potential attacks
  - List assets and stakeholders
  - Brainstorm how each stakeholder might cause a security or privacy breach for another
- Prioritize attacks by likelihood and impact
- Implement mitigations
- Use the list of attacks to drive Secure Software Development Lifecycle

Secure Mobile Development Guidance

Threat modeling

- Mobile app has two main components
  - Mobile client
  - Mobile Web services that support it
- Both can be attacked

Native APIs or Mobile Web?

- Apps written specifically for the platform, using native APIs
  - Take full advantage of the platform's features
  - User interface consistent with platform
- Mobile Web apps
  - Same as web app, but optimized for a smaller screen
- Cross-platform mobile development frameworks try to provide the best of both worlds

Device and Runtime Environment Integrity

- How can an app ensure that the OS hasn't been modified?
  - Or even the app itself?
- Mobile Device Management
  - Provides some assurance
- App integrity protection
  - Anti-debugging and code obfuscation

Limitations of Integrity Assurance

- If device is jailbroken or rooted
  - Environment can lie about what's happening
- Mobile Application Management (MAM)
  - Some provide private app stores
  - For closed-loop provisioning, patching, uninstallation, monitoring, and remote data wipe
- Maintaining/Patching your App
  - The app store is the main channel for updates

Secure Mobile App Guidelines

Category	Security Considerations
Traditional web application security (plus)	Secure mobile services with web application security Creating a walled garden for mobile access Reducing session timeout for mobile sessions Using a secure JavaScript subset Masking or tokenizing sensitive data
Storing sensitive data on the device	Avoid it! Mobile device sensitive data Security hardware Secure platform storage Mobile databases File system protections
Authenticating to mobile services	Authorization and authentication protocols Always generate your own identifiers Implement a timeout for cached credentials
Secure communications	Use only SSL/TLS Validate server certificates Use certificate pinning for certificate validation
WebView interaction	WebView cache WebView and JavaScript bridges
Preventing information leakage	Clipboard Logs

Secure Mobile App Guidelines

Additional iOS platform-specific guidelines	Traditional C application secure coding guidelines Keyboard cache Enable full ASLR using PIE Custom URI schemes guidelines Protect the stack Enable automatic reference counting Disable caching of application screenshots
Additional Android platform-specific guidelines	Traditional C++/Java application secure coding guidelines Ensure ASLR is enabled Secure intent usage guidelines Secure NFC guidelines

Secure Mobile App Guidelines

- Web app security
  - OWASP Top Ten
- Create a walled garden
  - Requests to Web app should parse the user-agent string to detect mobile requests
  - Redirect traffic to mobile interfaces/services
  - Don't serve mobile apps same content as computers
  - Legacy content may be aggressively cached by mobile browsers

Secure Mobile App Guidelines

- Reduce session timeout for mobile devices
  - Greater risk of MiTM attacks
  - Greater risk of device theft
- Use a secure JavaScript subset
  - Remove eval(), square brackets, "this"
  - Secure JavaScript subsets:

Resource	Link
ADSafe	adsafe.org
dojox.secure	dojotoolkit.org/reference-guide/1.8/dojox/secure.html
Caja	code.google.com/p/google-caja/
Microsoft Web Sandbox	websandbox.livelabs.com/

The Dangers of Square Bracket Notation

Issue #1: Bracket object notation with user input grants access to every property available on the object.

```
exampleClass[userInput[1]] = userInput[2]
```

- It can even lead to remote code execution
  - Link Ch 8f

Secure Mobile App Guidelines

- Mask or Tokenize Sensitive Data
  - Mobile devices have aggressive data caching
  - Increased risk of data exposure
  - Replace sensitive data with an alternate representation "mask" or "token"

Secure Mobile App Guidelines

- Storing sensitive data on the device
  - Avoid storing sensitive data when possible
  - Places to store data, strongest to weakest
    - Security hardware
    - Secure platform storage
    - Mobile databases
    - File system

Mobile Device Sensitive Data

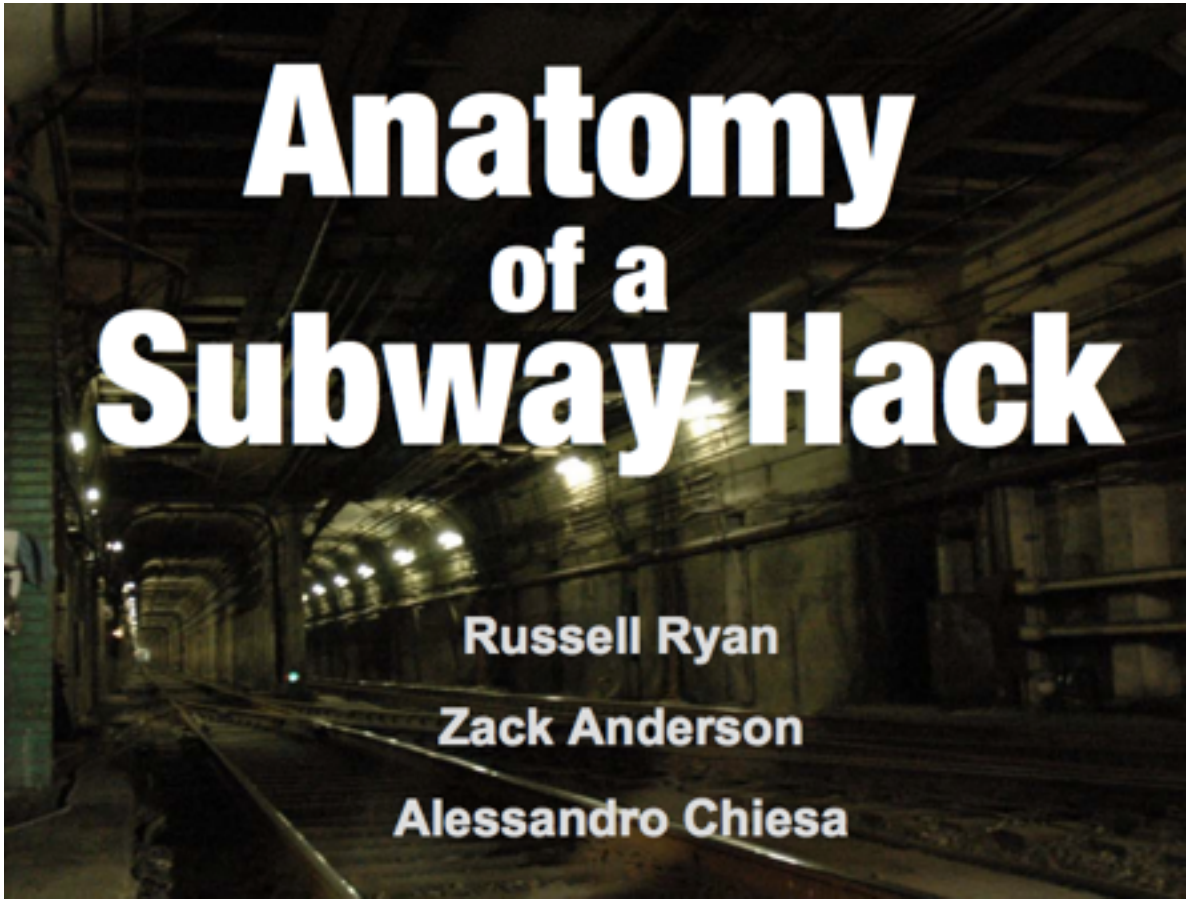
- Personal data
  - Contacts, pictures, call data, voicemails, etc.
- Sensor-based data
  - GPS, camera, microphone
- Identity data
  - Persistent credentials
  - Bearer tokens (like OAuth)
  - Usernames
  - Device-, user-, or application-specific UUIDs

Security Hardware

- Secure Element (SE) microprocessor
  - Used for mobile payment systems
  - Accessed using existing smartcard standards
    - ISO 7816 (contact)
    - ISO 14443 (contactless)
  - Considered fairly secure
  - Locks out after 5 to 10 failed PIN attempts
    - When used for a virtual wallet
  - BUT general-purpose apps don't have access to the SE

ISO 14443: MIFARE

- Used by BART and Boston T system
- MIFARE Classic used a 48-bit key
- Several vulnerabilities have been found


Anatomy
of a
Subway Hack
Russell Ryan
Zack Anderson
Alessandro Chiesa

- Link Ch 8k

Secure Platform Storage

- Apple's keychain
  - SQLite database
  - Protected by an OS service that limits access
  - Keychain items can only be accessed by the app that stored them
    - And other apps from the same developer
    - BUT root user can read the keychain

Keychain Weakness

- Root user can read everything in the keychain
  - Link Ch 8l

New open-source app extracts passwords stored in Mac OS X keychain

Proof-of-concept Keychaindump extracts passwords for all logged-in users.

by **Dan Goodin** - Sep 6, 2012 8:04am PDT

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Android KeyStore

- Intended to store cryptographic keys
- Has no inherent protection mechanism such as a password
- Apps must provide a mechanism like this to protect sensitive information;
  - Password from user
  - Use Password-Based Key Derivation Function 2 (PBKDF2) to generate an AES key
  - Encrypt data with AES

Mobile Databases

- Database can be encrypted with a single secret with third-party extensions to SQLite
  - SEE, SQLCipher, CEROD
- Apparently innocent data may expose personal identity
  - Such as images
- SQL injection attacks are possible
  - Via intents or network traffic
  - So use parameterized queries

File System Protections in iOS

- Default encryption of files on the data partition
- Centrally erasable metadata
- Cryptographic linking to a specific device, so files moved from one device to another are unreadable without the key
- Enabled by default in iOS 5 and above
- Apple's iOS Security White Paper (link Ch 8m)

File System Protections in Android

- Files stored in internal storage are private to the app that created them
  - Unless the app changes the default Linux file permissions or uses MODE_WORLD_WRITEABLE or MODE_WORLD_READABLE
- Files stored in external storage (such as SD cards) are accessible to all applications
- Android 3.0 and later provides file-system encryption

Google's 'encrypted-by-default' Android is NOT encrypting by default

It's sad that this isn't really a surprise

Google got in touch with us after publication to say:

> **In September, we announced that all new Android Lollipop devices would be encrypted by default. Due to performance issues on some Android partner devices we are not yet at encryption by default on every new Lollipop device.**
>
> **That said, our new Nexus devices are encrypted by default and Android users (Jelly Bean and above) have the option to encrypt the data on their devices in Settings ---> Security ---->Encryption. We remain firmly committed to encryption because it helps keep users safe and secure on the web.**

- From March 2, 2015
  - Link Ch 8o

Authenticating to Mobile Services

- As previously covered, OAuth and SAML make it possible to avoid storing or using a password in your mobile app
  - As if any developers cared...

Always Generate Your Own Identifiers

- Apps have used existing identifiers like
  - IMEI number, MAC address, phone number, etc.
- To identify users and devices
- But what happens when a device is stolen or sold?
- Also such identifiers often lack secrecy and entropy
  - Phone number is often publicly listed on Facebook, etc.

More Recommendations

- Implement a Timeout for Cached Credentials
  - Good for security but inconvenient
  - Rarely done
- Secure Communications
  - Use Only TLS
  - Direct HTTPS communications resist man-in-the-middle attacks including sslstrip
- Validate Server Certificates

Use Certificate Pinning for Validating Certificates

- Adds another step to verifying a server certificate
- Compares the certificate to a trusted copy of the certificate included in the app
- Exploits the special relationship between the app and the server
- The app can be more secure than a Web browser because it knows which server it should be connecting to

WebView Interaction

- WebView Cache Threats
  - May contain sensitive web form and authentication pages
  - If a user chooses to save credentials in the browser, they are in the cache
  - WebView cookies database could be used to hijack sessions with banks and other websites

WebView Interaction

- WebView Cache Mitigations
  - Disable autocomplete on all sensitive form inputs
  - Set no-cache HTTP header on server
  - WebView object on the client side can be set to never save authentication data and form data
  - Use clearCache() method to delete files stored locally on the device
  - On Android, you must delete files explicitly because clearCache() doesn't erase them all

WebView Interaction

- WebView Cache Mitigations
  - To reduce the risk from cached cookies, set up a session timeout on the server
  - Cookies should never be set to persist for a long time
  - To clear cookies on the client, use the CookieManager or the NSHTTPCookieStorage classes
  - On iOS, use NSURLCache to remove cached responses

WebView and JavaScript Bridges

- On Android, protect against reflection-based attacks by targeting API 17 or above
- On older devices:
  - Only use addJavaScriptInterface if really needed
  - Develop a custom JavaScript bridge with shouldOverrideUrlLoading
  - Reconsider why you need a bridge and remove it if feasible

WebView Countermeasures

- If an app uses a custom URI scheme
  - Be careful what functionality is exposed
  - Use input validation and output encoding to prevent injection attacks

Preventing Information Leakage

- Clipboard
  - Android and iOS support copy-and-paste
  - Access to clipboard is fairly unrestricted
  - Take explicit precautions to avoid sensitive data entering the clipboard
  - On Android, cell setLongClickable(false) on a field
  - On iOS, subclass UITextView to disable copy/paste

Preventing Information Leakage

- Logs
  - Watch for sensitive data in system and debug logs
  - Or the device driver dmesg buffer
  - Any Android app with the READ_LOGS permission can view the system log
  - On iOS, disable NSLog statements
  - X:Y coordinate buffers can expose PINs or passwords

iOS-Specific Guidelines

iOS-Specific Guidelines

- Keyboard cache
  - MDMs can add an enterprise policy to clear the keyboard dictionary at regular intervals
  - Users can do this with Settings, General, Reset, "Reset Keyboard Dictionary"
- Enable full ASLR
  - Usually on by default
  - Sometimes developer must explicitly code for it

iOS-Specific Guidelines

- Custom URI Scheme Guidelines
  - Use openURL instead of the deprecated handleOpenURL
  - Validate the sourceApplication parameter to restrict access to the custom URI to a specific set of applications
  - Validate the URL parameter; assume it contains malicious input

iOS-Specific Guidelines

- Protect the stack
  - With gcc, use –fstack-protector-all to enable Stack Smashing Protection (SSP)
  - Apple LLVM compiler automatically enables SSP
- Enable automatic reference counting
  - Automatically manages memory for Objective-C objects and blocks
  - Reduces chance of use-after-free vulnerabilities
  - And other C memory-allocation problems

iOS-Specific Guidelines

- Disable caching of application screenshots
  - iOS captures the screen when an app is suspended
  - Such as when user clicks the Home button or the Sleep/Wake button
  - Or the system launches another app
  - It does this to show transition animations
  - This could capture sensitive data
  - Prevent this by specifying a splash screen to display upon entering the background

Android-Specific Guidelines

Android-Specific Guidelines

- Traditional C++/Java secure coding
  - Google recommends using Java rather than C ++; it's more secure
- Ensure ASLR is Enabled
  - C and C++ must be compiled and linked with PIE

Secure Intent Usage

- Public components should not trust data received from intents
- Perform input validation on all data from intents
- Use explicit intents where possible
- Only export components if necessary
- Create a custom signature-protection-level permission to control access to implicit intents
- Use a permission to limit receivers of broadcast intents
- Don't put sensitive data in broadcast intents

Android-Specific Guidelines

- Secure NFC guidelines
  - Don't trust data from NFC tags
  - Perform input validation
  - Write-protect a tag before it is used to prevent it from being overwritten
- Test your controls
  - Make sure every setting is really working