idb - iOS Blackbox Pentesting

Daniel A. Mayer

ShmooCon 2014, January 17-19th
Washington, D.C.

Twitter: @DanlAMayer
Website: http://cysec.org

matasano SECURITY

Who we are…

- Me: Daniel A. Mayer
  - Appsec consultant with Matasano Security.
  - Ph.D. in Computer Science (Security and Privacy).
  - Twitter: @DanlAMayer
  - Website: http//cysec.org

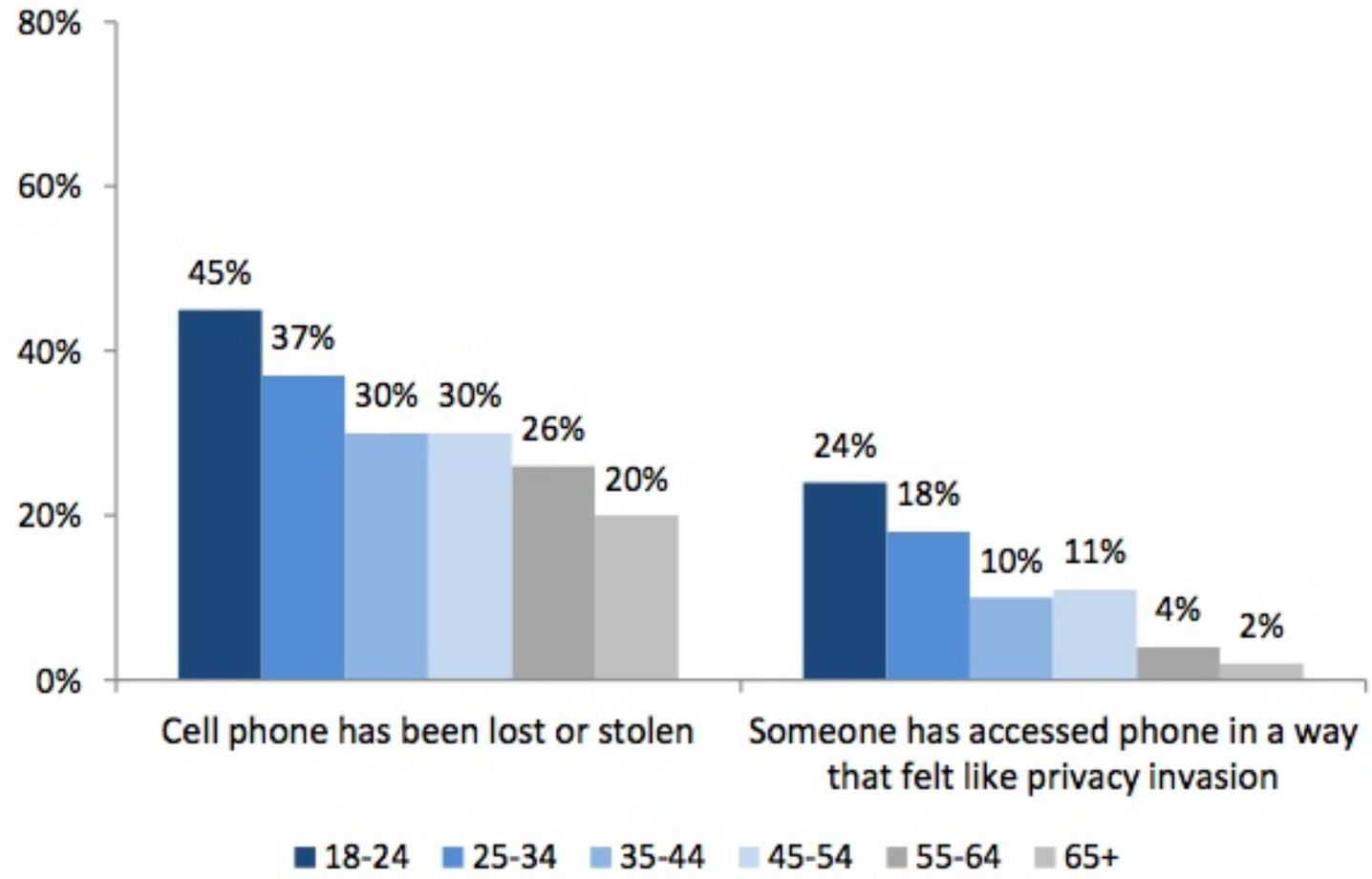
- Matasano Security
  - Application Security Consultancy.
  - Offices in New York, Chicago, Mountain View.
  - We are hiring! :-)
  - Part of nccgroup freedom from doubt

Anyone Lost or Got Their Phone Stolen?

Well, you are not alone...

Physical cell phone privacy experiences by age group

% of cell owners in each age group who have experienced the following



Source: Pew Research Center's Internet & American Life Project, March 15-April 3, 2012 Tracking survey. N=2,254 adults ages 18 and older, including 903 interviews conducted on respondent's cell phone. Margin of error is +/-2.6 percentage points based on cell phone owners (n=1,954).

matasano SECURITY

Agenda

1. Introduction
2. New Tool: idb
3. Common iOS Vulnerabilities
    1. Binary
    2. Local Storage
    3. Information Disclosure
    4. Inter-Process Communication
    5. Network Communication
4. Conclusion

Introduction

iOS Platform Security

- Apps are sandboxed ('seatbelt')
  - All apps share same UNIX user 'mobile'

- App code has to be signed
  - Bypassed when jailbroken
- Raising the bar
  - Data Execution Prevention (DEP)
  - Address Space Layout Randomization (ASLR)
- Passcode

matasano SECURITY

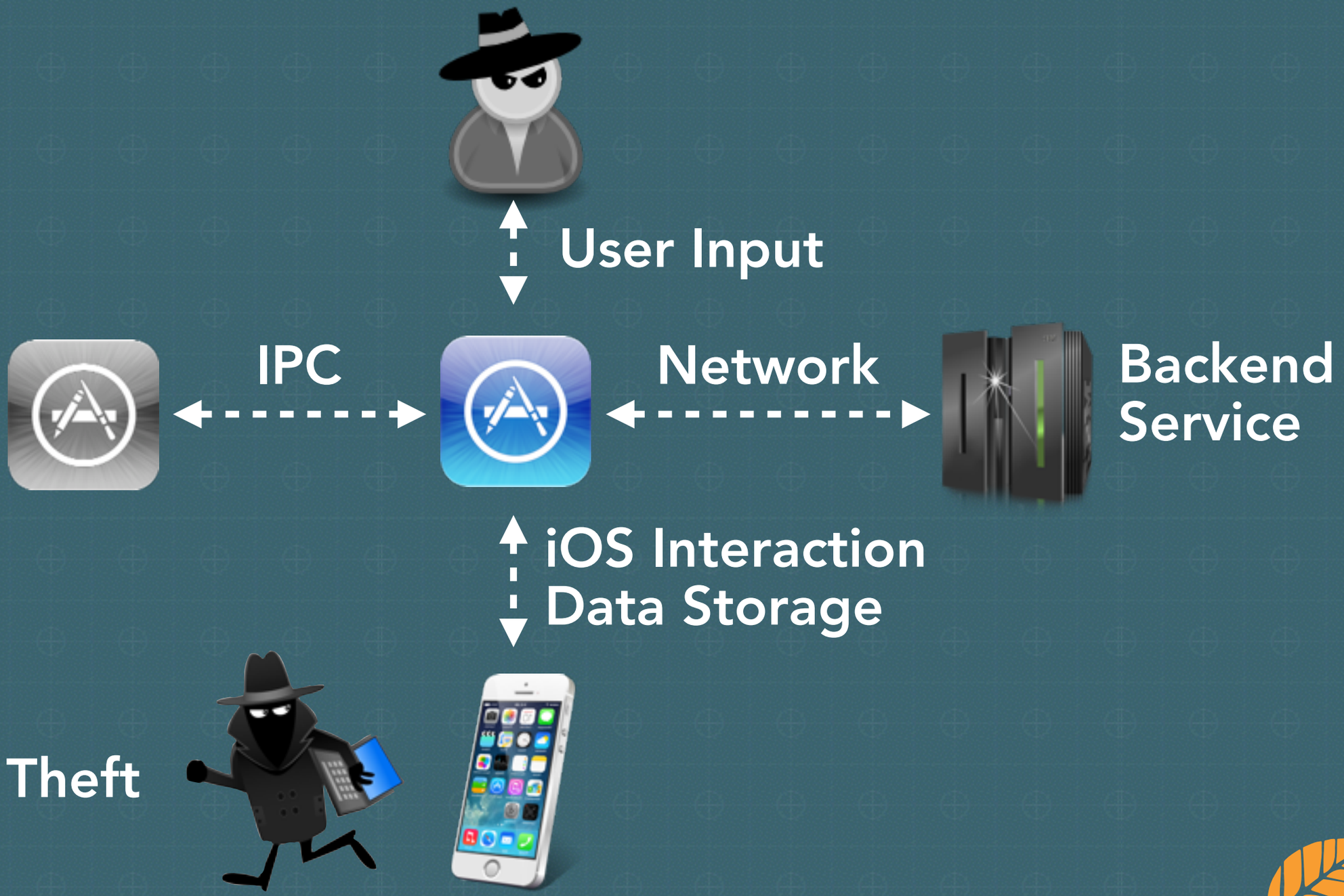
iOS Apps

1. Native applications
   - Objective-C(++), superset of C(++)
   - Cocoa touch for GUI

2. Web view applications
   - Display mobile websites in a `UIWebView`

iOS App Attack Surface

- Vulnerabilities typical arise at trust boundaries



matasano SECURITY

Pentest Setup

- Jail-broken iDevice
  - SSH access!
    - Full UNIX-like environment
    - Full file system access
  - Mobile (Cydia) Substrate
    - Patch system functions at runtime
    - http://www.cydiasubstrate.com/

> Unauthorized modification of iOS can cause security vulnerabilities, instability, shortened battery life, and other issues
>
> --Apple

- Intercepting Proxy
  - Monitor app communication

matasano SECURITY

Introducing idb

Existing Tool Landscape

- Many great tools [1]
  - Scattered
  - Static and dynamic

- Fully understand app's behavior in assessment

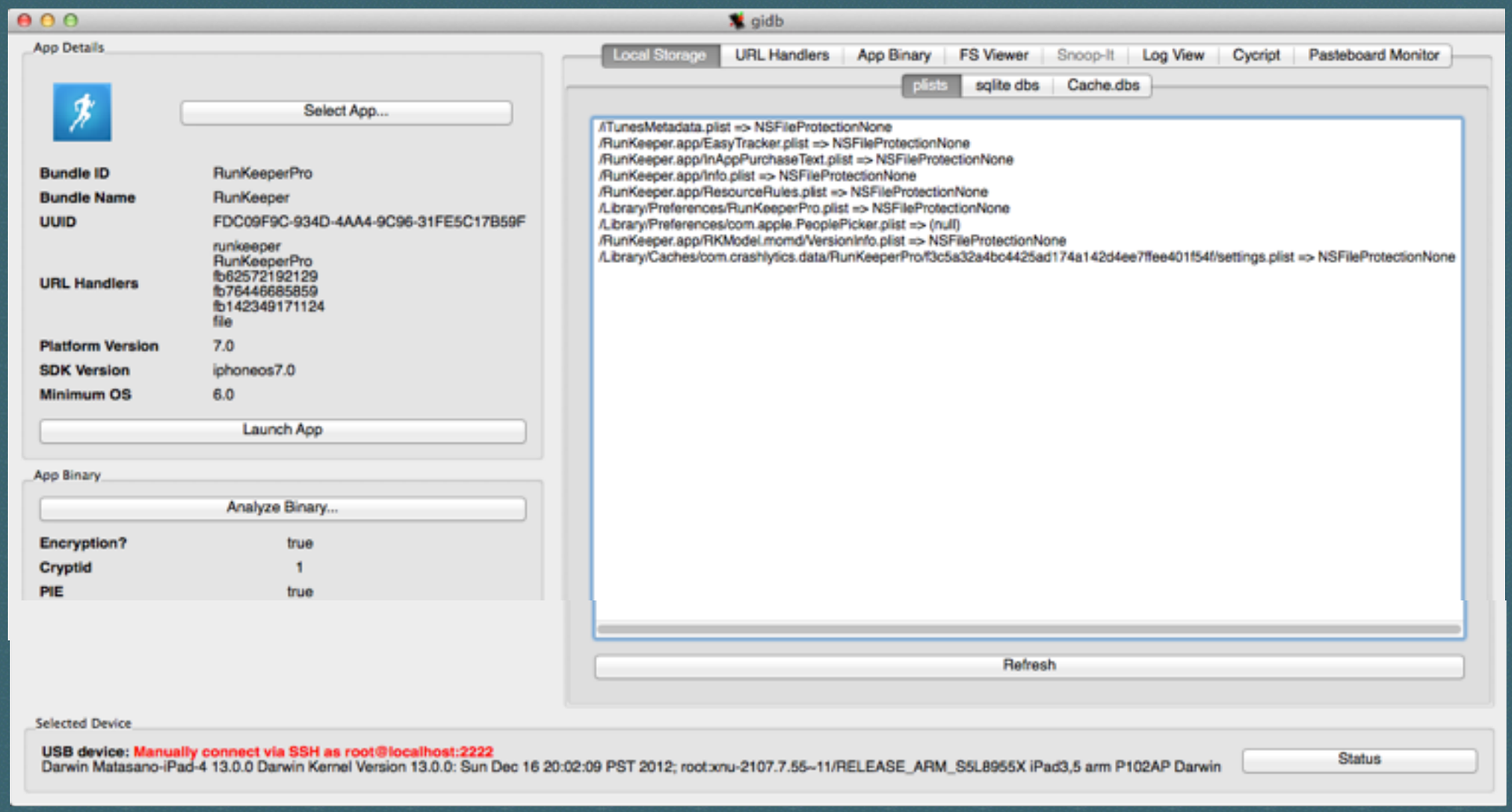
- My background is in dynamic testing
  - No "click and done" solution
  - Tool that automates analyses

[1] https://www.owasp.org/index.php/IOS_Application_Security_Testing_Cheat_Sheet

Introducing idb

- Ruby and Qt (4,500 loc)
- New tools
- Integrates existing tools

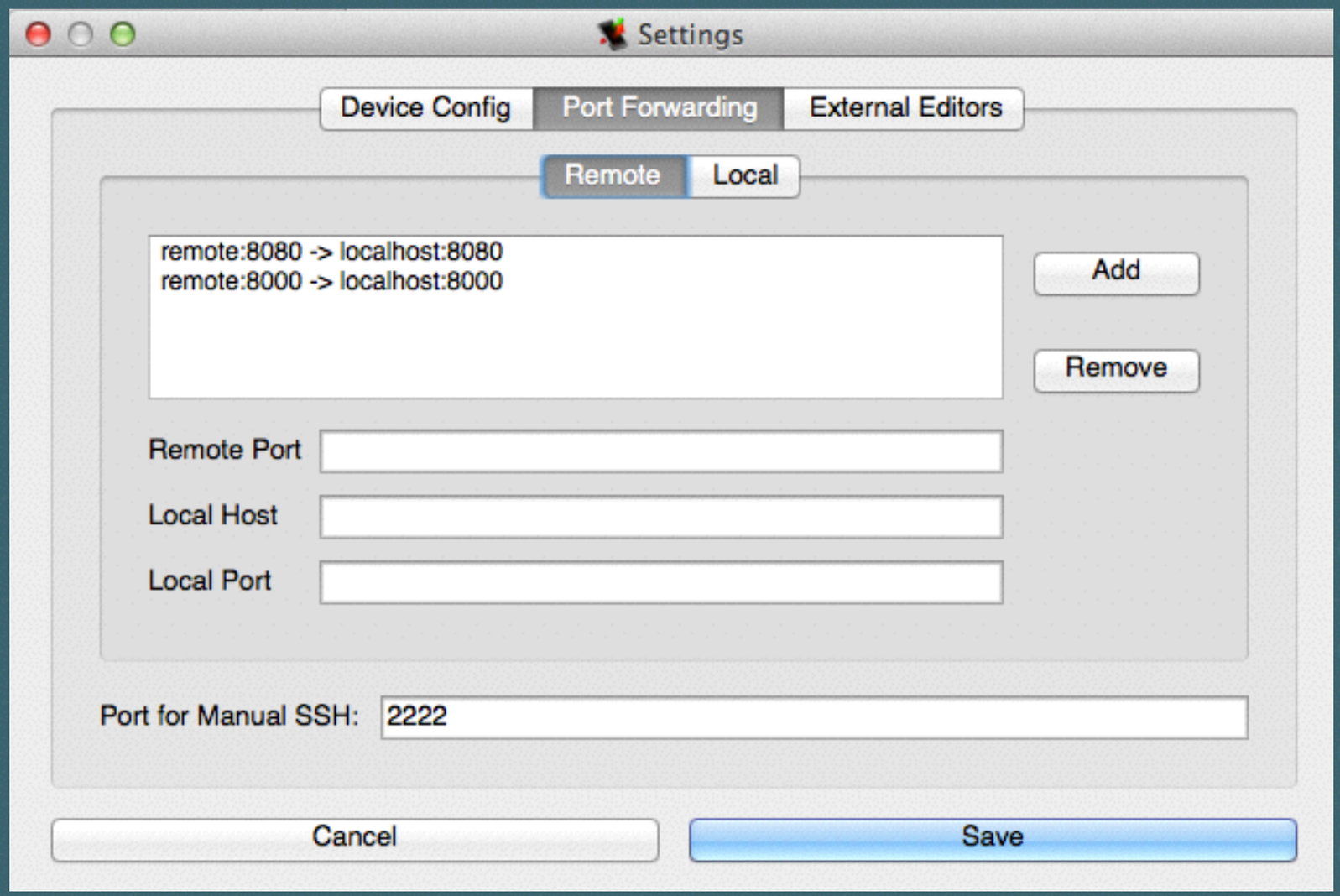
- Goal:
  - Easier setup and access
- Work in progress



matasano SECURITY

Demo: Pentesting Setup

- Connecting to device
  - SSH directly
  - SSH via USB
- Port forwarding
  - Remote
  - Local



matasano SECURITY

Common iOS App Vulnerabilities

The OWASP Mobile Top 10

1. Insecure Data Storage
2. Weak Server Side Controls
3. Insufficient Transport Layer Security
4. Client Side Injection
5. Poor Authentication and Authorization
6. Improper Session Handling
7. Security Decision via Untrusted Input
8. Side Channel Data Leakage
9. Broken Cryptography
10. Sensitive Information Disclosure

https://www.owasp.org/index.php/OWASP_Mobile_Security_Project

The OWASP Mobile Top 10

1. Insecure Data Storage
2. Weak Server Side Controls
3. Insufficient Transport Layer Security
4. Client Side Injection
5. Poor Authentication and Authorization
6. Improper Session Handling
7. Security Decision via Untrusted Input
8. Side Channel Data Leakage
9. Broken Cryptography
10. Sensitive Information Disclosure

https://www.owasp.org/index.php/OWASP_Mobile_Security_Project

The App Binary

- Native Code!
  - Buffer overflows
  - Format string flaws
    - `WithFormat` - don't let user specify the format! [1]
  - User after frees

- Used as storage space:
  - API keys
  - Credentials
  - Crypto Keys

[1] http://sebug.net/paper/Meeting-Documents/Ruxcon2011/iPhone%20and%20iPad%20Hacking%20-%20van%20Sprundel.ppt

Exploit Mitigation

- Take advantage of OS protections:
  - Compile as Position Independent Executable (PIE).

Linking	
Don't Create Position Independent Exe...	No
Apple LLVM compiler 4.2 - Code Generation	
Generate Position-Dependent Code	**Yes**

  - Enable stack canaries

Apple LLVM compiler 4.2 - Language	
Other C Flags	**-fstack-protector-all**

  - Use Automatic Reference Counting

Apple LLVM compiler 4.2 - Language	
Objective-C Automatic Reference Counting	**Yes**

- Do not store credentials in the binary.

Demo: Poor-Man's Reversing

- Basic binary information using otool

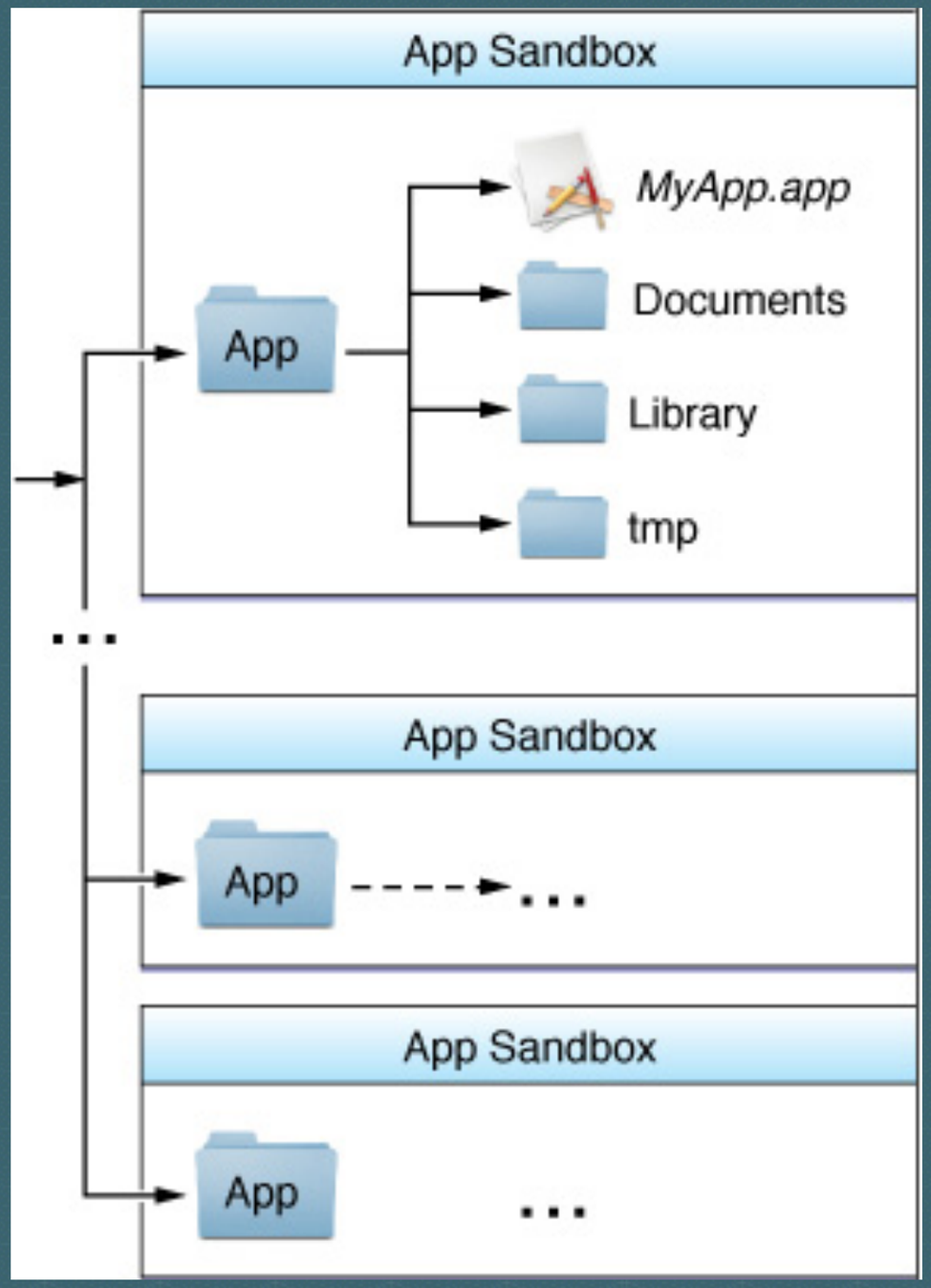
```
➤ RunKeeper.app git:(gui) ✗ otool -Vh RunKeeper
    flags
 NOUNDEFS DYLDLINK TWOLEVEL WEAK_DEFINES BINDS_TO_WEAK PIE
➜ RunKeeper.app git:(gui) ✗ otool -I -v RunKeeper|egrep  'stack_chk_(fail|guard)'
0x003d3dc8   748 ___stack_chk_fail
0x004e0044   749 ___stack_chk_guard
0x004e22e4   748 ___stack_chk_fail
➜ LumosityiPad.app git:(gui) ✗ otool -I -v LumosityiPad|grep _objc_release
0x006f7aa8  9934 _objc_release
0x0085aaf0  9934 _objc_release
```

- Strings

- Cycript
  - http://www.cycript.org/
  - JS to Objective-C

Local Storage

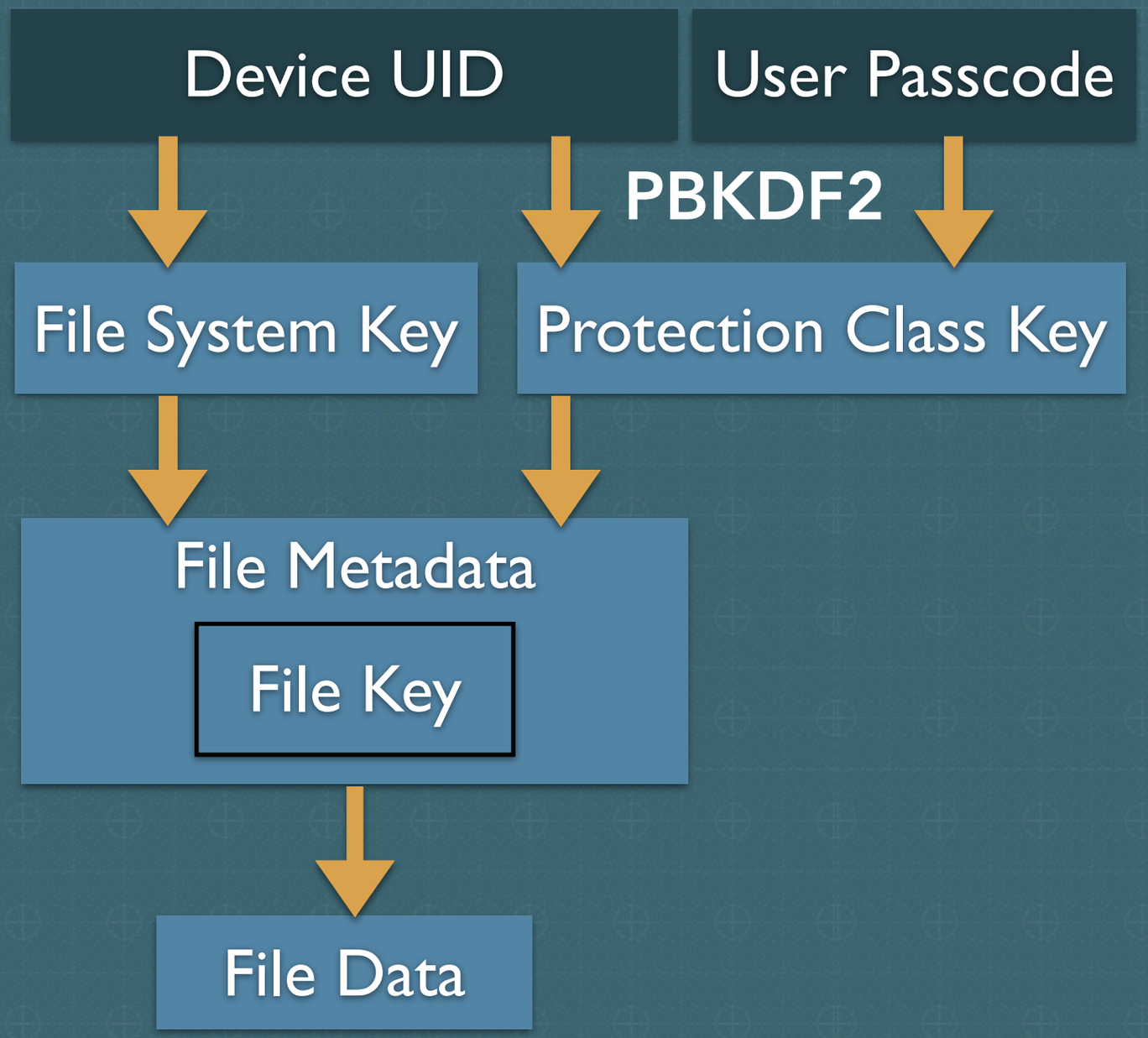
- Apps are sandboxed to
  - /private/var/mobile/Applications/[guid]/
- Sandbox accesible to app.
- Stored in backups.
- If stolen:
  - Jailbreak
  - File system access



matasano SECURITY

File System Encryption

- All files encrypted
- One key per File
- Passcode!
- Attacks:
  - PIN cracking
  - Backups
  - Jail-break not enough!



matasano SECURITY

Using the Data Protection API

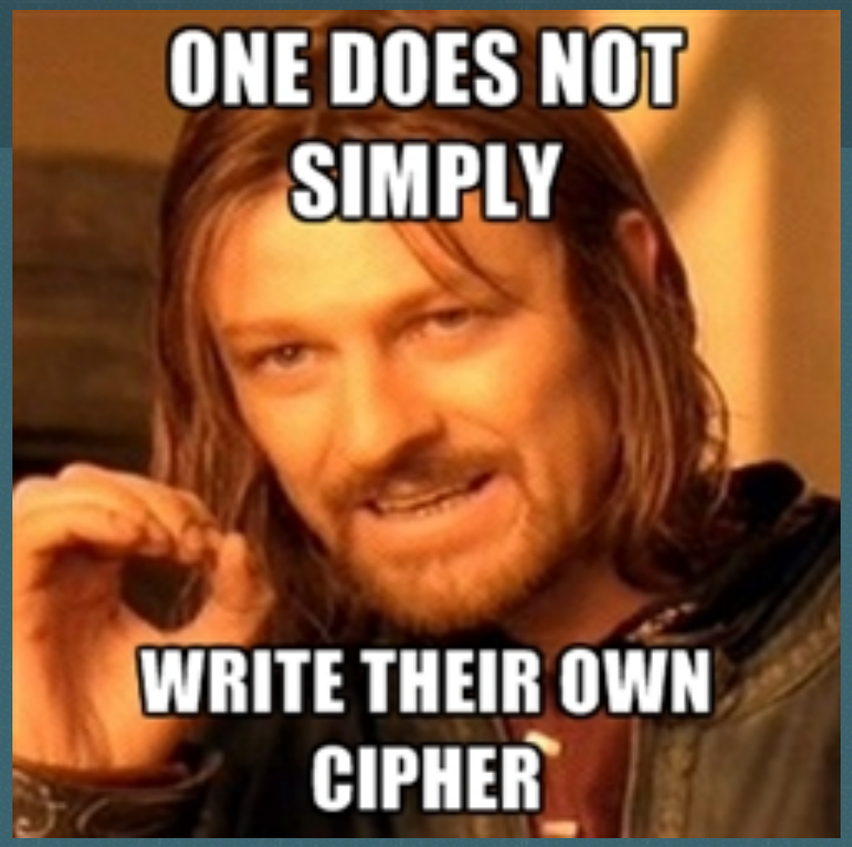
- Enforce a strong passcode
- Set a NSFileProtection when storing files

NSFileProtection	Meaning
Complete	Protected when device is locked.
CompleteUnlessOpen	If open, file can be read when locked.
CompleteUntilFirstUserAuthentication	Protected from boot until user unlocks.
None (Default!)	**No protection.**

- Example:

```
[[NSFileManager defaultManager] createFileAtPath:@“filename”
            contents:[@"super_secret" dataUsingEncoding:NSUTF8StringEncoding]
          attributes:[NSDictionary
dictionaryWithObject:NSFileProtectionComplete forKey:NSFileProtectionKey]];
```

Don’t do your own crypto



- Getting crypto right is hard!

- General problem on mobile:
  - Where does the key come from?
  - Have to use some Key Derivation Function (KDF)

- Shameless plug:
  - Do the Matasano crypto challenges!
  - Email: cryptopals@matasano.com

matasano SECURITY

SQLite

- SQLite: a small relational database API
- Popular to persist data
- Data stored unencrypted in a file


```
Matasano-iPad-4:/var/mobile/Applications/2D326DB2-2BBE-4612-B45B-17D72A86BE40/Documents root# sqlite
3 keyring.sql
sqlite> .tab
cards               program_migrations  programs            users
sqlite> select * from cards;
1|881|Qdoba Rewards|Qdoba Rewards||32967000138877|https://d1njjmh7h4p8yt.cloudfront.net/program/881/
logo_original_1361998489.jpg?1361998489|CODE128|0|0|3948860|1|2000|
```


matasano SECURITY

SQLite Mitigation

- Use Data Protection to encrypt sqlite file.
- Third-Party solutions
  - e.g., http://sqlcipher.net/

- Journal may leak deleted data.
  - Use `VACUUM` to rebuild DB.

Property List Files

- Structured storage (`NSUserDefaults`).
- Stored unencrypted in XML files or binary plist.
  - `plutil -convert xml1`
- Often used for crypto keys, credentials, etc.

com.path.Path.plist

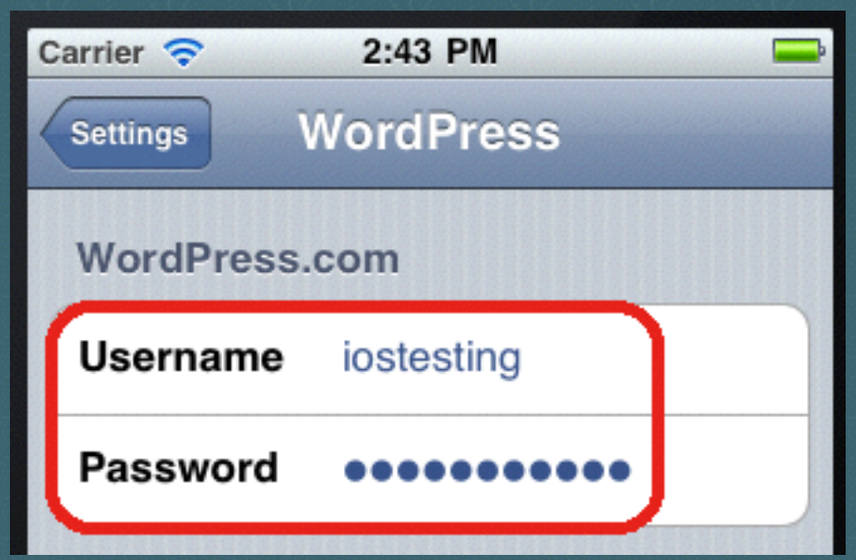
com.path.Path.plist 〉 No Selection

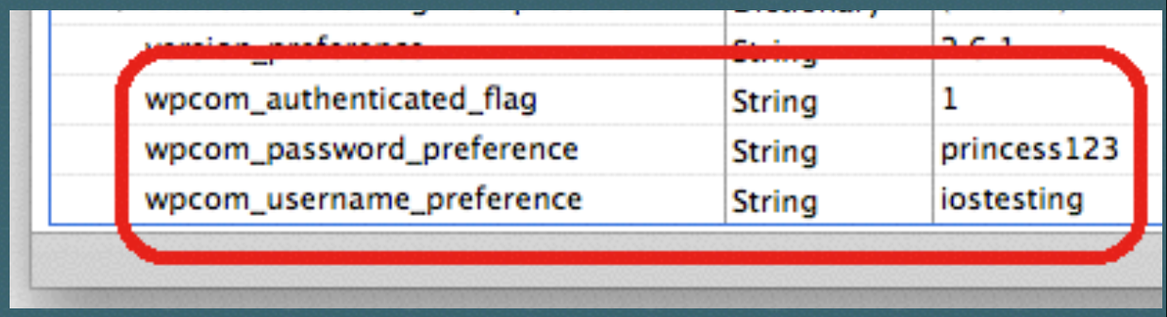
Key	Type	Value
▼ Root	Dictionary	(22 items)
▶ com.facebook.sdk:lastInstallRespons…	Dictionary	(1 item)
oauthToken	String	NjBjYWU3YTEtZjE5Zi00ODliLTlmYjMtZTdmZDlwOTMyZjUw
pushToken	Data	<b116765e 9c408f65 ab8c30d0 1553dea8 cb02a236 51ae29ff fbd75
lastActive	Number	1,390,079,217.96019
loggedIn	Boolean	YES
pathAPIHost3.2	String	https://api.path.com
jabberID	String	ngyyymzkzjatnde0mi00otlmlwjkzjktndg4zjgzymu3zgvm
resourceID	String	AB233754-937C-4508-9092-028B007DAEF5
login	String	aaaa@ccc.com

matasano SECURITY

Property List Files: Mitigation

- Don’t use for sensitive data!





http://software-security.sans.org/blog/2011/01/05/using-keychain-to-store-passwords-ios-iphone-ipad/

- File storage for binary data.
  - `NSProtectionComplete`!
- Use keychain for structured data.

matasano SECURITY

Keychain

- Key-Value store
- /private/var/Keychains/keychain-2.db
- Encryption similar to Data Protection
  - Device + Passcode
  - secItemAdd, secItemDelete, etc.

Protection Class	Meaning
kSecAttrAccessibleWhenUnlocked	Protected when device is locked.
kSecAttrAccessibleAfterFirstUnlock	Protected from boot until user unlocks.
kSecAttrAccessibleAlways (default)	**No protection.**

- `ThisDeviceOnly` variants: no migration

matasano SECURITY

Share Data Securely Between Your Apps

- Keychain Access Group
  - app_id = [bundle_seed] || [bundle_id]
    BEEF1337 || com.corp.myapp
  - [bundle_seed] generated by Apple.
  - Apps with same [bundle_seed] can share access.
  - kSecAttrAccessGroup

- Access through search dictionary.

```
[searchDictionary setObject:@“BEEF1337.com.app.family"
   forKey:(id)kSecAttrAccessGroup];
```


matasano SECURITY

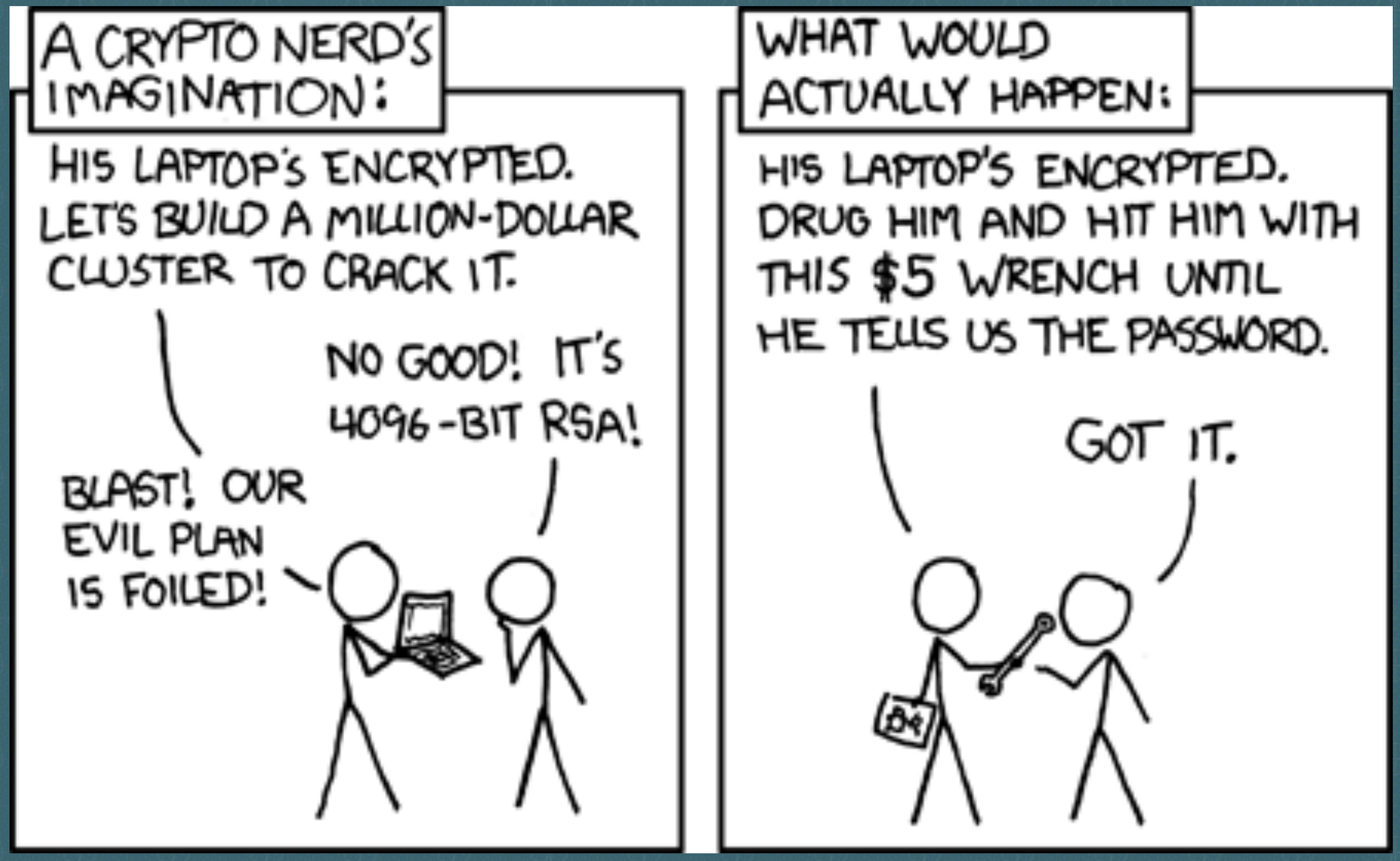
Demo: idb Local Storage Functions

- Use SSH connection to analyze sandbox
- Determine FileProtection using `NSFileManager`
  - https://github.com/dmayer/protectionclassviewer

```
    NSString *fileProtectionValue = [[[NSFileManager defaultManager]
                                      attributesOfItemAtPath:@“filename”
error:NULL] valueForKey:NSFileProtectionKey];
```

- Keychain viewer using `keychain_dump`
  - https://code.google.com/p/iphone-dataprotectionn
- Beta-level integration with snoop-it
  - https://code.google.com/p/snoop-it/

Use Crypto and done, right?

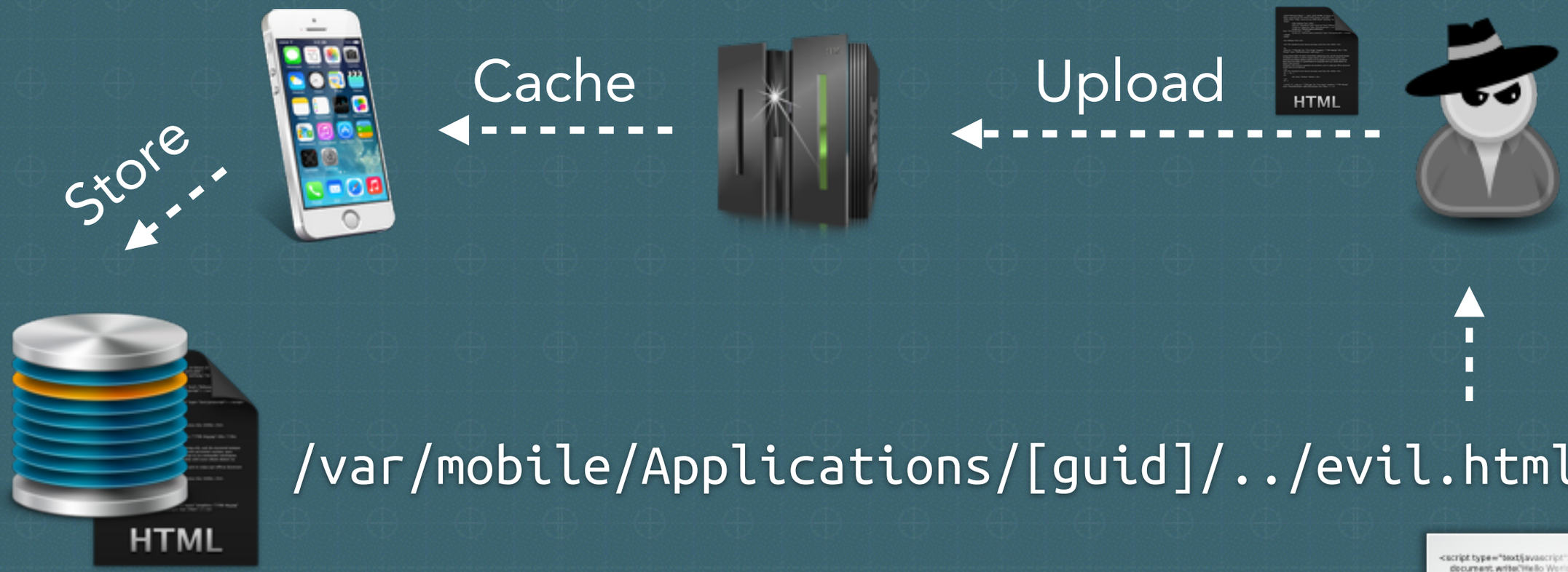


http://xkcd.com/538/

matasano SECURITY

Example: Remote File Read

- App locally caches documents (inc. HTML)




```
var xhttp  = new XMLHttpRequest();
xhttp.open("GET","file:///var/mobile/Applications/[..]/
file.pdf",false);
xhttp.send();
alert(xhttp.responseText);
// Dont' use alert unless you want entire PDF in alert box  :)
```

Information Disclosure: Screenshot

- iOS takes screenshot when app backgrounds.
- Stored unencrypted at
  - `/var/mobile/Applications/[guid]/Library/Caches/Snapshots/[bundle_id]/`

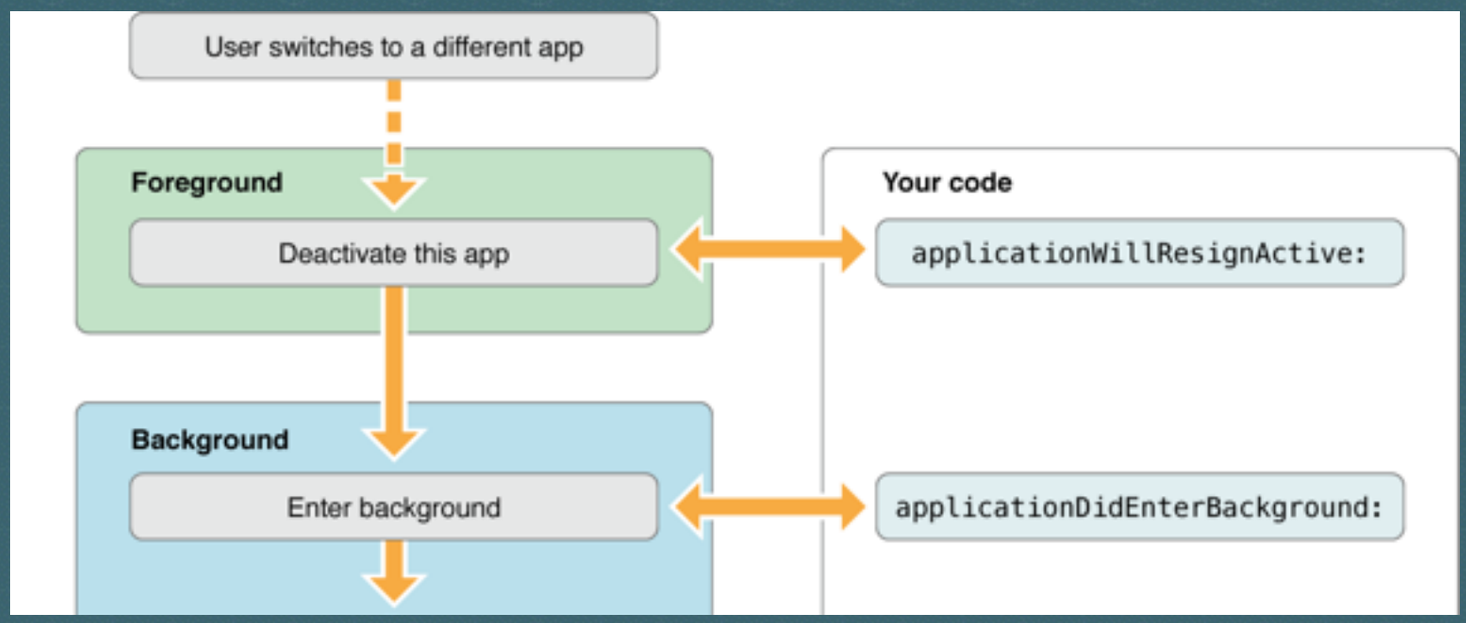
`./Main subfolder`


```
Matasano-iPad-4:/var/mobile/Applications/D3900CBF-6988-45D9-B58A-E4CB041C4CB8/Library/Caches/Snapsho
ts/com.google.chrome.ios root$ls -l
total 492
-rw-r--r-- 1 mobile mobile 500529 Jan 11 14:31 UIApplicationAutomaticSnapshotDefault-Portrait@2x.png
```


matasano SECURITY

Mitigation: Screenshot

- Hide sensitive information from screen
- Implement `applicationDidEnterBackround`
- Popular: Place launch image in foreground



- `ignoreSnapshotOnNextApplicationLaunch`
  - Prevents screenshot from being taken

matasano SECURITY

Data Leakage: Cache.db

- iOS caches requests and responses

```
sqlite> select * from cfurl_cache_response where request_key like '%password%';
8|0|259328918|0|https://api.[redacted]/v3/register/email/?client_id=1431599&timestamp=1389571536&
oauth_signature=b34f5da48330c58cc7cc59b0e33662cba1c35db27ee9dd223a0d5ff2b2f29f7fem[redacted]il=xxx%40ccc.com&
first_name=A&gender=male&last_name=B&locale=en_US&password=testtest&username=|2014-01-13 00:05:37
```

- Disable caching
  - Send no store headers from server

```
- (NSCachedURLResponse *)connection:(NSURLConnection *)connection
willCacheResponse:(NSCachedURLResponse *)cachedResponse
    { return nil; }
```


matasano SECURITY

Information Disclosure: Log Files

- 40 % of 40 tested banking apps disclose data [1]
- Log files accessible by other apps.

```
<v:Body>
<n0:loginWithRole id="o0" c:root="1" xmlns:n0="http://mobile.services.xxxxxxxxx.com/">
<in0 i:type="d:string">USER-ID</in1>
<in1 i:type="d:string">XRS</in2>
<in2 i:type="d:string">PASSWORD</in3>
<in3 i:type="d:string">xxxxxxxx</in4>
</n0:loginWithRole>
</v:Body>
```

- Wrap your NSLog statements, e.g.:

```
#ifdef DEBUG
    NSLog(@"password");
#fi
```

[1] http://blog.ioactive.com/2014/01/personal-banking-apps-leak-info-through.html

Demo: idb Information Disclosure

- Screenshot Tool
  - Walks through steps that create screenshot.
  - Displays screenshot in idb.

- iOS console available in
  - Xcode or iPhone Configuration Utility.

- idb uses `idevicesyslog` [1].

[1] http://www.libimobiledevice.org/

matasano SECURITY

Inter-Process Communication

- There is no proper IPC

- Poor-man's IPC
  - UIPasteboard

- Custom URL schemes
  - Apple's approved solution

- Consider using the keychain with access group

Pasteboard

- Any app can read it.
- Private Pasteboards are not private.
  - There seems to be no API to find all Pasteboards.

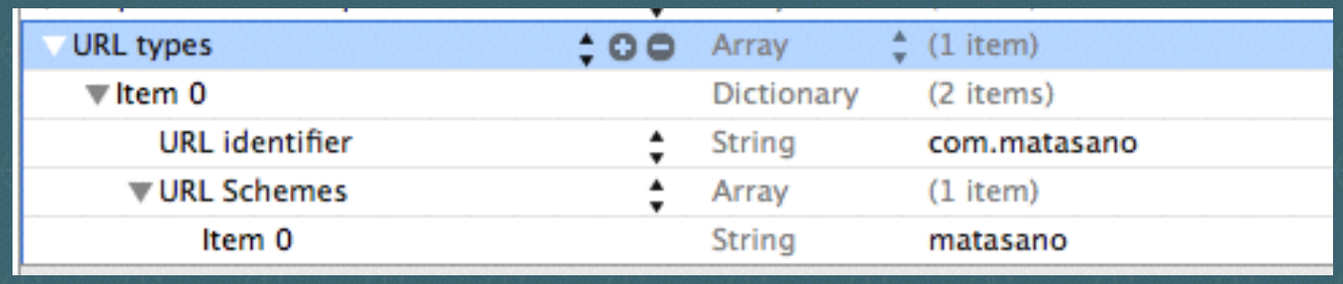
```
[UIPasteboard generalPasteboard];
[UIPasteboard pasteboardWithName:@"super_secret" create:NO ];
```

- Don’t use the Pasteboard for IPC.
- Delete content with `items = nil`.
- To prevent Copy/Paste, subclass `UITextView`.
  - `canPerformAction` should return “`NO`” for `copy:`

matasano SECURITY

URL Schemes

- Register in Info.plist
- Handle in:




```
-(BOOL) application:(UIApplication *)application openURL:(NSURL
*)url sourceApplication:(NSString *)sourceApplication annotation:
(id)annotation
{ // Handle request }
```

- Security Considerations
  - Malicious input
  - Trust
  - Hijacking

> **Note:** If more than one third-party app registers to handle the same URL scheme, there is currently no process for determining which app will be given that scheme.

https://developer.apple.com/library/ios/documentation/iPhone/Conceptual/iPhoneOSProgrammingGuide/AdvancedAppTricks/AdvancedAppTricks.html

matasano SECURITY

URL Schemes

- Exploiting Trust:
- `my_app://configure?server=..&port=..`
  - Inject attacker controlled server.
- `bank://redirect?page=http%3A%2F%2Fphish.me`
  - Display attacker controlled site in trusted app.
  - Intercept credentials

- Verify the caller of the URL handler
  - `sourceApplication` parameter.
- Perform strict input validation.

Demo: idb IPC Functions

- Pasteboard monitor
  - Runs binary on device which pulls content
  - Supports custom pasteboards
  - https://github.com/dmayer/pbwatcher

- URL Schemes
  - List
  - Invoke
  - Basic fuzzer

matasano SECURITY

Network Communication

- Communication with Network Services
  - HTTP/S
  - Socket connections
  - Push Notifications

- Challenge similar to browsers
  - Protect data in transit

- Typically done through SSL/TLS

An SSL Certificate Primer

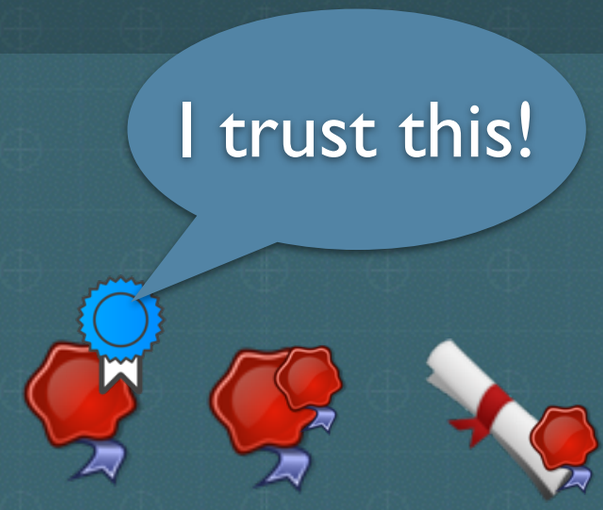
CA

Intermediate 1

Intermediate 2

company.com

I vouch that this key belongs to...



Verify

matasano SECURITY

iOS Certificate Validation

- Default: Accept if signed by CA in trust store
  - Check when using 3rd party libs
- iOS offers great flexibility in cert. validation
  - the good: can make cert. validation stronger
  - the bad: cert. check often overridden in dev
  - the ugly: easy to accept any cert

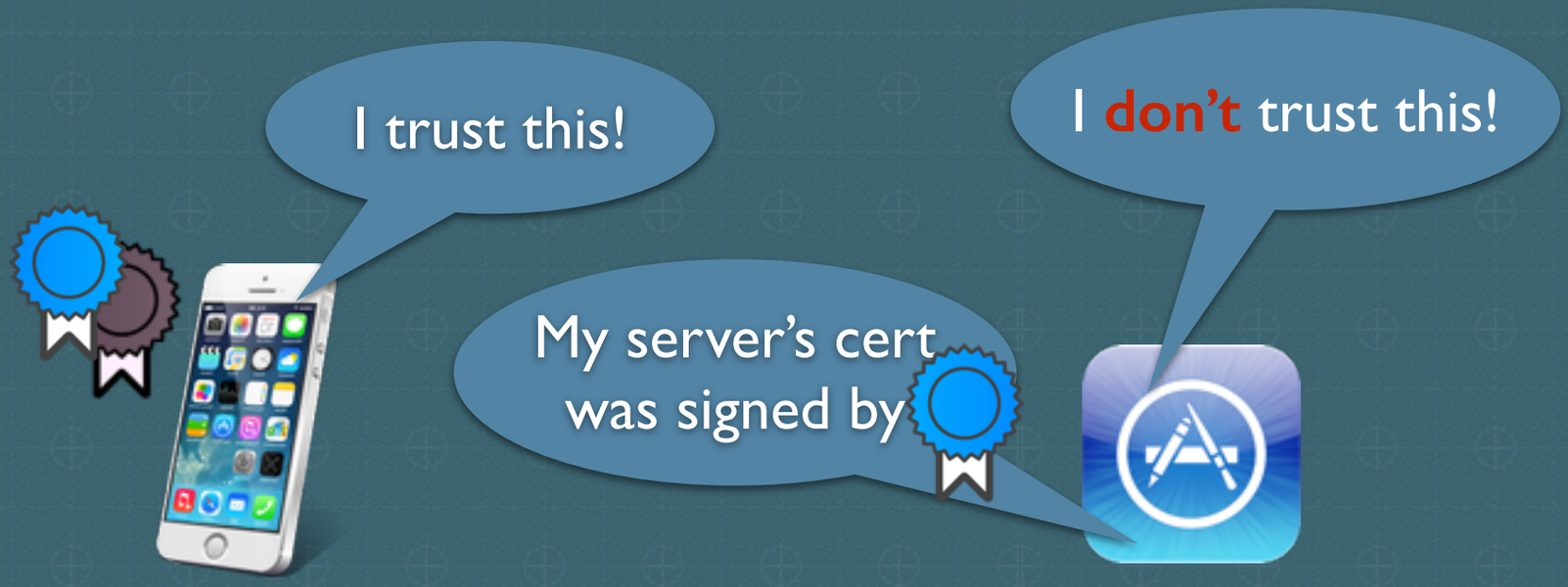
```
- (void)connection:(NSURLConnecti
willSendRequestForAuthentication
    NSURLProtectionSpace * pSpace
    NSURLCredential* cred = [NSUR
    [[challenge sender] useCreden
}
```

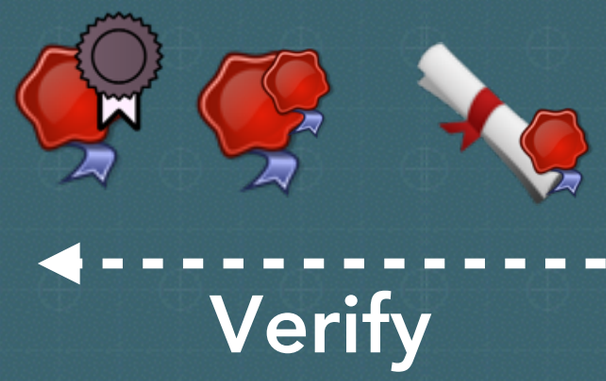
```
enticationChallenge *)challenge {
ctionSpace];
alForTrust:[pSpace serverTrust]];
ticationChallenge:challenge];
```

matasano SECURITY

Certificate Validation

- Don’t bypass certificate validation
  - In dev, use free certificates (e.g. startssl.com)
  - Install server cert explicitly on device.
- Implement certificate pinning!
  - https://github.com/iSECPartners/ssl-conservatory
  - https://www.owasp.org/index.php/Certificate_and_Public_Key_Pinning#iOS





matasano SECURITY

iOS CA Cert Management

- Simulator: `[sim]/Library/Keychains/TrustStore.sqlite3`
  - Fiddly: ASN.1 anyone?

- Device: `/private/var/Keychains/TrustStore.sqlite3`
  - Adding entry not sufficient
  - Fell back to 'MDM'-based install.

- Pentest Pinning bypass:
  - https://github.com/iSECPartners/ios-ssl-kill-switch

matasano SECURITY

Planned idb Features

- Hosts file editor
- Improvements
  - Grep for the log view
  - Search for the FS Browser
  - Robustness improvements
- Integration of more awesome tools.
  - class-dump-z, iOS SSL Kill Switch

Send me bug reports, feature / pull requests!

matasano SECURITY

Thanks!

Questions?

- Email+XMPP: mayer@cysec.org
- Twitter: @DanlAMayer
- Github: https://github.com/dmayer/idb

Square + Matasano CTF
https://microcorruption.com

- **Thanks to**
  - Jeff Jarmoc, Mike Tracy, Andy Schmitz, David Goldsmith

matasano SECURITY

Image Attributions

- iPhone icon, unchanged:
  - By Adrian Dediu, https://www.iconfinder.com/iphone5cunlock
  - License: https://creativecommons.org/licenses/by/3.0/us/
- CA certificate icon, unchanged:
  - By http://snipicons.com/
  - License: https://creativecommons.org/licenses/by-nc/3.0/
- Storage icon, unchanged:
  - By Barrymieny, http://barrymieny.deviantart.com
  - License: https://creativecommons.org/licenses/by-nc-sa/3.0/
- Key, unchanged:
  - Double-J designs, http://www.doublejdesign.co.uk/
  - License: https://creativecommons.org/licenses/by/3.0/us/
- Slide 21, cropped:
  - https://developer.apple.com/library/ios/documentation/iphone/conceptual/iphoneosprogrammingguide/ManagingYourApplicationsFlow/ManagingYourApplicationsFlow.html
- Slide 35, cropped:
  - https://developer.apple.com/library/ios/documentation/FileManagement/Conceptual/FileSystemProgrammingGuide/FileSystemOverview/FileSystemOverview.html