The Art of Building Bulletproof Mobile Apps

3-day Class

Combined iOS and Android edition

KRvW Associates, LLC

Mobile platforms

- How secure are today's mobile platforms?
  - Lots of similarities to web applications but...
- Gold rush mentality
  - Developers are on a death march to produce apps
  - Unprecedented rate
  - Security often suffers...

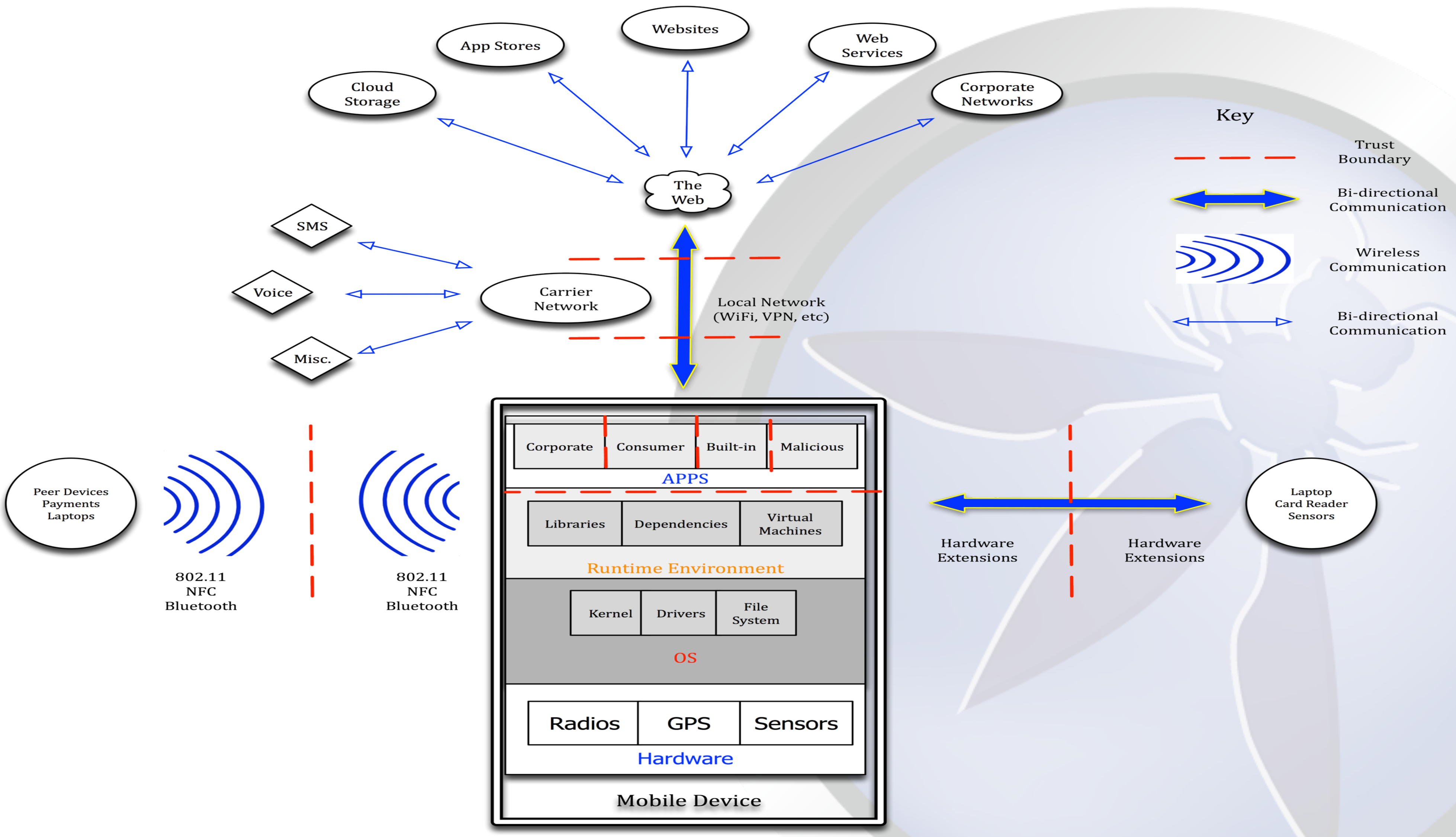
Mobile app threat model

Many considerations

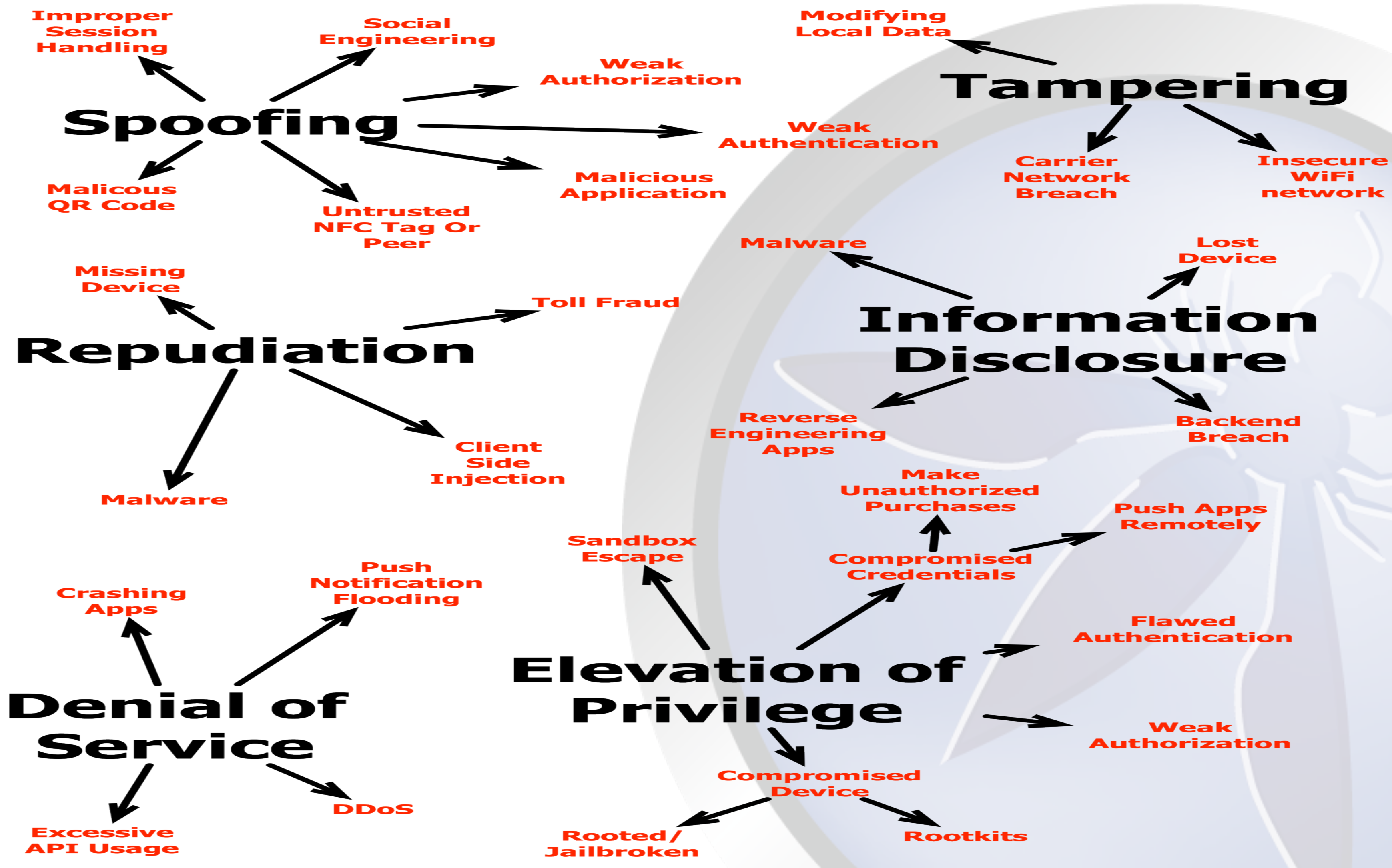
- Platforms vary substantially
- Similar but still very different than traditional web app--even when heavy with client-side code
- It's more than just apps
  - Cloud/network integration
  - Device platform considerations

LOADING ZONE
15 MINUTE
AUTHORISED VEHICLES EXCEPTED
7-10 AM
AUTHORISED VEHICLES EXCEPTED
10 AM - 10 PM
7-10 PM
TAXIS EXCEPTED WHEN PICKING UP/ DROPPING OFF PASSENGERS
TAXI ZONE
ALL OTHER TIMES
10 PM - 7 AM

Mobile Threat Model



Mobile Threat Model



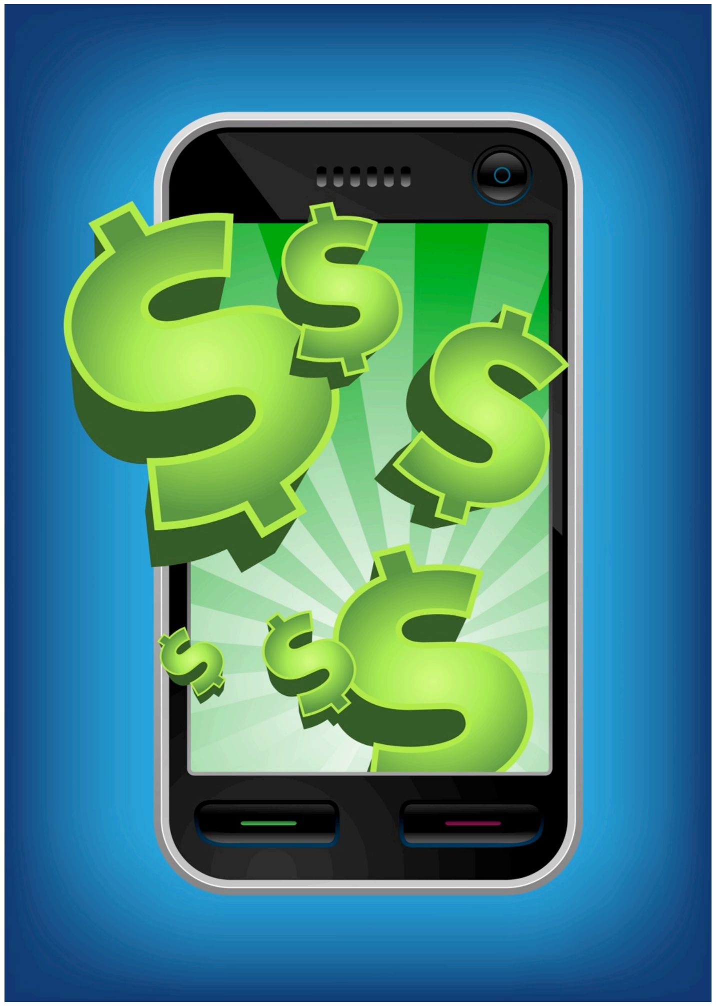
Biggest issue: lost/stolen device

Anyone with physical access to your device can get to a wealth of data

- PIN is not effective
- App data
- Keychains
- Properties

Disk encryption helps, but we can't count users using it

See forensics results



Second biggest: insecure comms

Without additional protection, mobile devices are susceptible to the "coffee shop attack"

- Anyone on an open WiFi can eavesdrop on your data
- No different than any other WiFi device really

Your apps MUST protect your users' data in transit

Typical mobile app

- Most mobile apps are basically web apps
  - Clients issue web services request
    - SOAP or RESTful
  - Servers respond with XML data stream
- But with more client "smarts"
- Almost all web weaknesses are relevant, and more

OWASP Top-10 (2010)

1. Injection
2. Cross-site scripting
3. Broken authentication and session management
4. Insecure direct object reference
5. Cross site request forgery
6. Security misconfiguration
7. Insecure crypto storage
8. Failure to restrict URL access
9. Insecure transport layer protection
10. Unvalidated redirects and forwards (new)

OWASP Mobile Top 10 Risks	
M1- Insecure Data Storage	M6- Improper Session Handling
M2- Weak Server Side Controls	M7- Security Decisions Via Untrusted Inputs
M3- Insufficient Transport Layer Protection	M8- Side Channel Data Leakage
M4- Client Side Injection	M9- Broken Cryptography
M5- Poor Authorization and Authentication	M10- Sensitive Information Disclosure

A lot to consider

That's a lot of mistakes to avoid (and there are more)

- What are the key differences between the web list and the mobile list?
- What assumptions must we then make in our apps?
- What assumptions are *unsafe*?

Let’s consider the basics

We’ll cover these (from the mobile top 10)

- Protecting secrets
  - At rest
  - In transit
- Input/output validation
- Authentication
- Session management
- Access control
- Privacy concerns

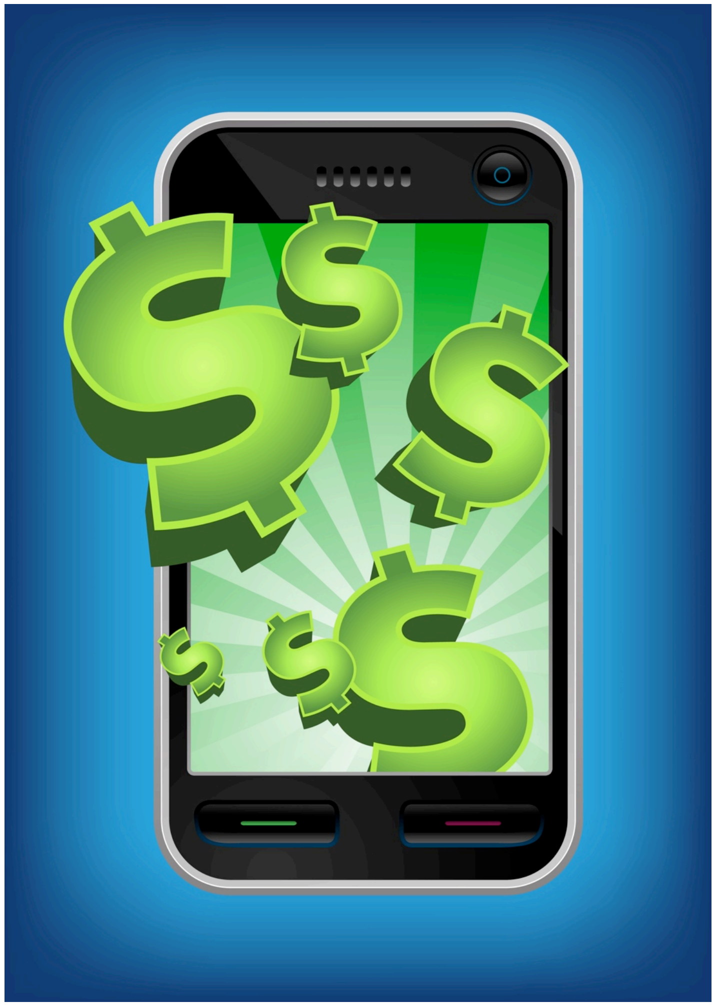
Attack vector: lost/stolen device

Anyone with physical access to your device can get to a wealth of data

- PIN is not effective
- App data
- Keychains
- Properties

See forensics studies

<u>Your app must protect users' local data storage</u>



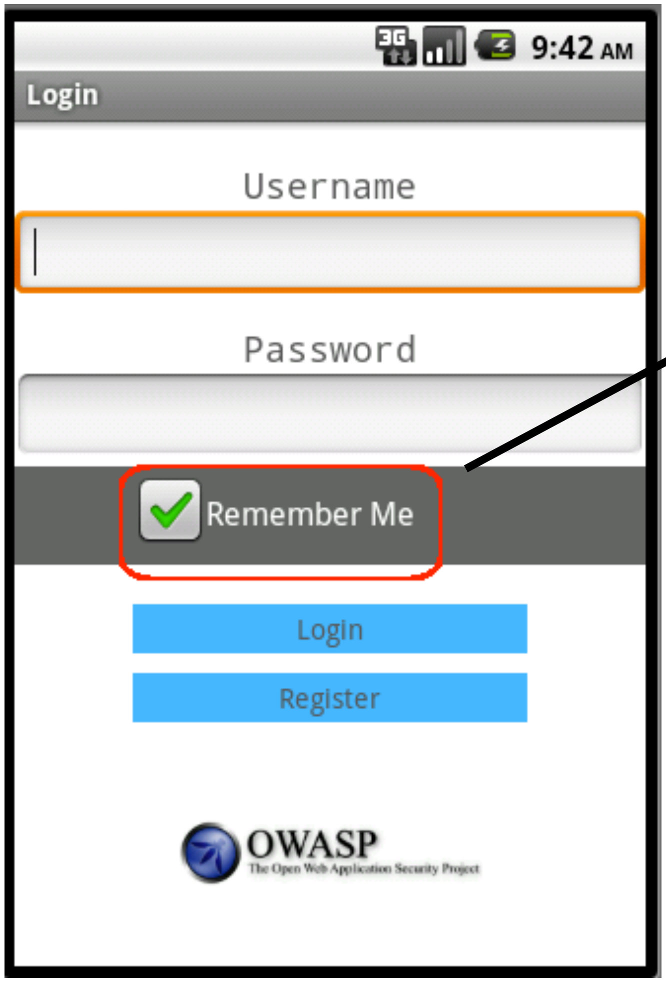
M1- Insecure Data Storage

- Sensitive data left unprotected
- Applies to locally stored data + cloud synced
- Generally a result of:
  - Not encrypting data
  - Caching data not intended for long-term storage
  - Weak or global permissions
  - Not leveraging platform best-practices

Impact

- Confidentiality of data lost
- Credentials disclosed
- Privacy violations
- Non-compliance

M1- Insecure Data Storage



```
public void saveCredentials(String userName, String password) {

    SharedPreferences credentials = this.getSharedPreferences(
            "credentials", MODE_WORLD_READABLE);
    SharedPreferences.Editor editor = credentials.edit();
    editor.putString("username", userName);
    editor.putString("password", password);
    editor.putBoolean("remember", true);
    editor.commit();
}
```

Very Bad

Convenient!

M1- Insecure Data Storage
Prevention Tips

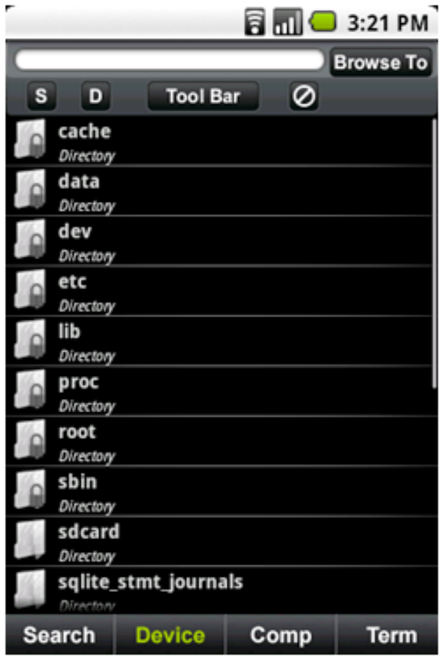
- Store ONLY what is absolutely required
- Never use public storage areas (ie- SD card)
- Leverage secure containers and platform provided file encryption APIs
- Do not grant files world readable or world writeable permissions

Control #	Description
1.1-1.14	Identify and protect sensitive data on the mobile device
2.1, 2.2, 2.5	Handle password credentials securely on the device

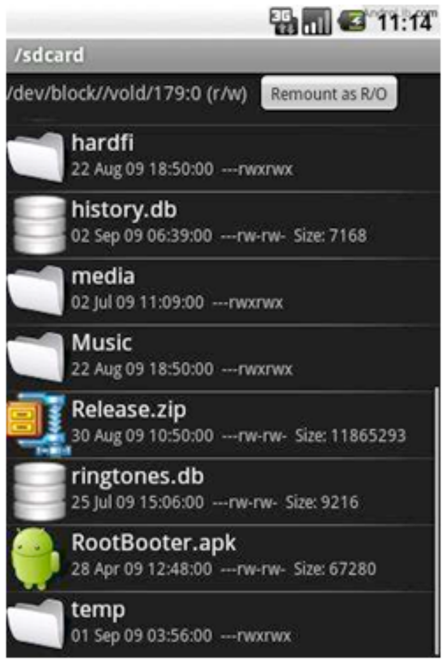
Local storage on Android

Android phones can easily be mounted and the filesystem and data can be viewed

Passwords, secret keys and other sensitive data must never be written to disk in plaintext



```
cache
Directory
data
Directory
dev
Directory
etc
Directory
lib
Directory
proc
Directory
root
Directory
sbin
Directory
sdcard
Directory
sqlite_stmt_journals
Directory
```

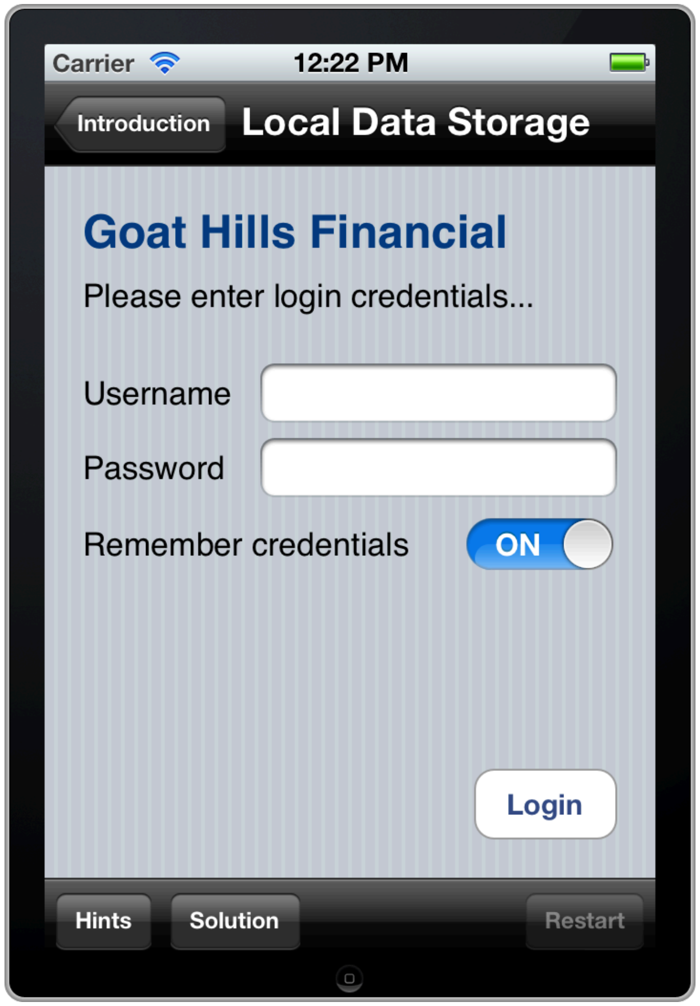


```
/dev/block//vold/179:0 (r/w)
hardfi
22 Aug 09 18:50:00 ---rwxrwx
history.db
02 Sep 09 06:39:00 ---rw-rw- Size: 7168
media
02 Jul 09 11:09:00 ---rwxrwx
Music
22 Aug 09 18:50:00 ---rwxrwx
Release.zip
30 Aug 09 10:50:00 ---rw-rw- Size: 11865293
ringtones.db
25 Jul 09 15:06:00 ---rw-rw- Size: 9216
RootBooter.apk
28 Apr 09 12:48:00 ---rw-rw- Size: 67280
temp
01 Sep 09 03:56:00 ---rwxrwx
```

SQLlite example

Let's look at a database app that stores sensitive data into a SQLite db

- We'll recover it trivially by looking at the unencrypted database file



Protecting secrets at rest

Encryption is the answer, but it's not quite so simple

- Where did you put that key?
- Surely you didn't hard code it into your app
- Surely you're not counting on the user to generate and remember a strong key

Key management is a non-trivially solved problem

How bad is it?

- It's tough to get right
  - Key management is everything
- We've seen many examples of failures
  - Citi and others
- Consider lost/stolen device as worst case
  - Would you be confident of your app/data in hands of biggest competitor?

Attack vector: coffee shop attack

Exposing secrets through non-secure connections is rampant

- Firesheep description

Most likely attack targets

- Authentication credentials
- Session tokens
- Sensitive user data

<u>At a bare minimum, your app *needs* to be able to withstand a coffee shop attack</u>

M3- Insufficient Transport Layer Protection

- Complete lack of encryption for transmitted data
  - Yes, this unfortunately happens often
- Weakly encrypted data in transit
- Strong encryption, but ignoring security warnings
  - Ignoring certificate validation errors
  - Falling back to plain text after failures

Impact

- Man-in-the-middle attacks
- Tampering w/ data in transit
- Confidentiality of data lost

M3- Insufficient Transport Layer Protection Prevention Tips

- Ensure that all sensitive data leaving the device is encrypted
- This includes data over carrier networks, WiFi, and even NFC
- When security exceptions are thrown, it's generally for a reason…DO NOT ignore them!

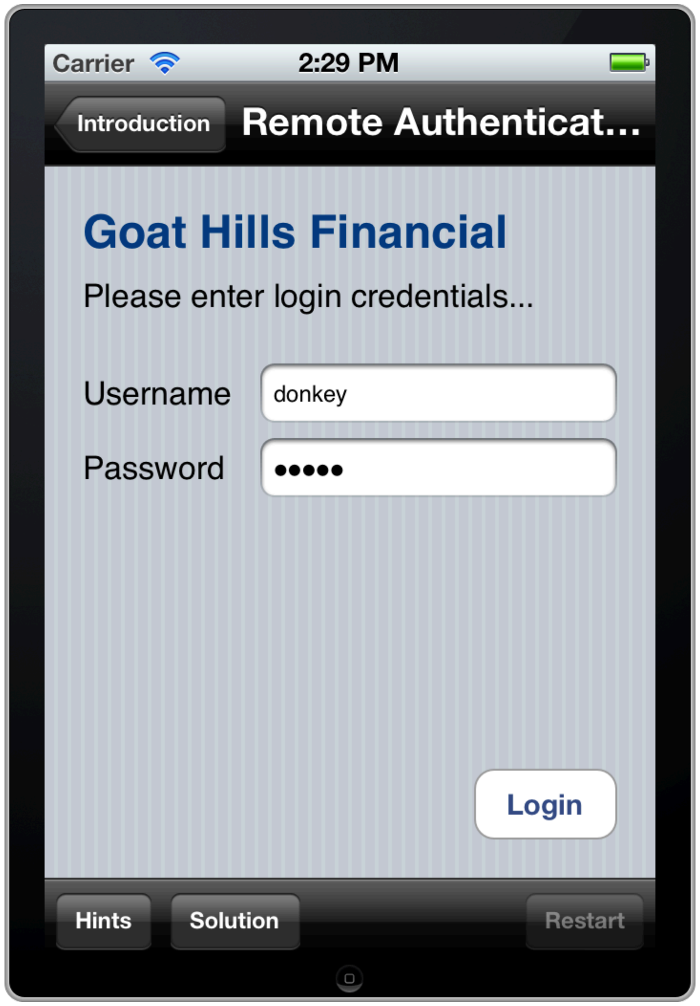
Control #	Description
3.1.3.6	Ensure sensitive data is protected in transit

Coffee shop attack -- credentials

This one is trivial, but let’s take a look

In this iGoat exercise, the user’s credentials are sent plaintext

- Simple web server running on Mac responds
- If this were on a public WiFi, a network sniffer would be painless to launch



Goat Hills Financial

Please enter login credentials...

Username donkey

Password •••••

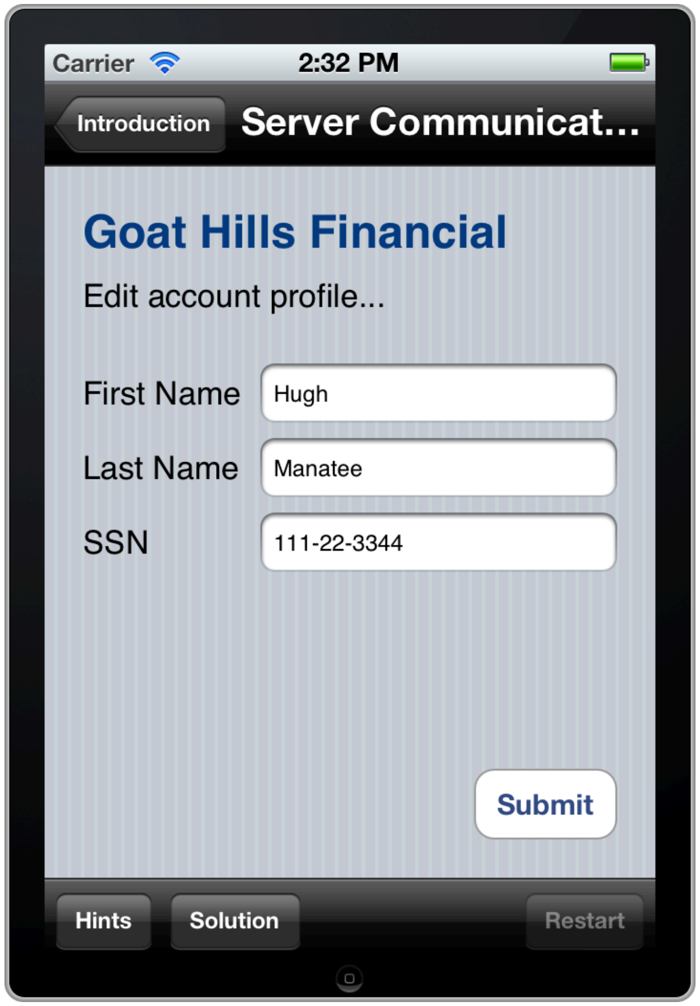
Login

Protecting users’ secrets in transit

- Always consider the coffee shop attack as lowest common denominator
- We place a lot of faith in SSL
  - But then, it’s been subjected to scrutiny for years

Passing secrets

In this simple example, we'll send customer data to a proxy server and intercept via a simulated coffee shop attack



Goat Hills Financial

Edit account profile...

First Name	Hugh
Last Name	Manatee
SSN	111-22-3344

How bad is it?

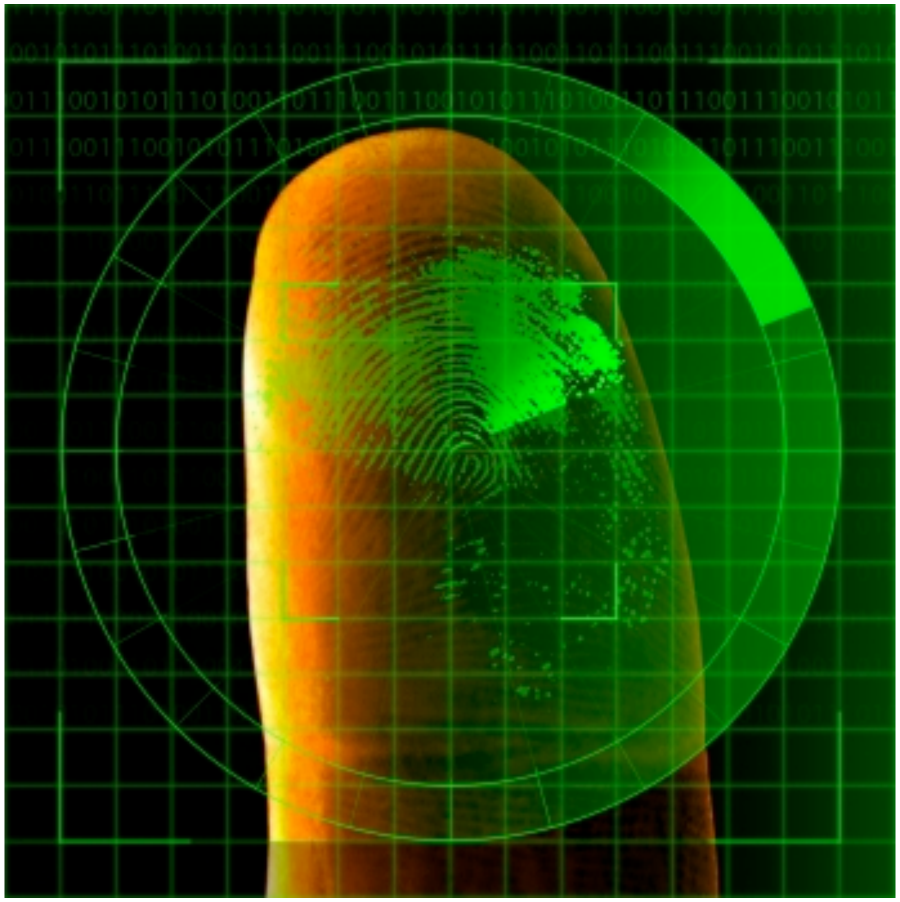
Neglecting SSL on network comms is common

- Consider the exposures
    - Login credentials
    - Session credentials
    - Sensitive user data

Will your app withstand a concerted coffee shop attacker?

Authentication

- Verifying a user's identity can be tricky
  - Passwords
  - Hardware tokens
  - Biometrics
- Each has pros and cons
- The mechanics of auth will reside on the server
  - Apps can access securely, or not...



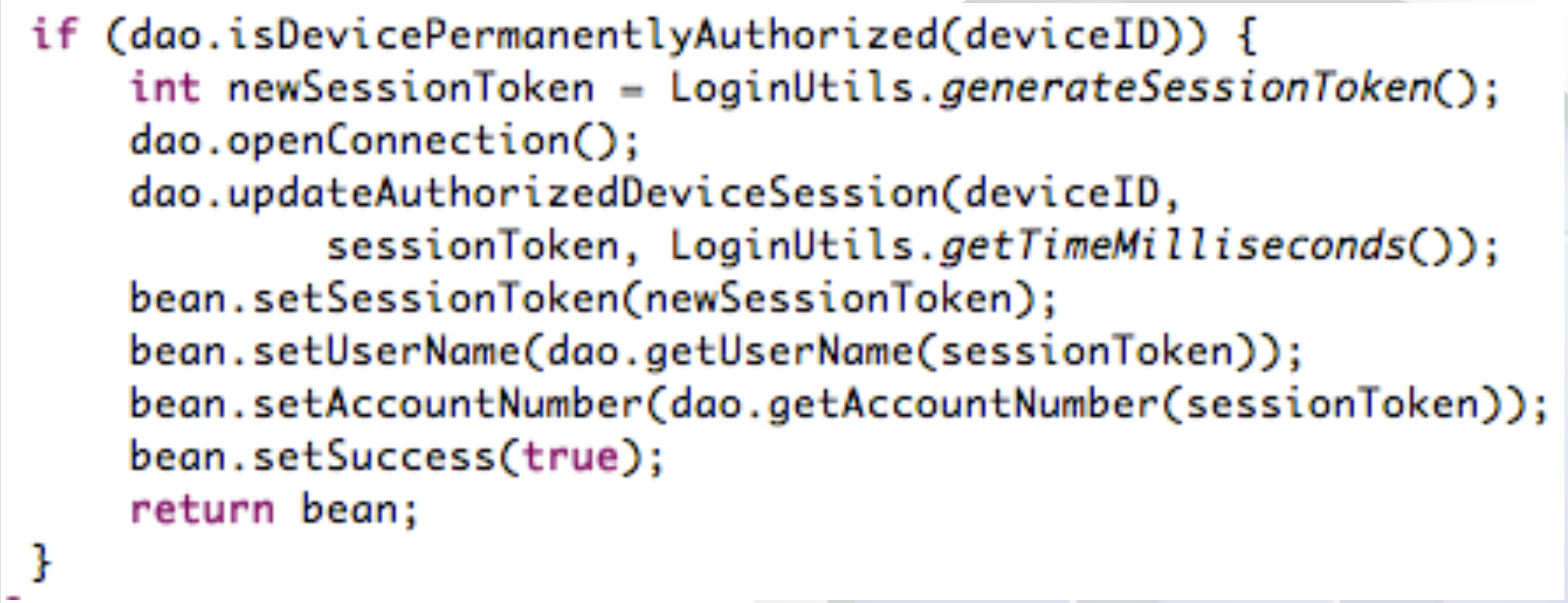
M5- Poor Authorization and Authentication

- Part mobile, part architecture
- Some apps rely solely on immutable, potentially compromised values (IMEI, IMSI, UUID)
- Hardware identifiers persist across data wipes and factory resets
- Adding contextual information is useful, but not foolproof

Impact

- Privilege escalation
- Unauthorized access

M5- Poor Authorization and Authentication



```
if (dao.isDevicePermanentlyAuthorized(deviceID)) {
    int newSessionToken = LoginUtils.generateSessionToken();
    dao.openConnection();
    dao.updateAuthorizedDeviceSession(deviceID,
            sessionToken, LoginUtils.getTimeMilliseconds());
    bean.setSessionToken(newSessionToken);
    bean.setUserName(dao.getUserName(sessionToken));
    bean.setAccountNumber(dao.getAccountNumber(sessionToken));
    bean.setSuccess(true);
    return bean;
}
```

M5- Poor Authorization and Authentication Prevention Tips

- Contextual info can enhance things, but only as part of a multi-factor implementation
- Out-of-band doesn't work when it's all the same device
- Never use device ID or subscriber ID as sole authenticator

Control #	Description
4.1-4.6	Implement user authentication/authorization and session management
8.4	Authenticate all API calls to paid resources

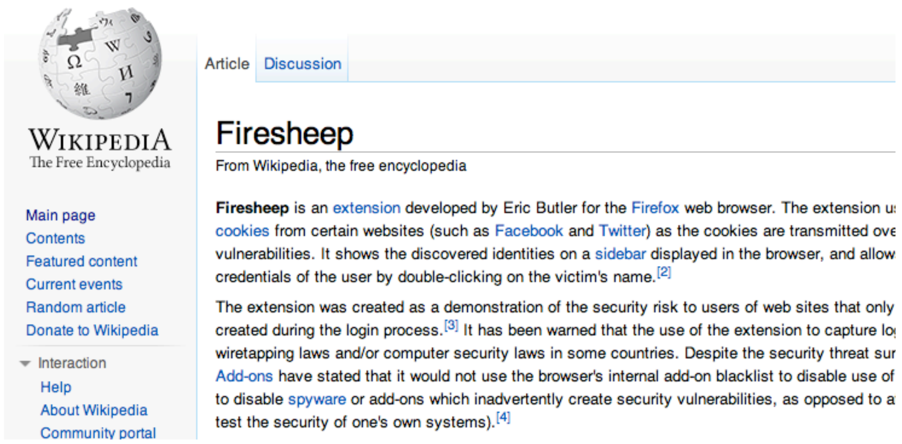
How bad is it?

Authentication exposures are common

– Tools like Firesheep make capture of auth and session credentials painless

Mobile systems offer no inherent improvements over web apps here

– It's up to the developer



Firesheep

From Wikipedia, the free encyclopedia

Firesheep is an extension developed by Eric Butler for the Firefox web browser. The extension u
cookies from certain websites (such as Facebook and Twitter) as the cookies are transmitted ove
vulnerabilities. It shows the discovered identities on a sidebar displayed in the browser, and allow
credentials of the user by double-clicking on the victim's name.[2]

The extension was created as a demonstration of the security risk to users of web sites that only
created during the login process.[3] It has been warned that the use of the extension to capture lo
wiretapping laws and/or computer security laws in some countries. Despite the security threat sur
Add-ons have stated that it would not use the browser's internal add-on blacklist to disable use of
to disable spyware or add-ons which inadvertently create security vulnerabilities, as opposed to a
test the security of one's own systems).[4]

Session management

- Web technologies have no inherent session management at all
  - Controlled and managed by server side
  - Session ID passed to client and returned with HTTP responses and requests
- Hugely susceptible to replay
  - Think coffee shop...

M6- Improper Session Handling

- Mobile app sessions are generally MUCH longer
- Why? Convenience and usability
- Apps maintain sessions via
  - HTTP cookies
  - OAuth tokens
  - SSO authentication services
- Bad idea= using a device identifier as a session token

Impact

- Privilege escalation
- Unauthorized access
- Circumvent licensing and payments

M6- Improper Session Handling
Prevention Tips

- Don’t be afraid to make users re-authenticate every so often
- Ensure that tokens can be revoked quickly in the event of a lost/stolen device
- Utilize high entropy, tested token generation resources

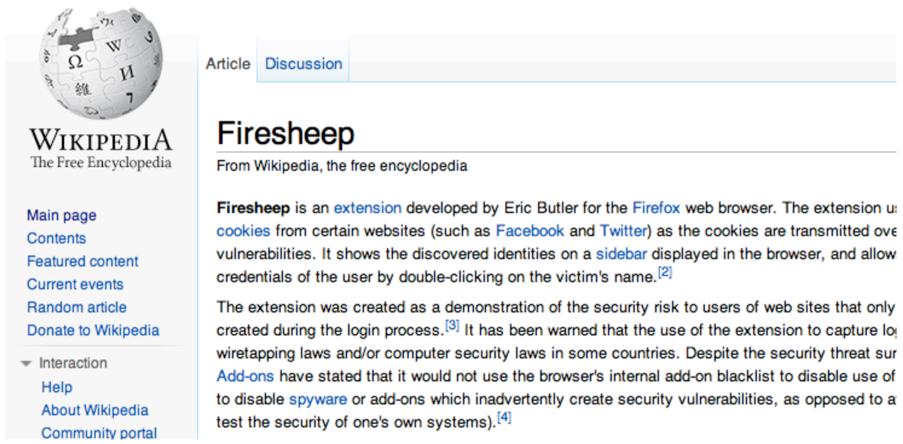
Control #	Description
1.13	Use non-persistent identifiers
4.1-4.6	Implement user authentication/authorization and session management

Session management basics

- Web contains no inherent session management
- Unique ID assigned to each session on server
- ID passed to browser and returned in each GET/POST
  - JSESSIONID for Java EE
- Once authenticated, session token is as powerful as valid username/password
- Must be rigorously protected
  - Confidential
  - Random
  - Unpredictable
  - Unforgeable

How bad is it?

- Many web apps toss around session credentials in plain text
  - Firesheep was written to draw attention to this
- Are mobile apps any better?
  - Some are, some aren’t



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test the security of one's own systems).[4]

Privacy concerns

Kind of like protecting secrets, eh?

Yes, but some special concerns too

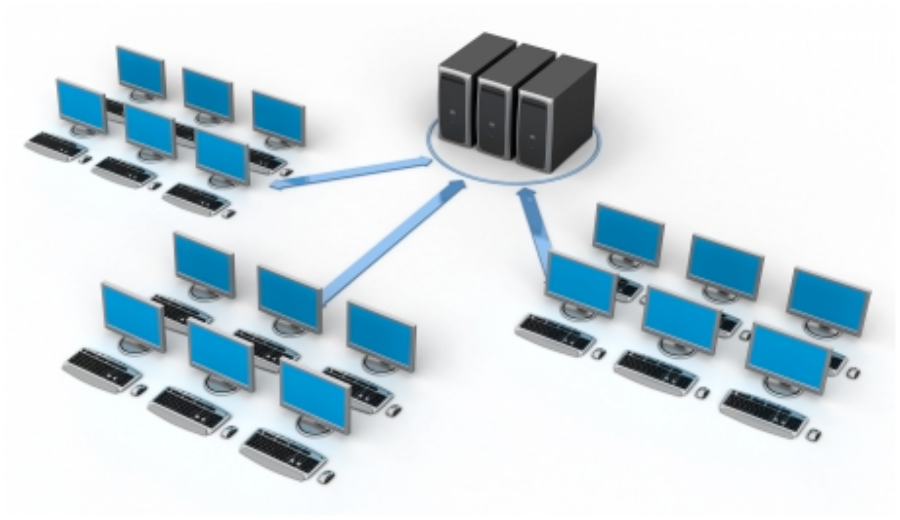
Let’s analyze a typical app

– Finder or iPhone Explorer

Attack vector: web app weakness

Remember, modern mobile devices share a lot of weaknesses with web applications

- Many shared technologies
- A smart phone is *sort of* like a mobile web browser
  - Only worse in some regards



Input and output validation

Problems abound

- Data must be treated as dangerous until proven safe
- No matter where it comes from

Examples

- Data injection
- Cross-site scripting

Where do you think input validation should occur?

SQL Injection

Most common injection attack

- Attacker taints input data with SQL statement
- Application constructs SQL query via string concatenation
- SQL passes to SQL interpreter and runs on server

Consider the following input to an HTML form

- Form field fills in a variable called “CreditCardNum”
- Attacker enters
  - ‘
  - ‘ --
  - ‘ or 1=1 --
- What happens next?

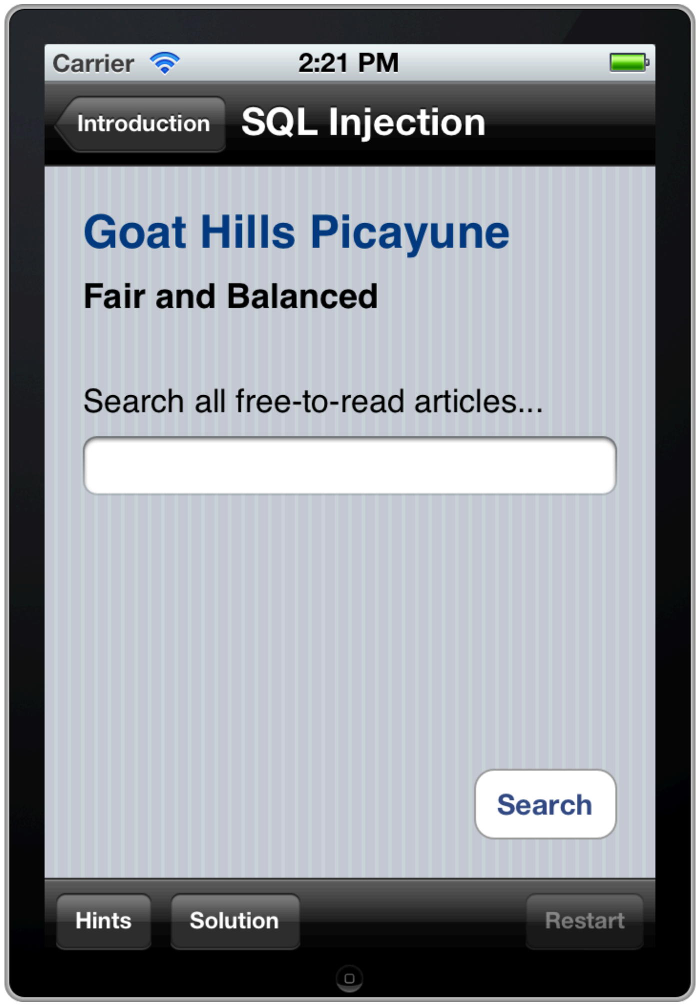
SQL injection exercise - client side

In this one, a local SQL db contains some restricted content

– Attacker can use “SQLi” to view restricted info

Not all SQLi weaknesses are on the server side!

Question: Would db encryption help?



Goat Hills Picayune

Fair and Balanced

Search all free-to-read articles...

Other injection dangers

SQL injection is common but others exist

- XML
- LDAP
- Command shell
- Comma delimited files
- Log files

Context is everything

- Must be shielded from presentation layer

Input validation will set you free

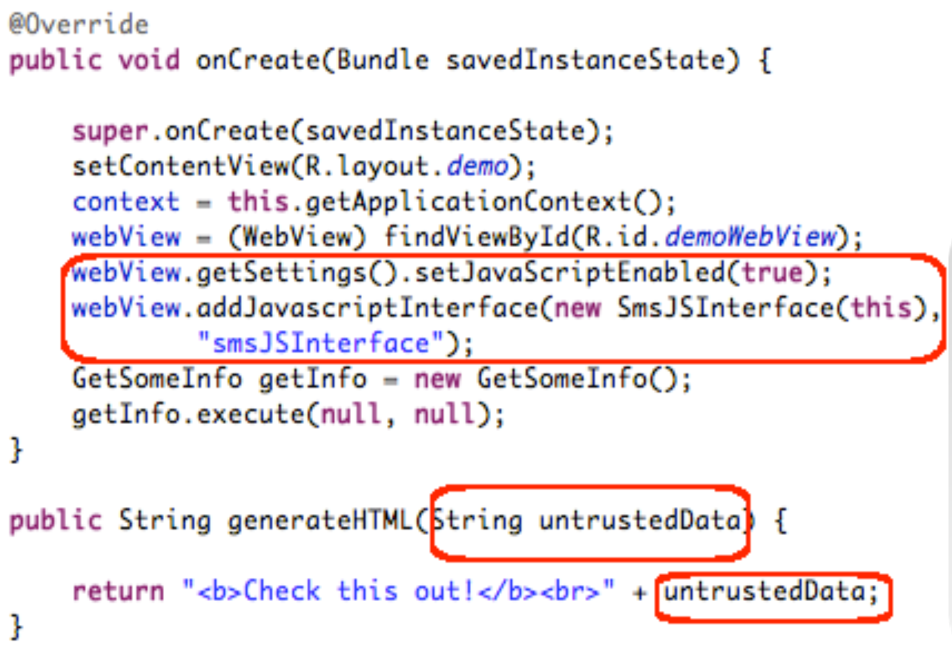
- Positive validation is vital

Cross-site scripting (XSS)

- The "go jump in a lake" problem
  - Script data entered into software and replayed in victim's context
  - Browser cannot tell good from bad
- iOS UIWebView calls can open these up on client
  - Web redirects can further exacerbate the problem

M4- Client Side Injection

Garden Variety XSS….



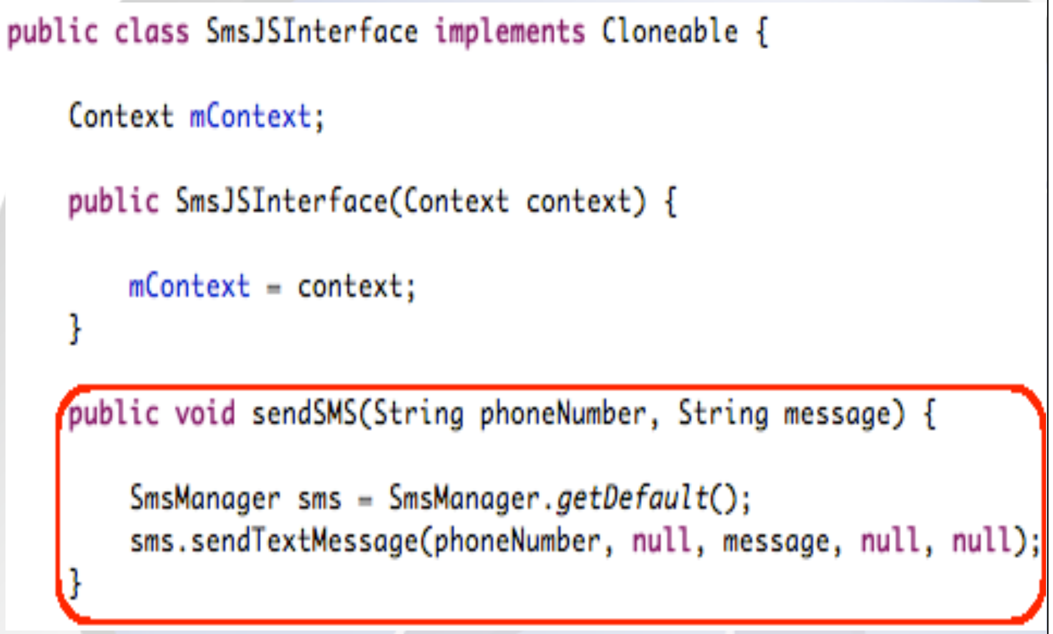
```
@Override
public void onCreate(Bundle savedInstanceState) {

    super.onCreate(savedInstanceState);
    setContentView(R.layout.demo);
    context = this.getApplicationContext();
    webView = (WebView) findViewById(R.id.demoWebView);
    webView.getSettings().setJavaScriptEnabled(true);
    webView.addJavascriptInterface(new SmsJSInterface(this),
            "smsJSInterface");
    GetSomeInfo getInfo = new GetSomeInfo();
    getInfo.execute(null, null);
}

public String generateHTML(String untrustedData) {

    return "<b>Check this out!</b><br>" + untrustedData;
}
```

With access to:



```
public class SmsJSInterface implements Cloneable {

    Context mContext;

    public SmsJSInterface(Context context) {

        mContext = context;
    }

    public void sendSMS(String phoneNumber, String message) {

        SmsManager sms = SmsManager.getDefault();
        sms.sendTextMessage(phoneNumber, null, message, null, null);
    }
```

M4- Client Side Injection
Prevention Tips

- Sanitize or escape untrusted data before rendering or executing it
- Use prepared statements for database calls…concatenation is still bad, and always will be bad
- Minimize the sensitive native capabilities tied to hybrid web functionality

Control #	Description
6.3	Pay particular attention to validating all data received from and sent to non-trusted third party apps before
10.1-10.5	Carefully check any runtime interpretation of code for errors

How bad is it?

Developers trust too much, remember?

- Don't fall for that trap

Consider all the data in your system

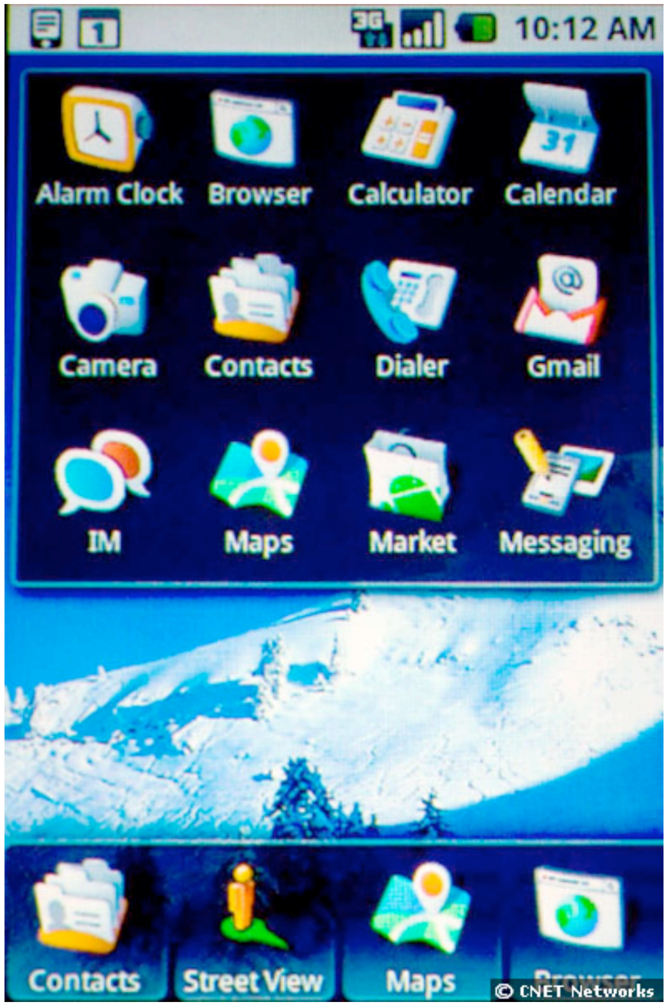
- All the interfaces and connections
- How much of it do you trust?

How about Android?

Several issues

- WebKit based browser and web apps
- WebView in other apps
- SQLite interface
- Web services interfaces to servers

Just to name a few



Access control

Largely a server side issue, but can be exacerbated by poor input validation

How bad is it?

This one is murkier to say without extensive testing

- But in my experience testing apps, access control was always lacking

M7- Security Decisions Via Untrusted Inputs

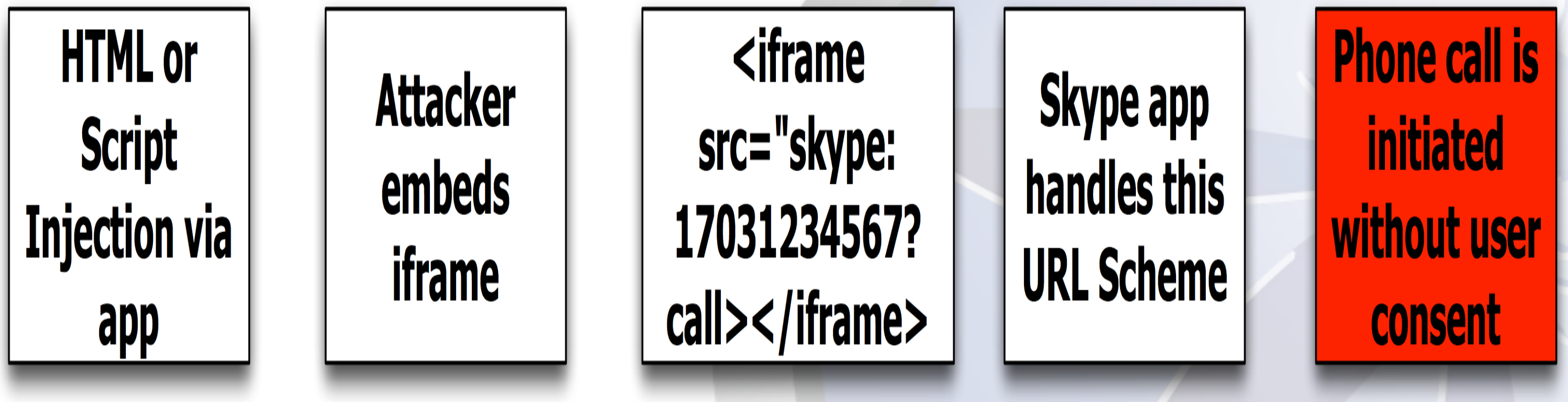
- Can be leveraged to bypass permissions and security models
- Similar but different depending on platform
  - iOS- Abusing URL Schemes
  - Android- Abusing Intents
- Several attack vectors
  - Malicious apps
  - Client side injection

Impact

- Consuming paid resources
- Data exfiltration
- Privilege escalation

M7- Security Decisions Via Untrusted Inputs

Skype iOS URL Scheme Handling Issue


HTML or Script Injection via app
Attacker embeds iframe
<iframe src="skype:17031234567?call></iframe>
Skype app handles this URL Scheme
Phone call is initiated without user consent

- http://software-security.sans.org/blog/2010/11/08/insecure-handling-url-schemes-apples-ios/

M7- Security Decisions Via Untrusted Inputs
Prevention Tips

- Check caller’s permissions at input boundaries
- Prompt the user for additional authorization before allowing
- Where permission checks cannot be performed, ensure additional steps required to launch sensitive actions

Control #	Description
10.2	Run interpreters at minimal privilege levels

M8- Side Channel Data Leakage

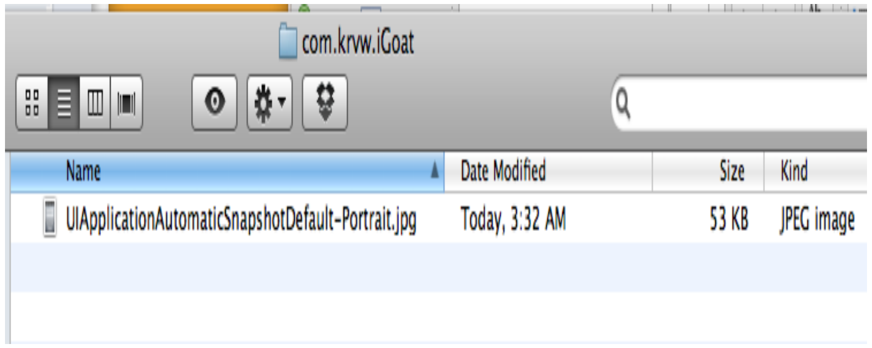
- Mix of not disabling platform features and programmatic flaws
- Sensitive data ends up in unintended places
  - Web caches
  - Keystroke logging
  - Screenshots (ie- iOS backgrounding)
  - Logs (system, crash)
  - Temp directories
- Understand what 3rd party libraries in your apps are doing with user data (ie- ad networks, analytics)

Impact

- Data retained indefinitely
- Privacy violations

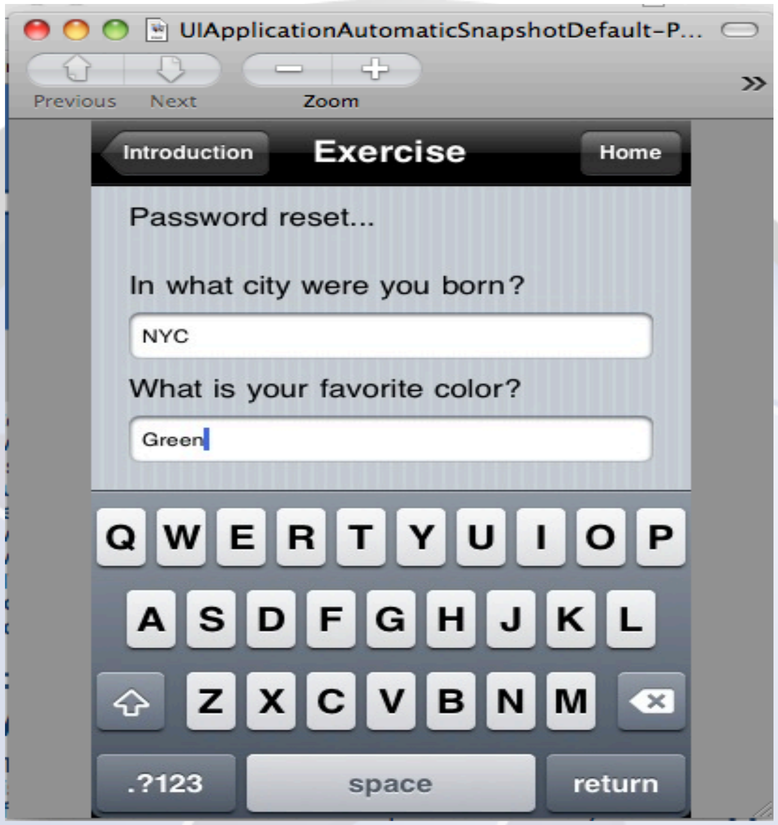
M8- Side Channel Data Leakage

Screenshots



com.krvw.iGoat

Name	Date Modified	Size	Kind
UIApplicationAutomaticSnapshotDefault-Portrait.jpg	Today, 3:32 AM	53 KB	JPEG image



Password reset...

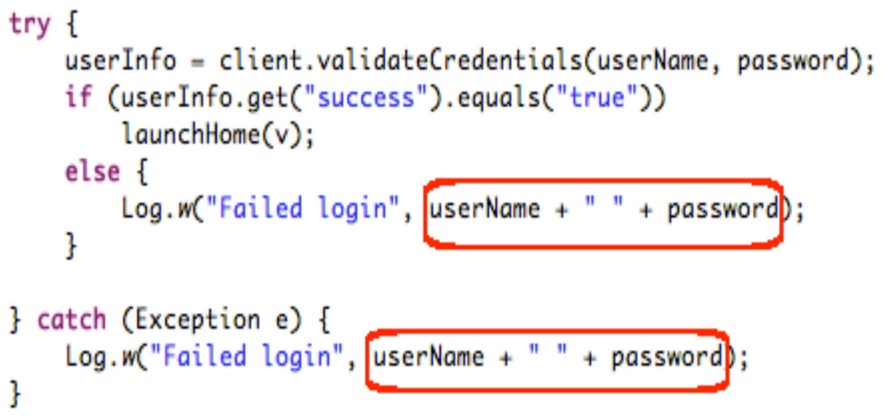
In what city were you born?

NYC

What is your favorite color?

Green

Logging



```
try {
    userInfo = client.validateCredentials(userName, password);
    if (userInfo.get("success").equals("true"))
        launchHome(v);
    else {
        Log.w("Failed login", userName + " " + password);
    }

} catch (Exception e) {
    Log.w("Failed login", userName + " " + password);
}
```

M8- Side Channel Data Leakage
Prevention Tips

- Never log credentials, PII, or other sensitive data to system logs
- Remove sensitive data before screenshots are taken, disable keystroke logging per field, and utilize anti-caching directives for web content
- Debug your apps before releasing them to observe files created, written to, or modified in any way
- Carefully review any third party libraries you introduce and the data they consume
- Test your applications across as many platform versions as possible

Control #	Description
7.3	Check whether you are collecting PII, it may not always be obvious
7.4	Audit communication mechanisms to check for unintended leaks (e.g. image

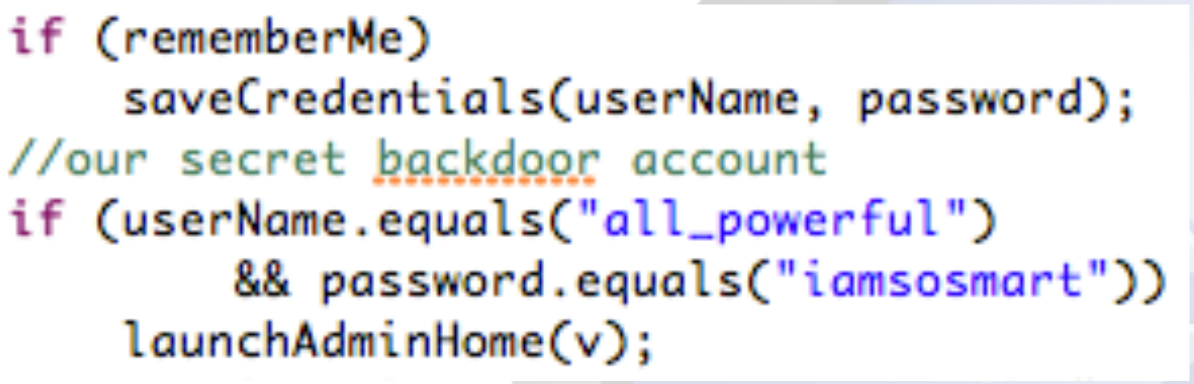
M10- Sensitive Information Disclosure

- We differentiate by stored (M1) vs. embedded/hardcoded (M10)
- Apps can be reverse engineered with relative ease
- Code obfuscation raises the bar, but doesn't eliminate the risk
- Commonly found "treasures":
  - API keys
  - Passwords
  - Sensitive business logic

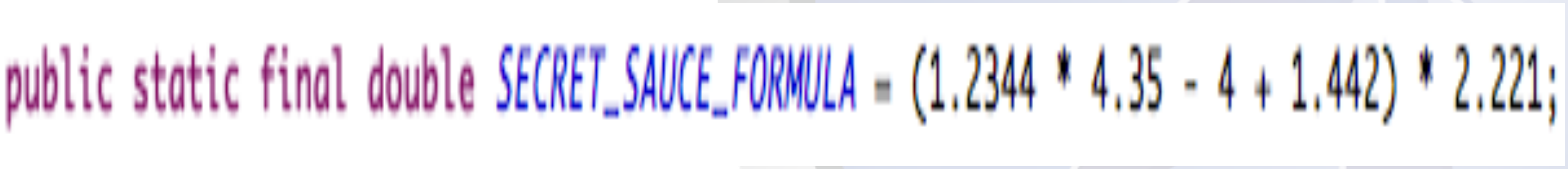
Impact

- Credentials disclosed
- Intellectual property exposed

M10- Sensitive Information Disclosure



```
if (rememberMe)
    saveCredentials(userName, password);
//our secret backdoor account
if (userName.equals("all_powerful")
        && password.equals("iamsosmart"))
    launchAdminHome(v);
```



```
public static final double SECRET_SAUCE_FORMULA = (1.2344 * 4.35 - 4 + 1.442) * 2.221;
```

M10- Sensitive Information Disclosure
Prevention Tips

- Private API keys are called that for a reason…keep them off of the client
- Keep proprietary and sensitive business logic on the server
- Almost never a legitimate reason to hardcode a password (if there is, you have other problems)

Control #	Description
2.10	Do not store any passwords or secrets in the application binary

Platform Architecture - Android

What the Android / hardware platform offers us in the way of protection

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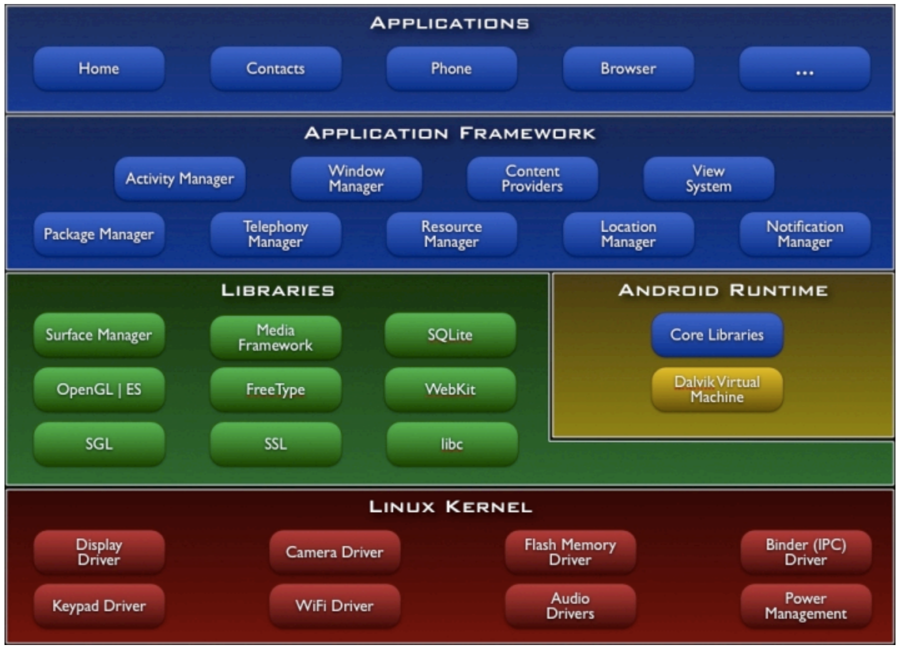
Android application architecture

The Android platform is a Java-based stack with a modified linux kernel

- Apps can reach down as they choose to
- Only published APIs are permitted, however

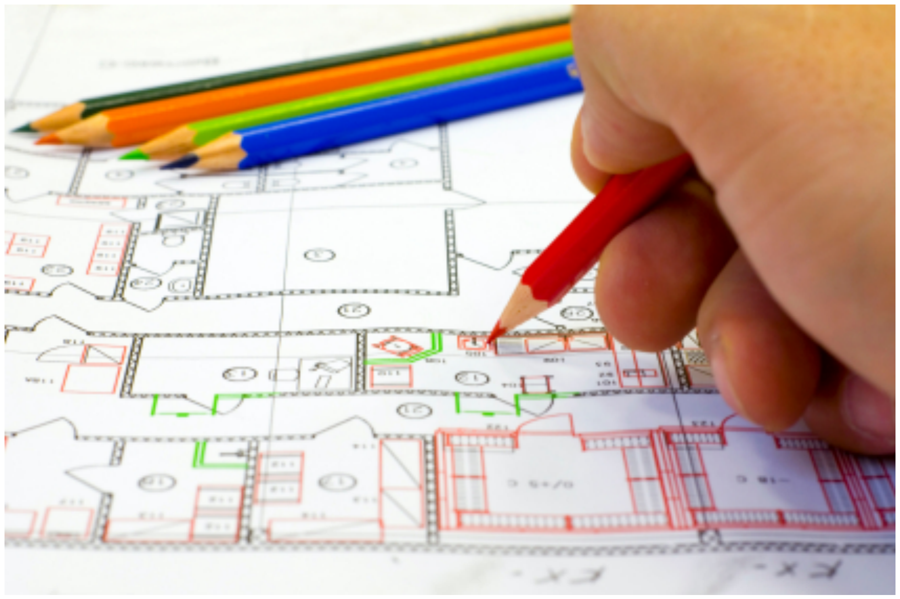
See http://developer.android.com/guide/basics/what-is-android.html



Android fundamentals

App components

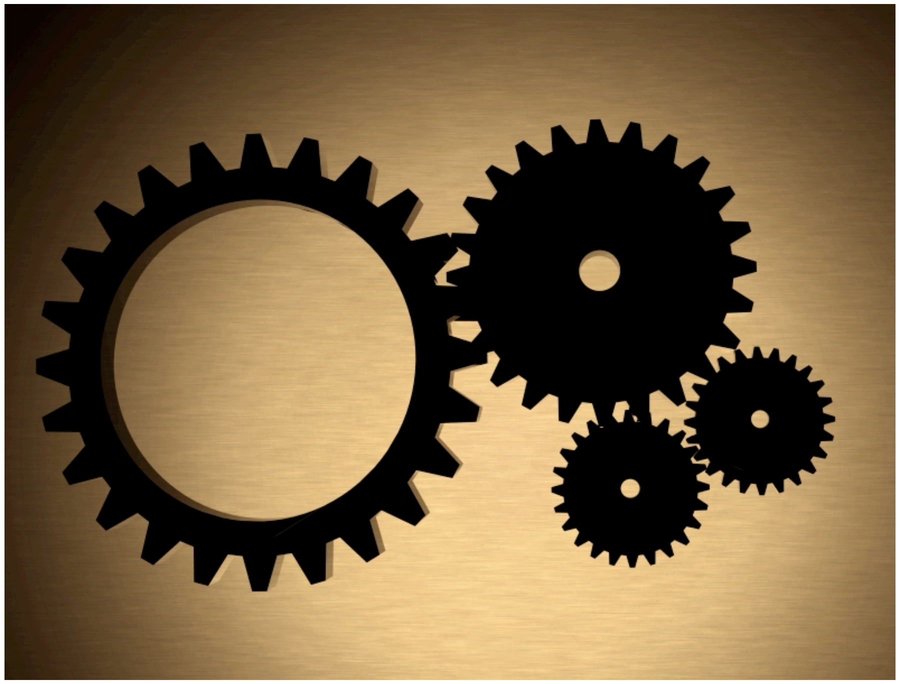
- Activities
  - Single screen and user interface
  - Activated by an *intent*
- Services
  - Background task with no user interface
  - Activated by an *intent*
- Content providers
  - Manages shared set of app data
  - Activated when targeted by a *content resolver*
- Broadcast receivers
  - Listens for system-wide broadcast announcements
  - Activated by an *intent*



For all intents and purposes

Intents

- Handy little objects (android.content.Intent)
- Explicit and implicit
- Messaging between apps
  - Essentially an API for one app to invoke another via messaging
- The key to building a mesh of cooperating apps
- How does that affect isolation?



App manifest

Defines an app's components and permissions

- AndroidManifest.xml
- Approved (or not) in a single yes/no from user
- No line item veto by user
- Permissions include
  - SMS
  - Phone call
  - File i/o

Example

```
<?xml version="1.0" encoding="utf-8"?>
<manifest ... >
    <application android:icon="@drawable/
app_icon.png" ... >
        <activity
android:name="com.example.project.ExampleActivity"
                  android:label="@string/
example_label" ... >
        </activity>
        ...
    </application>
</manifest>
```

Manifest permissions

Declare what permissions an app needs

– Examples include

```
android.permission.CALL_EMERGENCY_NUMBERS
android.permission.READ_OWNER_DATA
android.permission.SET_WALLPAPER
android.permission.DEVICE_POWER
```

– Granular to specific activity

```
    <manifest . . . >

    <permission
  android:name="com.example.project.DEBIT_ACCT".../>

    <uses-permission
  android:name="com.example.project.DEBIT_ACCT" />
  . . .


  <application . . .>
      <activity
android:name="com.example.project.FreneticActivity"

android:permission="com.example.project.DEBIT_ACCT"
      . . . >
      . . .
      </activity>
   </application>

  </manifest>
```

Manifest issues

- Interesting aspect of an app’s sandbox
- Permissions can be defined quite rigorously
- App code is obligated to comply
- But it’s all up to the developer to get it right
- User has no insight or configurability

Key security features

- Application sandboxing
  - No app can perform any action harmful to other apps or the OS
- Application Signing
- File IDs and Permissions
- SSL

Application sandboxing

By default, apps are only permitted to access resources in their sandbox

- Each app gets a unique UNIX-style UID
- File permissions keep files private per app at file system
- Inter-app comms are by established APIs only
  - URLs
  - File IO

Sounds pretty good, eh?

Encryption on Android

- Android 2.2 has software based encryption
  - Standard Java classes
  - Bouncy Castle works too
- Android 3.0 and 4.0 include hardware based encryption
  - But our apps can't rely on this

See http://www.unwesen.de/2011/06/12/encryption-on-android-bouncycastle/

SSL and x.509 certificate handling

- API provided for SSL and certificate verification
  - javax.crypto.*
  - Basic client to server SSL is pretty easy
    - Self-signed certs are frustrating
  - Mutual verification of certificates is achievable, but API is complex
- Overall, pretty solid
  - Whew!

And a few glitches...

No ubiquitous hardware encryption

Legacy phones not receiving OS updates

- What is “Android” really?

No centralized app store

- apps are not reviewed consistently before introduction into one of the many app stores
- Trojan Android apps have been spotted many times

Discouraged?

If we build our apps using these protections only, we'll have problems

- But consider risk
- What is your app's "so what?" factor?
- What data are you protecting?
- From whom?
- Might be enough for some purposes

But for a serious enterprise...

The protections provided are simply not adequate to protect serious data

- Financial
- Privacy
- Credit cards

We need to further lock down

- But how much is enough?

Application Architecture

How do we build our apps securely?

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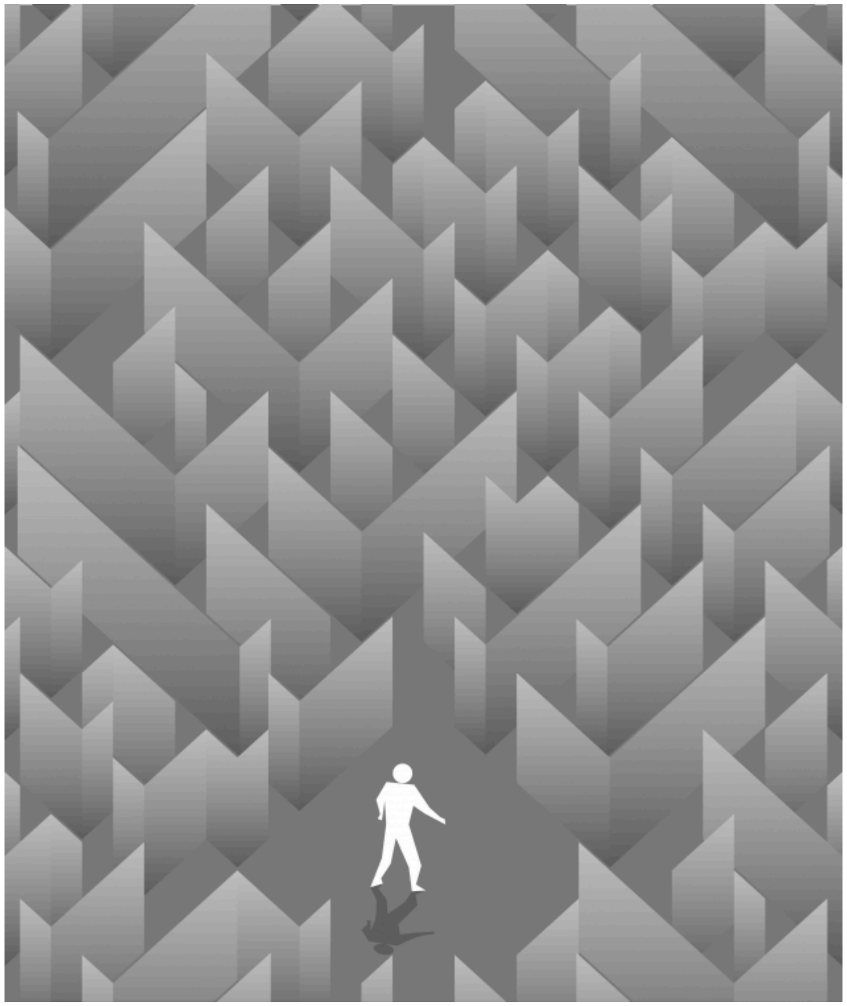
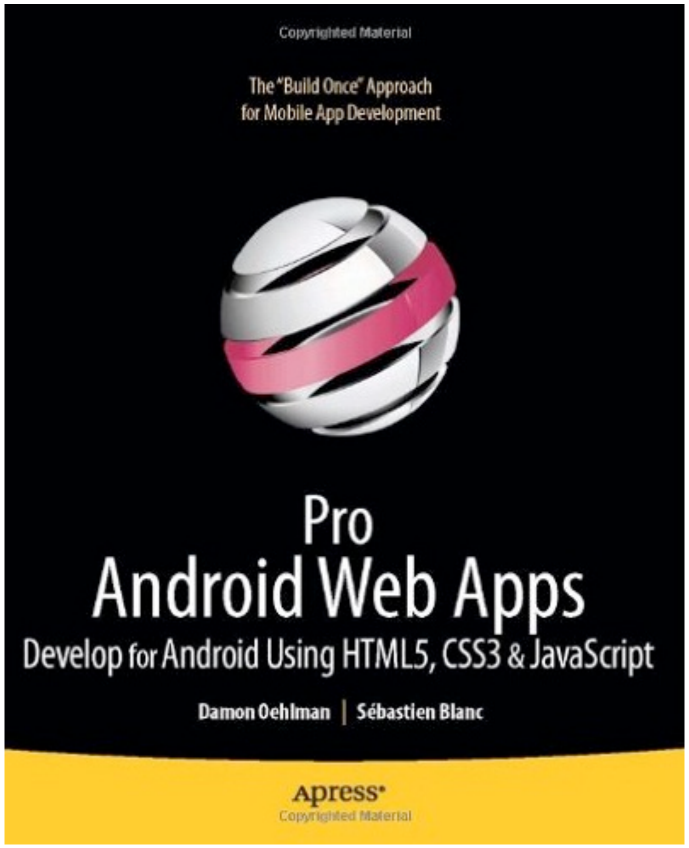
Common app types

- Web app
- Web-client hybrid
- App
  - Stand alone
  - Client-server
  - Networked
- Decision time...



Web applications

- Don't laugh--you really can do a lot with them
  - Dashcode is pretty slick
    - And mostly works on Android
  - Can give a very solid UI to a web app
- Pros and cons
  - Data on server (mostly)
  - No app store to go through
  - Requires connectivity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The "Build Once" Approach for Mobile App Development
Pro Android Web Apps
Develop for Android Using HTML5, CSS3 & JavaScript
Damon Oehlman | Sébastien Blanc
Apress
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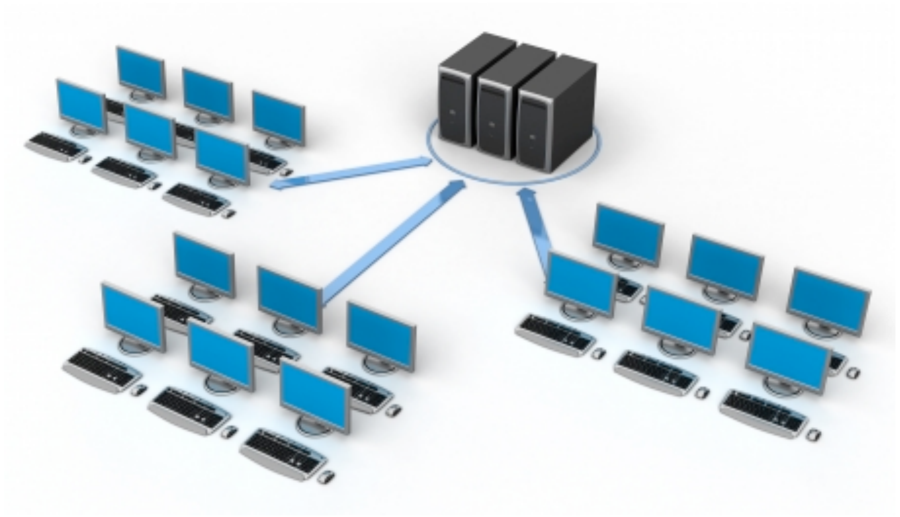
Web-client hybrid

- Local app with web views
  - Still use Dashcode on web views
  - Local resources available via Javascript
    - Location services, etc
- Best of both worlds?
  - Powerful, dynamic
  - Still requires connection

Android app -- client-server

- Most common app for enterprises
  - Basically alternate web client for many
  - But with Android UI on client side
  - Server manages access, sessions, etc.
- Watch out for local storage
  - Avoid if possible
  - Encrypt if not



Android app -- networked

Other network architectures also

- Internet-only
- P2P apps

Not common for enterprise purposes

Common Security Mechanisms

Now let’s build security in

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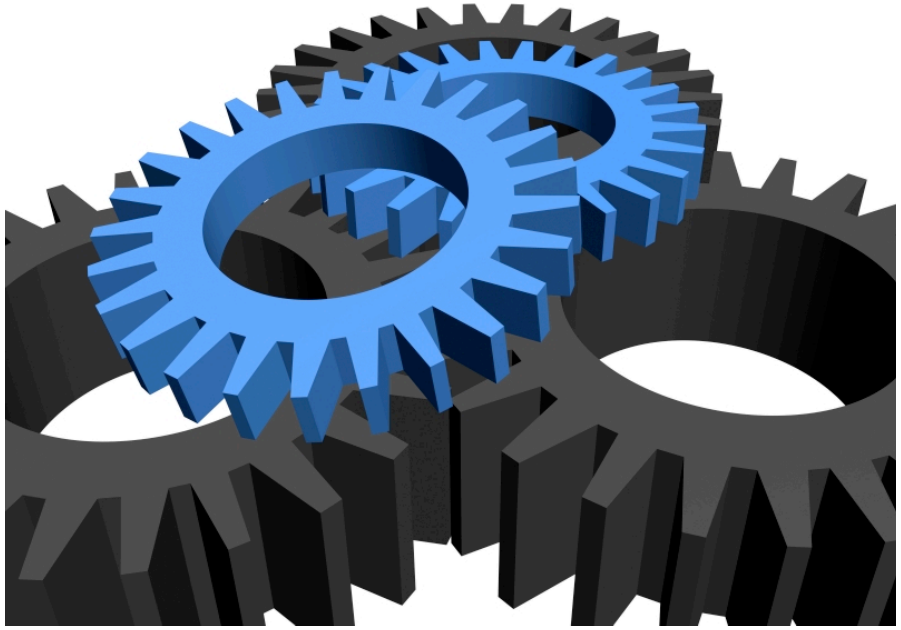
Common mechanisms

- Input validation
- Output escaping
- Authentication
- Session handling
- Protecting secrets
  - At rest
  - In transit
- SQL connections



Input validation

Positive vs negative validation

- Dangerous until proven safe
- Don't just block the bad

Consider the failures of desktop anti-virus tools

- Signatures of known viruses

Input validation architecture

- We have several choices
  - Some good, some bad
- Positive validation is our aim
- Consider tiers of security in an enterprise app
  - Tier 1: block the bad
  - Tier 2: block and log
  - Tier 3: block, log, and take evasive action to protect

Input validation

```
  private void validateDataFormat(String t){
    Pattern p = Pattern.compile("^REGEX GOES HERE!$");
    Matcher m = p.matcher(t);
        m.find();
    if (m.matches()){
        this.myString = m.group(0);
        this.setIsValid(true);
        this.setStatus(0);
    } else {
        this.myString = "Invalid Input String";
        this.setIsValid(false);
        this.setStatus(99); //  String parsing error
    }
}
```

Output escaping

Principle is to ensure data output does no harm in output context

- Output escaping of control chars
  - How do you drop a "<" into an XML file?
- Consider all the possible output contexts

Output encoding details

- Intent is to take dangerous data and output harmlessly
  - Context matters greatly
  - Especially want to block Javascript (XSS)
- In Android, not as much control, but
  - Never point WebView to untrusted content

Output encoding (server side)

Context

<body> UNTRUSTED DATA HERE </body>

<div> UNTRUSTED DATA HERE </div>

    other normal HTML elements

```
String safe =
ESAPI.encoder().encodeForHTML(request.getParameter(“input”));
```

Simple output encoding (client)

Basic output encoders are available too

```
String requestURL =
   String.format("http://www.example.com/?a=%s&b=%s",
      Uri.encode("foo bar"),
      Uri.encode("100% fubar'd"));
```

Or

```
import static org.apache.commons.lang.StringEscapeUtils.escapeHtml;
   String source = "The sign (<) and ampersand (&) must be escaped";
   String escaped = escapeHtml(source);
```

These simplistic encoders are not substitutes for robust encoding on the server, however

Authentication

This next example is for authenticating an app user to a server securely

- Server takes POST request, just like a web app

Authentication (POST-style)

```
   DefaultHttpClient client = new DefaultHttpClient();
HttpPost httppost = new HttpPost(LOGIN_SERVLET_URI);
List<BasicNameValuePair> params = new
      ArrayList<BasicNameValuePair>();
params.add(new BasicNameValuePair("userName", userName));
params.add(new BasicNameValuePair("password", password));

UrlEncodedFormEntity p_entity =
    new UrlEncodedFormEntity(params, HTTP.UTF_8);
httppost.setEntity(p_entity);
HttpResponse response = client.execute(httppost);
HttpEntity responseEntity = response.getEntity();
```

Authentication (JSON POST-style)

```
  public static String getGoogleAuthKey(String _USERNAME,
String _PASSWORD) throws UnsupportedEncodingException, IOException {
    Document doc = Jsoup.connect(_GOOGLE_LOGIN_URL).data(
        "accountType", "GOOGLE",
        "Email", _USERNAME,
        "Passwd", _PASSWORD,
        "service", "reader",
        "source", "&lt;your app name&gt;")
   .userAgent("&lt;your app name&gt;")
   .timeout(4000)
   .post();

  // RETRIEVES THE RESPONSE TEXT inc SID and AUTH. We only want the AUTH key.
  String _AUTHKEY =
  doc.body().text().substring(doc.body().text().indexOf("Auth="),
  doc.body().text().length());
  _AUTHKEY = _AUTHKEY.replace( "Auth=","" );
  return _AUTHKEY;
}
```

Mutual authentication

We may also want to use x.509 certificates and SSL to do strong mutual authentication

More complicated, but stronger

Example is long--see src at: http://stackoverflow.com/questions/4064810/using-client-server-certificates-for-two-way-authentication-ssl-socket-on-androi

Session handling

Normally controlled on the server for client-server apps

Basic session rules apply

- Server generates session token, once authenticated
- Session token identifies user/session until invalidated

Testing does help, though

Testing

Pitfalls to test for

- Credentials encrypted in transit?
- Using mobile device ID for auth or session
- GET vs. POST
- Username enumeration or harvesting?
- Dictionary and brute force attacks
- Bypassing
- Password remember and reset
- Password geometry
- Logout and browser caching

Dynamic validation is very helpful

Examples – HTTP 1

```
POST http://www.example.com/AuthenticationServlet HTTP/1.1
Host: www.example.com
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.1; it; rv:1.8.1.14) Gecko/20100404
Accept: text/xml,application/xml,application/xhtml+xml
Accept-Language: it-it,it;q=0.8,en-us;q=0.5,en;q=0.3
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
Referer: http://www.example.com/index.jsp
Cookie:
JSESSIONID=LVrRRQQXgwyWpW7QMnS49vtW1yBdqn98CGlkP4jTvVCGdyPkmn3S
!
Content-Type: application/x-www-form-urlencoded
Content-length: 64

delegated_service=218&User=test&Pass=test&Submit=SUBMIT
```

Examples – HTTP 2

```
POST https://www.example.com:443/login.do HTTP/1.1
Host: www.example.com
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.1; it; rv:1.8.1.14) Gecko/
20100404
Accept: text/xml,application/xml,application/xhtml+xml,text/html
Accept-Language: it-it,it;q=0.8,en-us;q=0.5,en;q=0.3
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
Referer: https://www.example.com/home.do
Cookie: language=English;
Content-Type: application/x-www-form-urlencoded
Content-length: 50

Command=Login&User=test&Pass=test
```

Examples – HTTP 3

```
POST https://www.example.com:443/login.do HTTP/1.1
Host: www.example.com
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.1; it; rv:1.8.1.14) Gecko/20100404
Accept: text/xml,application/xml,application/xhtml+xml,text/html
Accept-Language: it-it,it;q=0.8,en-us;q=0.5,en;q=0.3
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
Referer: http://www.example.com/homepage.do
Cookie:
SERVTIMSESSIONID=s2JyLkvDJ9ZhX3yr5BJ3DFLkdphH0QNSJ3VQB6pLhjkW6F
Content-Type: application/x-www-form-urlencoded
Content-length: 45

User=test&Pass=test&portal=ExamplePortal
```

Examples – HTTP 4

```
GET https://www.example.com/success.html?user=test&pass=test HTTP/
1.1
Host: www.example.com
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.1; it; rv:1.8.1.14)
Gecko/20100404
Accept: text/xml,application/xml,application/xhtml+xml,text/html
Accept-Language: it-it,it;q=0.8,en-us;q=0.5,en;q=0.3
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
Referer: https://www.example.com/form.html
If-Modified-Since: Mon, 30 Jun 2010 07:55:11 GMT
If-None-Match: "43a01-5b-4868915f"
```

Access control (authorization)

On the Android device itself, apps have access to everything in their sandbox

Server side must be designed and built in like any web app

Authorization basics

Question every action

- Is the user allowed to access this
  - File
  - Function
  - Data
  - Etc.

By role or by user

- Complexity issues
- Maintainability issues
- Creeping exceptions

Role-based access control

Must be planned carefully

Clear definitions of

- Users
- Objects
- Functions
- Roles
- Privileges

Plan for growth

Even when done well, exceptions will happen

ESAPI access control

In the presentation layer:

```
<% if ( ESAPI.accessController().isAuthorizedForFunction( ADMIN_FUNCTION ) ) { %>
 <a href="/doAdminFunction">ADMIN</a>
 <% } else { %>
 <a href="/doNormalFunction">NORMAL</a>
 <% } %>
```

In the business logic layer:

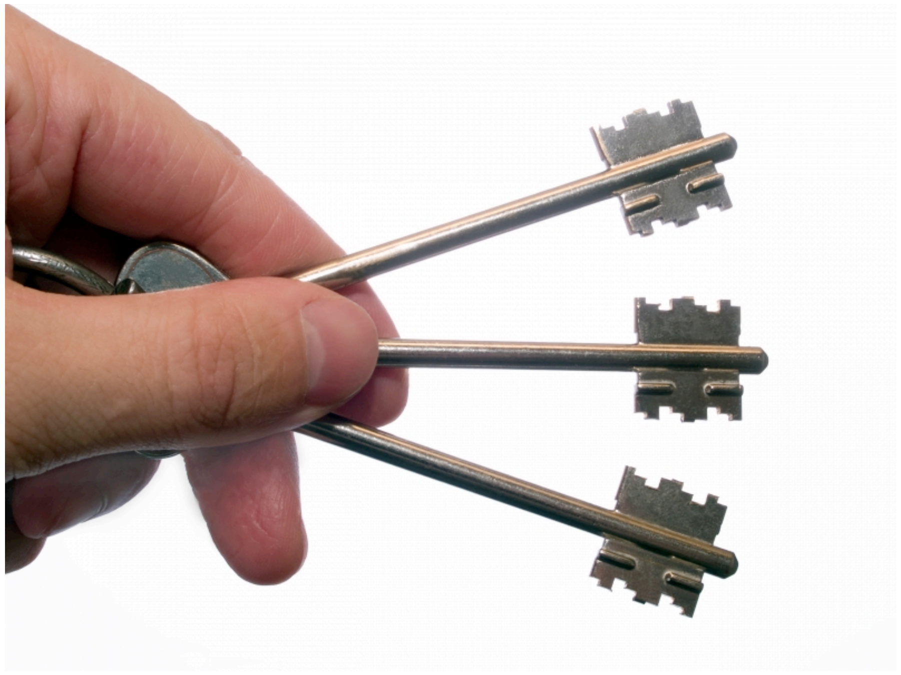
```
try {
    ESAPI.accessController().assertAuthorizedForFunction( BUSINESS_FUNCTION );
    // execute BUSINESS_FUNCTION
 } catch (AccessControlException ace) {
            ... attack in progress
 }
```

Protecting secrets at rest

The biggest problem by far is key management

- How do you generate a strong key?
- Where do you store the key?
- What happens if the user loses his key?

Too strong and user support may be an issue



Built-in file permissions (weak)

Uses Java 2 standard file permissions at OS level

- Weak, but still a good idea

Things to avoid

- MODE_WORLD_READABLE
- MODE_WORLD_WRITABLE

Protecting secrets at rest (keychain)

Recently released in 4.0 (API 14)

- Jury is still out on this one

Enter SQLcipher

Open source extension to SQLite
- Free
- Uses OpenSSL to AES-256 encrypt database
- Uses PBKDF2 for key expansion
- Generally accepted crypto standards

SQLCIPHER
Open Source Full Database Encryption for SQLite

Available from
- http://sqlcipher.net
- https://guardianproject.info/code/sqlcipher/ -- Android port

Protecting secrets at rest (SQLcipher)

Start with

```
import info.guardianproject.database.sqlcipher.SQLiteDatabase;
import info.guardianproject.database.sqlcipher.SQLiteOpenHelper;
```

Then use

```
mDb.execSQL("PRAGMA rekey = '" + password + "'");
```

All the rest is standard SQLite!

Toughest problem is still *key management*

SQLcipher example

- See notepadbot (aka "notecipher")
  - Android example notepad
  - SQLcipher enabled
- Available from
  - https://github.com/guardianproject/notepadbot

Protecting secrets in transit

Key management still matters, but SSL largely takes care of that

- Basic SSL is pretty straight forward
  - JSSE standards mostly apply
- Mutual certificates are stronger, but far more complicated

Protecting secrets in transit

Basic HTTPS example

```
final HttpPost httppost = new HttpPost("https://www.myurl.com");
final List<NameValuePair> postlist = Utils.HttpGetToHttpPost(Arguments);
httppost.setEntity(new UrlEncodedFormEntity(postlist));
final HttpResponse response = httpclient.execute(httppost);
```

Turning on strict name validation

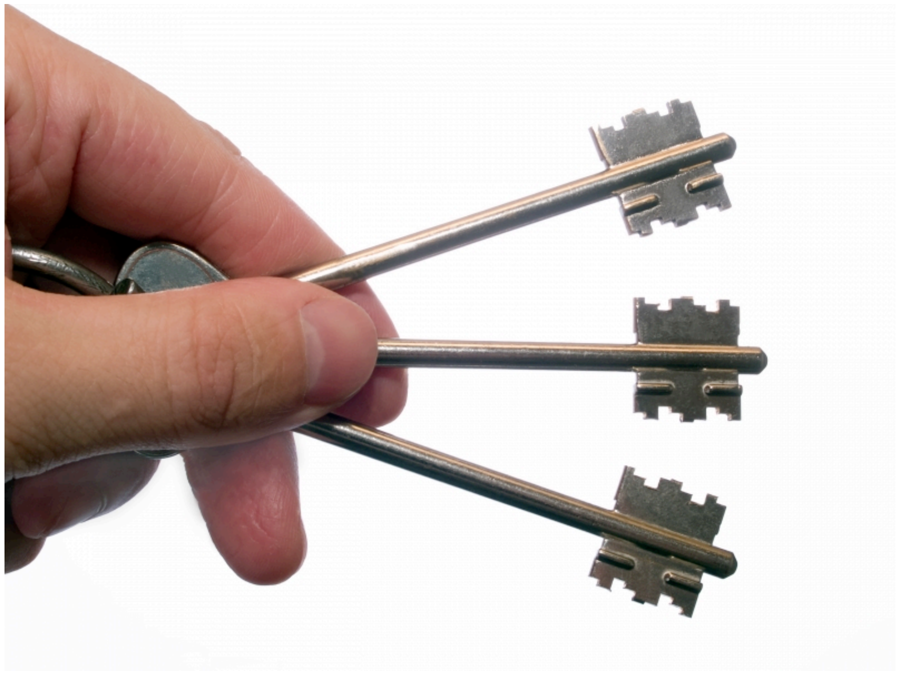
Basic HTTPS example

```
SSLSocketFactory sf = new SSLSocketFactory(SSLContext.getInstance("TLS"));
sf.setHostnameVerifier(SSLSocketFactory.STRICT_HOSTNAME_VERIFIER);
```

SSL pitfalls to avoid

Several common mistakes

- Disabling certificate verification
  - Don’t laugh, people do it
  - Test environments, etc.
- Using self-signed certs
- Storing certs unsafely
  - Secret should be secret



SSL tutorials

Several on-line tutorials describe SSL pitfalls and workarounds

- http://www.virtualzone.de/2011-02-27/how-to-use-apache-httpclient-with-httpsssl-on-android/
- http://thinkandroid.wordpress.com/2009/12/31/creating-an-http-client-example/
- http://blog.synyx.de/2010/06/android-and-self-signed-ssl-certificates/

SQL connections

Biggest security problem is using a mutable API

- Dynamic string constructed queries are weak to SQL injection

Must use immutable API

- Such as PreparedStatement

SQL connections

Prepared statements

```
String update = "update zoo set family = ? where name = ?;";
prst = conn.prepareStatement(update);
prst.setString(1, "canine");
prst.setString(2, "basset hound");
prst.executeUpdate();
```

Getting Started

Putting theory into practice

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Where to begin?

You’re armed with good knowledge

– Perhaps too much?

How do you build with confidence?

Dive deeper

We're off to a good start, but you should take deep dive

- Build reference library
  - Technology docs
  - Vulnerability and attack descriptions
- Testing tools
- On-line sources
  - iTunes University
    - Stanford courseware
    - Apple courseware

Include the key stakeholders

Plenty of people/orgs have a vested interest in your success

- Business owner (or rep)
- Information security
- Privacy officer

Process practice

Spend some time practicing what we've done

- Threat modeling
- Code reviews
- Testing

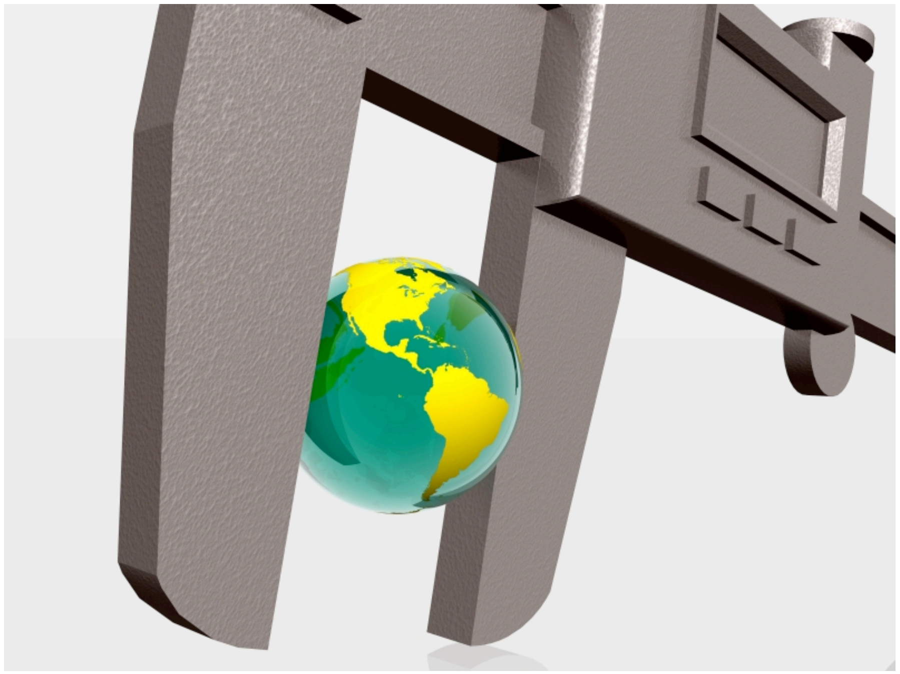
Small steps and practice help tremendously

- Small scale projects first

Design decisions matter

Threat modeling is easily omitted

- Time spent here is time well spent
- Results help build overall understanding
- Feed code review process
- Feed test process



Technology watch

Keep an eye on relevant developments

- Vulnerabilities
- Security tools

Participate in community

- Conferences
- Forums
- Associations
  - OWASP
  - FIRST

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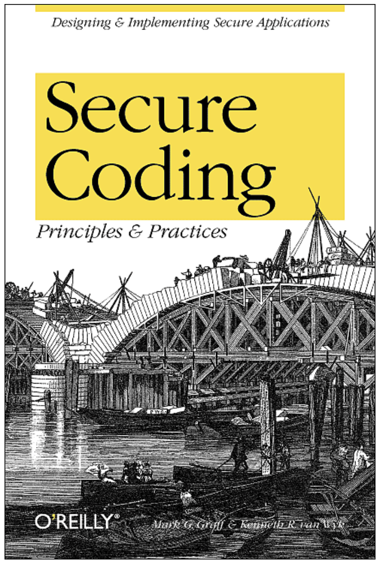
Designing & Implementing Secure Applications
Secure Coding
Principles & Practices
O'REILLY
Mark G. Graff & Kenneth R. van Wyk