Developing Secure Mobile Apps

SecAppDev 2011

Apple iOS (Xcode) edition

KRvW Associates, LLC

Platform Architecture

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

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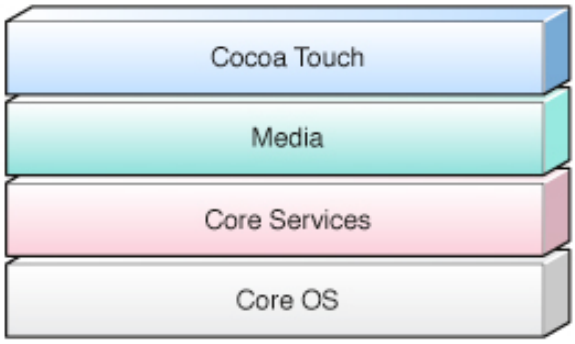
iOS application architecture

The iOS platform is basically a subset of a regular Mac OS X system's

- From user level (Cocoa) down through Darwin kernel
- Apps can reach down as they choose to
- Only published APIs are permitted, however



Key security features

Application sandboxing
App store protection
Hardware encryption
Keychains
SSL and certificates

Application sandboxing

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

- Inter-app comms are by established APIs only
  - URLs, keychains (limited)
- File i/o in ~/Documents only

Sounds pretty good, eh?

App store protection

Access is via digital signatures

- Only registered developers may introduce apps to store
- Only signed apps may be installed on devices

Sounds good also, right?

- But then there's jailbreaking...
- Easy and free
- Completely bypasses sigs

Hardware encryption

- Each iOS device (as of 3g) has hardware crypto module
  - Unique AES-256 key for every iOS device
  - Sensitive data hardware encrypted
- Sounds brilliant, right?
  - Well...

Keychains

- Keychain API provided for storage of small amounts of sensitive data
  - Login credentials, passwords, etc.
  - Encrypted using hardware AES
- Also sounds wonderful
  - Wait for it...

SSL and x.509 certificate handling

- API provided for SSL and certificate verification
  - Basic client to server SSL is easy
  - Mutual verification of certificates is achievable, but API is complex
- Overall, pretty solid
  - Whew!

And a few glitches...

- Keyboard data
- Screen snapshots
- Hardware encryption is flawed

Keyboard data

All “keystrokes” are stored

- Used for auto-correct feature
- Nice spell checker

Key data can be harvested using forensics procedures

- Passwords, credit cards...
- Needle in haystack?

Screen snapshots

Devices routinely grab screen snapshots and store in JPG

- Used for minimizing app animation
- It looks pretty

WHAT?!

- It’s a problem
- Requires local access to device, but still...

But the clincher

Hardware module protects unique key via device PIN

- PIN can trivially be disabled
- Jailbreak software

No more protection...

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

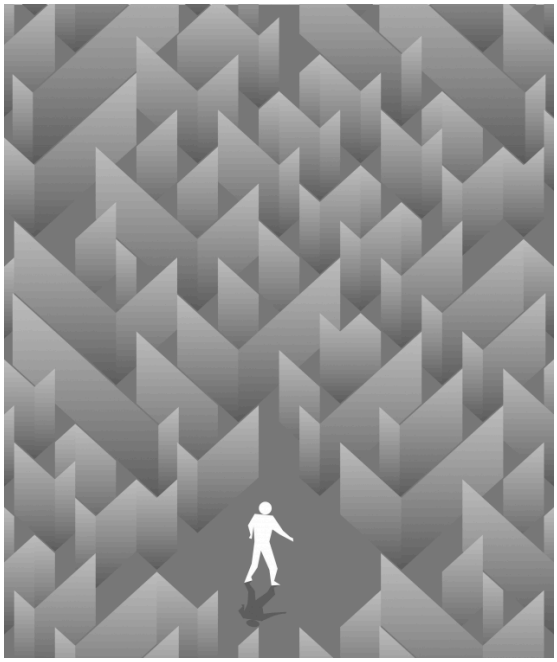
Web app

Web-client hybrid

App

- Stand alone
- Client-server
- Networked

Decision time...



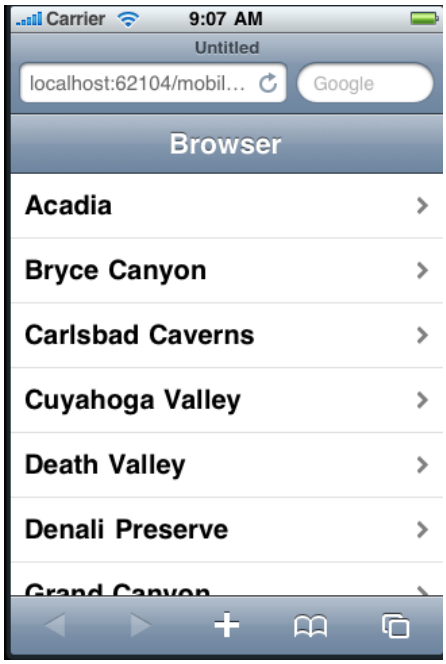
Web applications

Don't laugh--you really can do a lot with them

- Dashcode is pretty slick
- 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



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

iOS app -- client-server

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

iOS 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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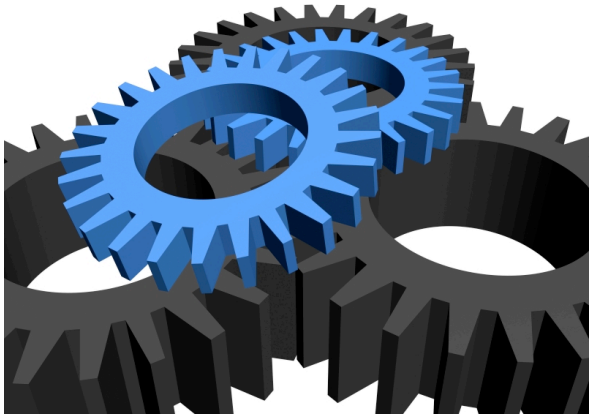
Common mechanisms

- 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 (in iOS)

```
// RFC 2822 email addres regex.
NSString *emailRegex =
   @"(?:[a-z0-9!#$%\\&'*+/=?\\^_`{|}~-]+(?:\\.[a-z0-9!#$%\\&'*+/=?\\^_`{|}"
   @"~-]+)*|\"(?:[\\x01-\\x08\\x0b\\x0c\\x0e-\\x1f\\x21\\x23-\\x5b\\x5d-\\"
   @"x7f]|\\\\[\\x01-\\x09\\x0b\\x0c\\x0e-\\x7f])*\")@(?:(?:[a-z0-9](?:[a-"
   @"z0-9-]*[a-z0-9])?\\.)+[a-z0-9](?:[a-z0-9-]*[a-z0-9])?|\\[(?:(?:25[0-5"
   @"]|2[0-4][0-9]|[01]?[0-9][0-9]?)\\.){3}(?:25[0-5]|2[0-4][0-9]|[01]?[0-"
   @"9][0-9]?|[a-z0-9-]*[a-z0-9]:(?:[\\x01-\\x08\\x0b\\x0c\\x0e-\\x1f\\x21"
   @"-\\x5a\\x53-\\x7f]|\\\\[\\x01-\\x09\\x0b\\x0c\\x0e-\\x7f])+)\\])";

// Create the predicate and evaluate.
NSPredicate *regExPredicate =
   [NSPredicate predicateWithFormat:@"SELF MATCHES %@", emailRegEx];
BOOL validEmail = [regExPredicate evaluateWithObject:emailAddress];

if (validEmail) {
   ...
} else {
   ...
}
```

Input validation (server side Java)

```
protected final static String ALPHA_NUMERIC =
     "^[a-zA-Z0-9\s.\-]+$";
// we only want case insensitive letters and numbers
public boolean validate(HttpServletRequest request, String
parameterName) {
boolean result = false;
Pattern pattern = null;
parameterValue = request.getParameter(parameterName);
if(parameterValue != null) {
   pattern = Pattern.compile(ALPHA_NUMERIC);
   result = pattern.matcher(parameterValue).matches();
   return result;
} else
{ // take alternate action }
```


Output encoding

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

- This is normally server side code
- Intent is to take dangerous data and output harmlessly
- Especially want to block Javascript (XSS)
- In iOS, not as much control, but
  - Never point UIWebView to untrusted content

Output encoding (server side)

Context
<body> UNTRUSTED DATA HERE </body>
 UNTRUSTED DATA HERE
other normal HTML elements

String safe = ESAPI.encoder().encodeForHTML(request.getParameter ("input"));

Authentication

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

- Server takes POST request, just like a web app

Authentication (forms-style)

```
// Initialize the request with the YouTube/Google ClientLogin URL (SSL).
NSString youTubeAuthURL = @"https://www.google.com/accounts/ClientLogin";
NSMutableRequest *request =
  [NSMutableURLRequest requestWithURL:[NSURL URLWithString:youTubeAuthURL]];

[request setHTTPMethod:@"POST"];

// Build the request body (form submissions POST).
NSString *requestBody =
  [NSString stringWithFormat:@"Email=%@&Passwd=%@&service=youtube&source=%@",
    emailAddressField.text, passwordField.text, @"Test"];

[request setHTTPBody:[requestBody dataUsingEncoding:NSUTF8StringEncoding]];

// Submit the request.
[[NSURLConnection alloc] initWithRequest:request delegate:self];

// Implement the NSURLConnection delegate methods to handle response.
...
```

Mutual authentication

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

More complicated, but stronger

Certificate framework in NSURL is complex and tough to use

(Example is long--see src)

Authentication (mutual)

```
/ Delegate method for NSURLConnection that determines whether client can handle
// the requested form of authentication.
- (BOOL)connection:(NSURLConnection *)connection
  canAuthenticateAgainstProtectionSpace:(NSURLProtectionSpace *)protectionSpace {

  // Only handle mutual auth for the purpose of this example.
  if ([[protectionSpace authenticationMethod] isEqual:NSURLAuthenticationMethodClientCertificate]) {
    return YES;
  } else {
    return NO;
  }
}

// Delegate method for NSURLConnection that presents the authentication
// credentials to the server.
- (void)connection:(NSURLConnection *)connection
  didReceiveAuthenticationChallenge:(NSURLAuthenticationChallenge *)challenge {

  id<NSURLAuthenticationChallengeSender> sender = [challenge sender];
  NSURLCredential *credential;
  NSMutableArray *certArray = [NSMutableArray array];
```

Session handling

Normally controlled on the server for client-server apps

Varies tremendously from one tech and app container to another

Basic session rules apply

Testing does help, though

Testing

Checklist

- Credentials encrypted in transit?
- 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 iOS 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:

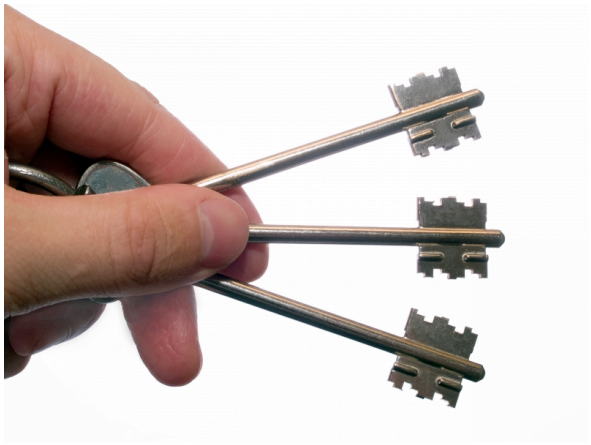
```
try {
    ESAPI.accessController().assertAuthorizedForFunction( BUSINESS_FUNCTION );
    // execute BUSINESS_FUNCTION
 } catch (AccessControlException ace) {
            ... attack in progress
 }
```

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 protection (weak)

```
// API for writing to a file using writeToFile API

- (BOOL)writeToFile:(NSString *)path options:
(NSDataWritingOptions)mask error:(NSError **)
errorPtr

// To protect the file, include the
// NSDataWritingFileProtectionComplete option
```

Protecting secrets at rest (keychain)

```
// Write username/password combo to keychain.
BOOL writeSuccess = [SFHFKeychainUtils storeUsername:username
andPassword:password
    forServiceName:@"com.krvw.ios.KeychainStorage" updateExisting:YES
error:nil];
...

// Read password from keychain given username.
NSString *password = [SFHFKeychainUtils getPasswordForUsername:username
    andServiceName:@"com.krvw.ios.KeychainStorage" error:nil];
...

// Delete username/password combo from keychain.
BOOL deleteSuccess = [SFHFKeychainUtils deleteItemForUsername:username
    andServiceName:@"com.krvw.ios.KeychainStorage" error:nil];
...
```


Enter SQLcipher

- Open source extension to SQLite
  - Free
  - Uses OpenSSL to AES-256 encrypt database
  - Uses PBKDF2 for key expansion
  - Generally accepted crypto standards
- Available from
  - http://sqlcipher.net

Protecting secrets at rest (SQLcipher)

```
sqlite3_stmt *compiledStmt;
// Unlock the database with the key (normally obtained via user input).
// This must be called before any other SQL operation.
sqlite3_exec(credentialsDB, "PRAGMA key = 'secretKey!'", NULL, NULL, NULL);
// Database now unlocked; perform normal SQLite queries/statments.
...
// Create creds database if it doesn't already exist.
const char *createStmt =
  "CREATE TABLE IF NOT EXISTS creds (id INTEGER PRIMARY KEY AUTOINCREMENT, username TEXT, password
TEXT)";
sqlite3_exec(credentialsDB, createStmt, NULL, NULL, NULL);
// Check to see if the user exists.
const char *queryStmt = "SELECT id FROM creds WHERE username=?";
int userID = -1;
if (sqlite3_prepare_v2(credentialsDB, queryStmt, -1, &compiledStmt, NULL) == SQLITE_OK) {
    sqlite3_bind_text(compiledStmt, 1, [username UTF8String], -1, SQLITE_TRANSIENT);
    while (sqlite3_step(compiledStmt) == SQLITE_ROW) {
        userID = sqlite3_column_int(compiledStmt, 0);
    }
}
if (userID >= 1) {
  // User exists in database.
  ...
}
```


Protecting secrets in transit

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

- Basic SSL is pretty easy in NSURL
- Mutual certificates are stronger, but far more complicated
- NSURL is awkward, but it works
  - See previous example

Protecting secrets in transit

```
// Note the "https" protocol in the URL.
NSString *userJSONEndpoint =
   [[NSString alloc] initWithString:@"https://www.secure.com/api/user"];

// Initialize the request with the HTTPS URL.
NSMutableURLRequest *request =
   [MSMutableURLRequest requestWithURL:[NSURL URLWithString:userJSONEndpoint]];

// Set method (POST), relevant headers and body (jsonAsString assumed to be
// generated elsewhere).
[request setHTTPMethod:@"POST"];
[request setValue:@"application/json" forHTTPHeaderField:@"Content-Type"];
[request setValue:@"application/json" forHTTPHeaderField:@"Accept"];
[request setHTTPBody:[jsonAsString dataUsingEncoding:NSUTF8StringEncoding]];

// Submit the request.
[[NSURLConnection alloc] initWithRequest:request delegate:self];

// Implement delegate methods for NSURLConnection to handle request lifecycle.
...
```


SQL connections

- Biggest security problem is using a mutable API
  - Weak to SQL injection
- Must use immutable API
  - Similar to PreparedStatement in Java or C#

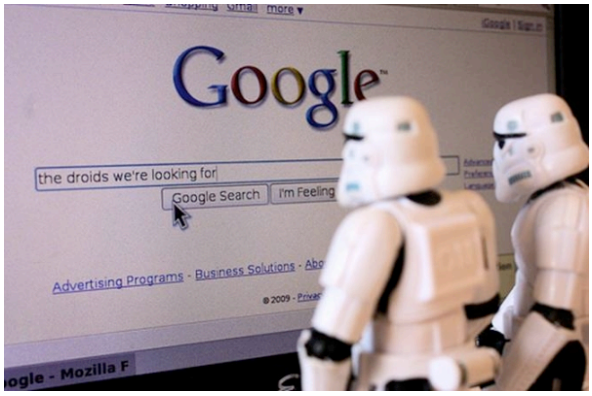
SQL connections

```
// Update a users's stored credentials.
sqlite3_stmt *compiledStmt;
const char *updateStr = "UPDATE credentials SET username=?, password=? WHERE id=?";

// Prepare the compiled statement.
if (sqlite3_prepare_v2(database, updateStr, -1, &compiledStmt, NULL) == SQLITE_OK) {
    // Bind the username and password strings.
    sqlite3_bind_text(compiledStmt, 1, [username UTF8String], -1, SQLITE_TRANSIENT);
    sqlite3_bind_text(compiledStmt, 2, [password UTF8String], -1, SQLITE_TRANSIENT);

    // Bind the id integer.
    sqlite3_bind_int(compiledStmt, 3, userID);

    // Execute the update.
    if (sqlite3_step(compiledStmt) == SQLITE_DONE) {
        // Update successful.
    }
}
```


Putting it together - design patterns

Let's dive into a few patterns

- Class/whiteboard discussions
- App scenarios



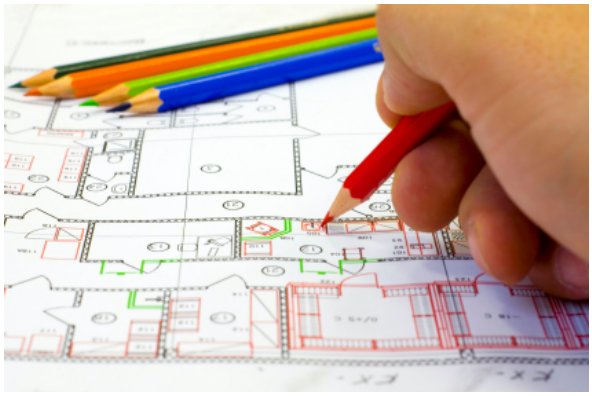
Stand-alone

App contains some user data

- Consumer grade
  - Recipes, wine cellar, etc.
- No networking
- All data local
- Location data perhaps

What should we do?

- What are the issues?



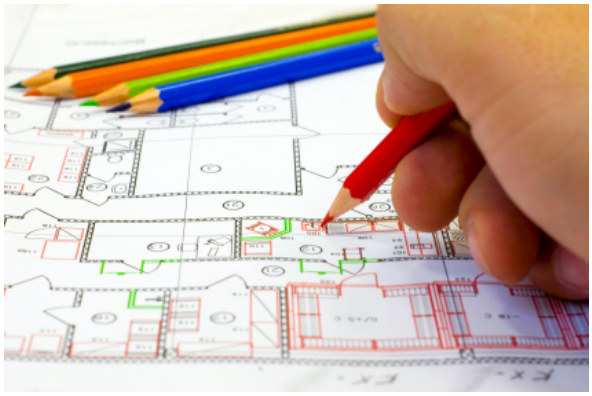
Client-server social net app

Social network app

- The real data is on the server side
- Authentication via app
- Presentation layer/view in app

What are the issues?

- And the solutions?



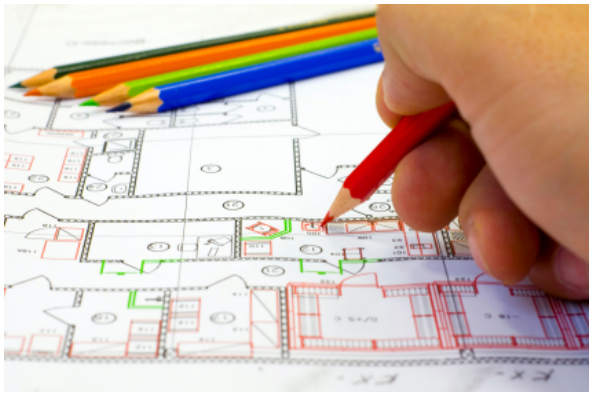
Client-server financial app

This one is used for financial information and transactions

- Stock trading site
- Mobile payments

How would we proceed?

- Issues and security requirements?
- Special concerns?

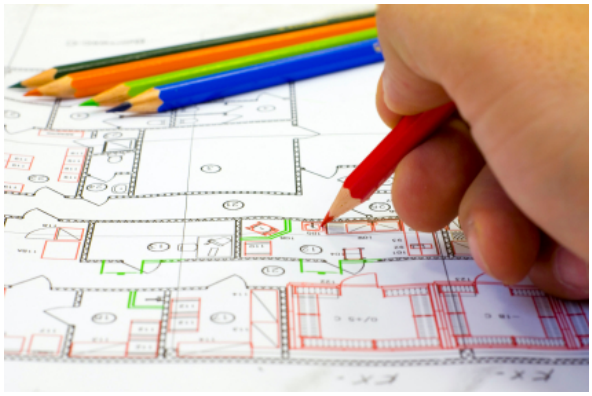


Client-server enterprise app

Internal enterprise app

- Used by employees for some important enterprise purpose
  - Supply chain, customer data, sales, etc.
  - Company's "crown jewels"

What are the issues?



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