Keeping Secrets Secure

Fingerprint Authentication & the Android Keystore

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Who am I?

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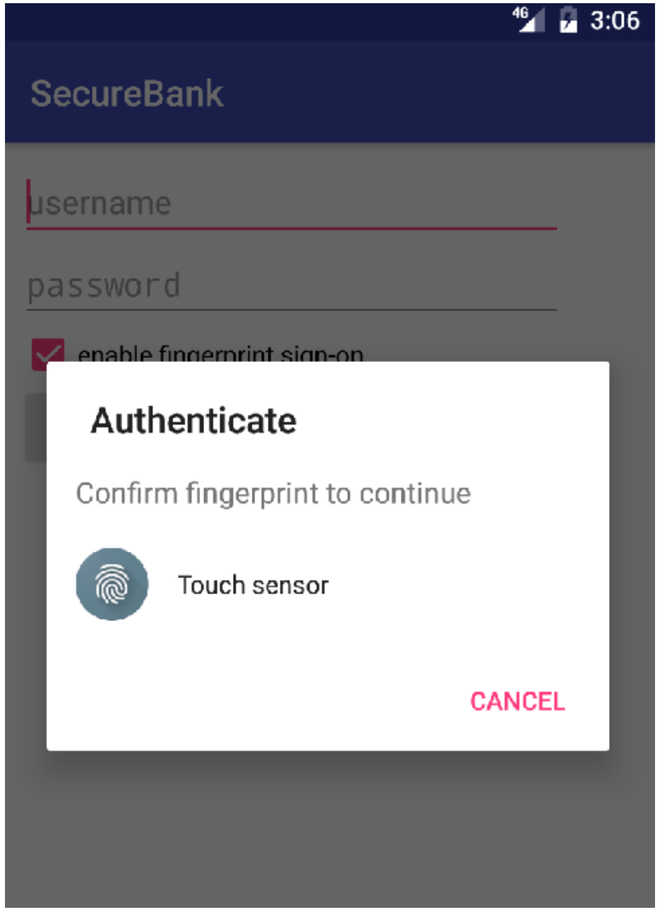
SecureBank



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http://github.com/bignerdranch/android-securebank

The Story So Far

(typical web service situation)

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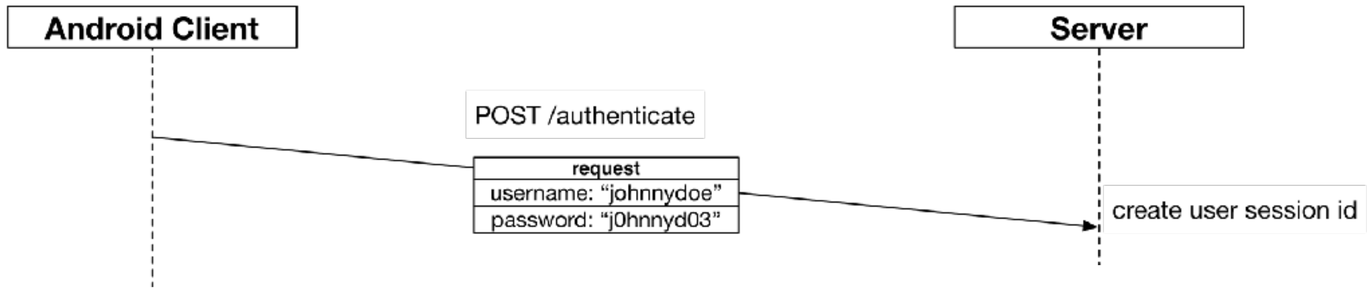
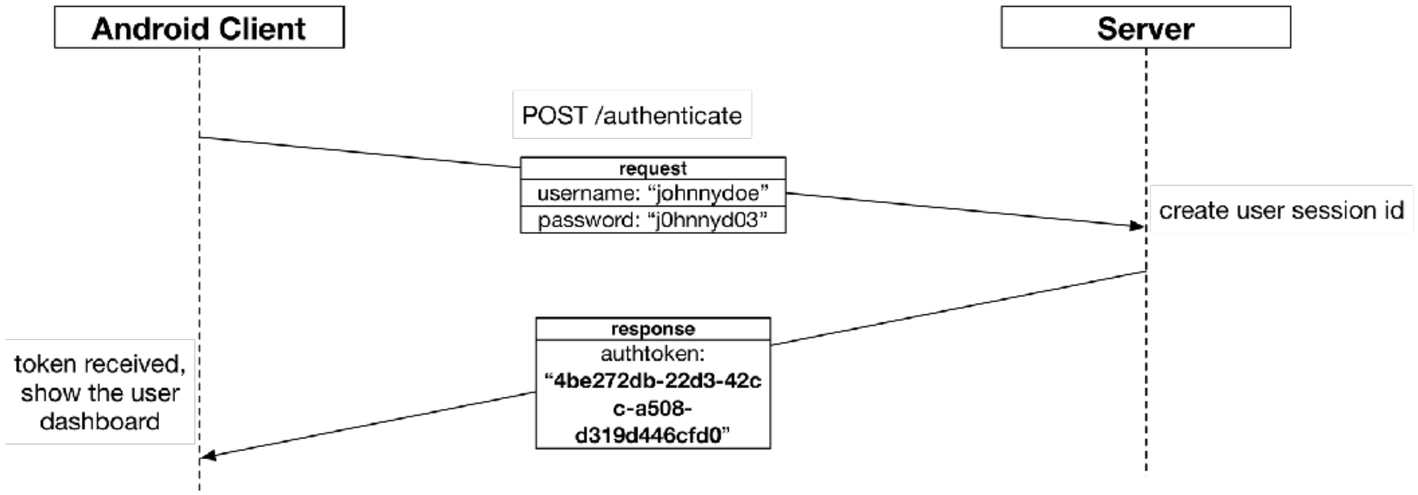


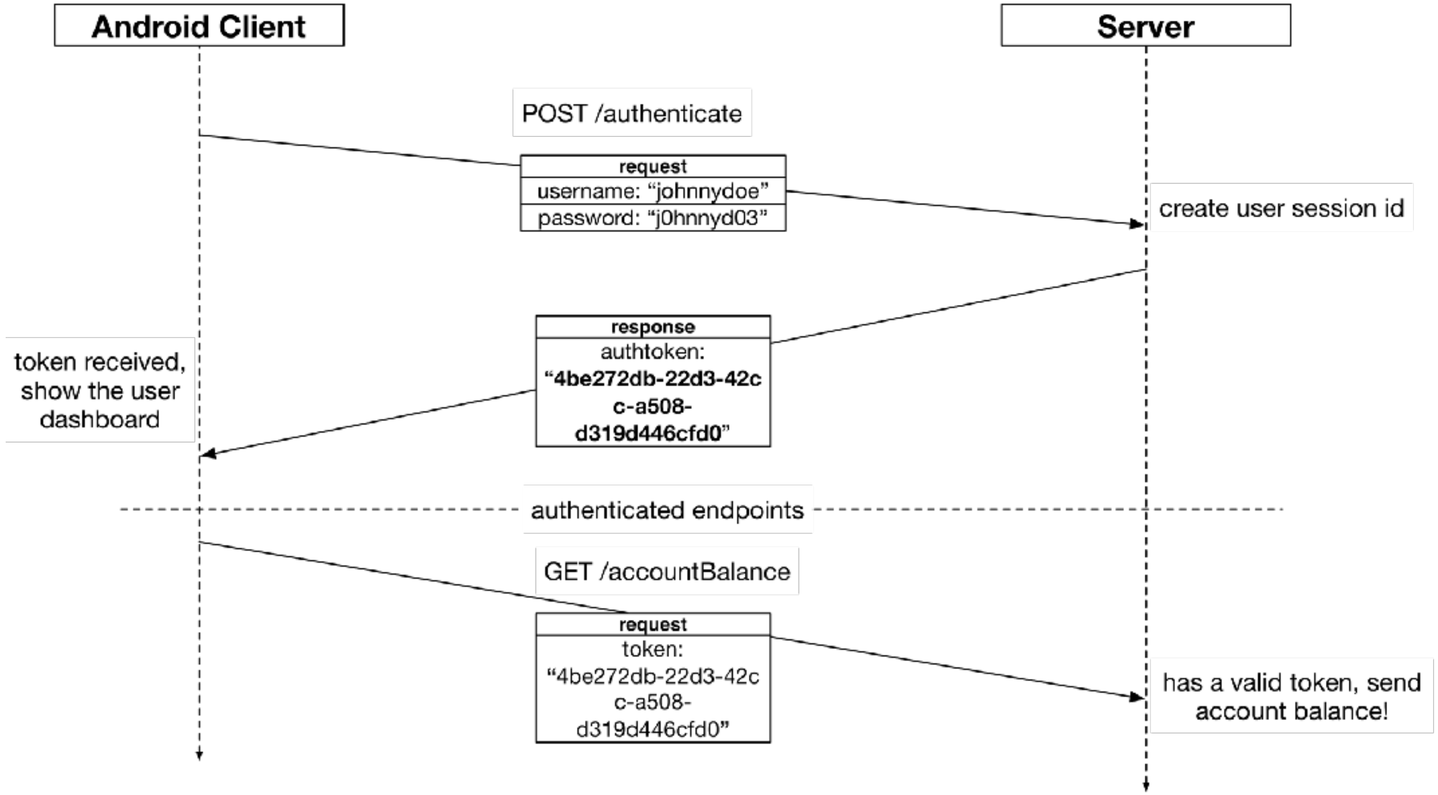
(typical web service situation)

The Story So Far



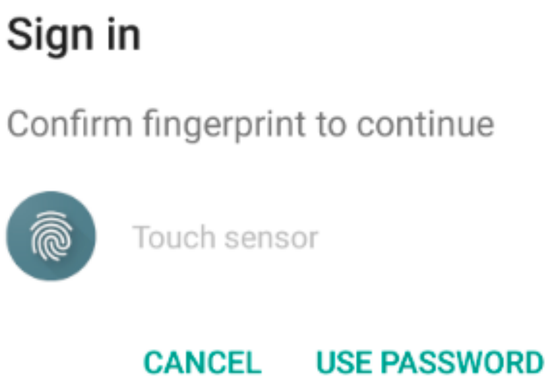
(typical web service situation)

The Story So Far



(typical web service situation)

New Feature



A user should be allowed to sign in using their fingerprint, optionally.

Central Problem

What should i save locally if i want to implement fingerprint authentication, and how can i do it securely ?

Getting it Wrong!

Storing the **password itself** in the application Shared Preferences

/data/data/securebankcorp.mobile.client.android/shared_prefs:

```
<map>
  <string name="username">johnnydoe</string>
  <string name="password">pizza2017</string>
  <boolean name="rememberUsername" value="true" />
</map>
```

Getting it Wrong!

Encrypting the **password or token**, but **using keys and encryption constants that are defined in application code**


```
<map>
   <string name="username">johnnydoe</string>
      <string
name="password">2A52D2D7A0F3802DB9E7AE118C99F3F1B04C07240601C0EFC8EAC0E28E22198
17B2FEC7376BD53B7D606288219D7E03AAD5A899D706BC1448D44B1D908A2DD416480652CF29F
1EEAF20AA93C4224991218E058B1C4BA4873E6363F2F0E5A35A773B21B78541EA54BFFB3D22AAE2
39A0CDD20CC50F8E6201F7B6A4D7B4AB73C46A92B0109E559343CDE6B170B1B6DAE63B42EEA8DD
CCEBFC84FD610F9F9FEDFE8D8432843FEF65954D1F67919FA06AEFABF1AFEEA23B071DA478851B5E
1973664D81104B845D899CCFF437E390C40CD2D5E3038C87C4FCBD8B9F49774FB54CDC0</
string>
</map>
```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Getting it Wrong!

Encrypting the **password or token**, but **using keys and encryption constants that are defined in application code:**

```
.class public Lcom/securebanking/MainActivity;
.super Landroid/app/Activity;
.source "MainActivity.java"

# static fields
.field static final synthetic $assertionsDisabled:Z

.field static final DEFAULT_KEY_NAME:Ljava/lang/String; = "default_key"

.field private static final SECRET_KEY:Ljava/lang/String; = "NOTSOSECRET"

.field private static final TAG:Ljava/lang/String;

```

apktool -d release.apk

Proposed Solution

- Upon a user authenticating, capture the session token
- Create a SecretKey and store it in the **AndroidKeyStore**
- Use a Cipher w/ SecretKey to encrypt & decrypt the token
- Hook it up to work with the Fingerprint API

code at :

http://github.com/bignerdranch/android-securebank

also check out:

https://github.com/googlesamples/android-FingerprintDialog

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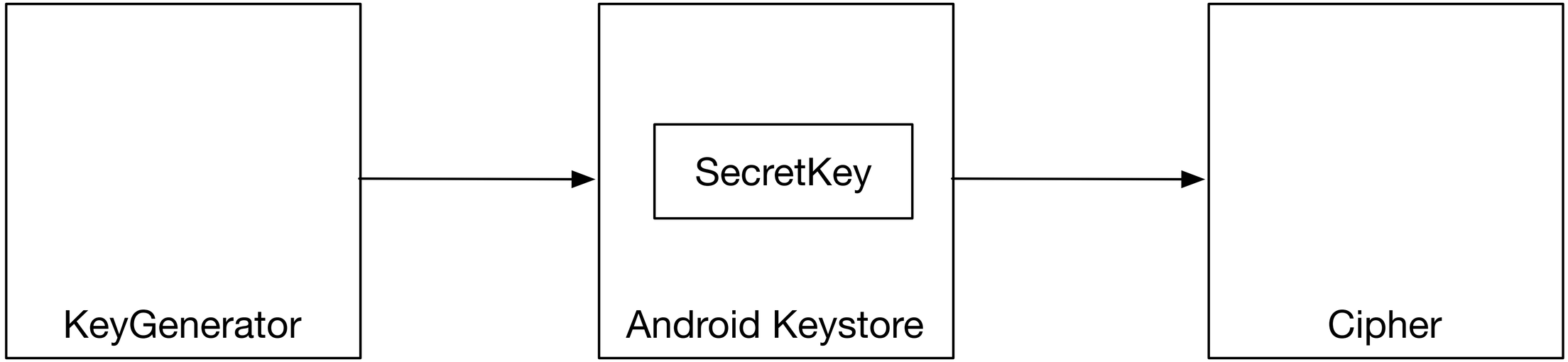
Creating A Secret Key



Make a (secret) Key

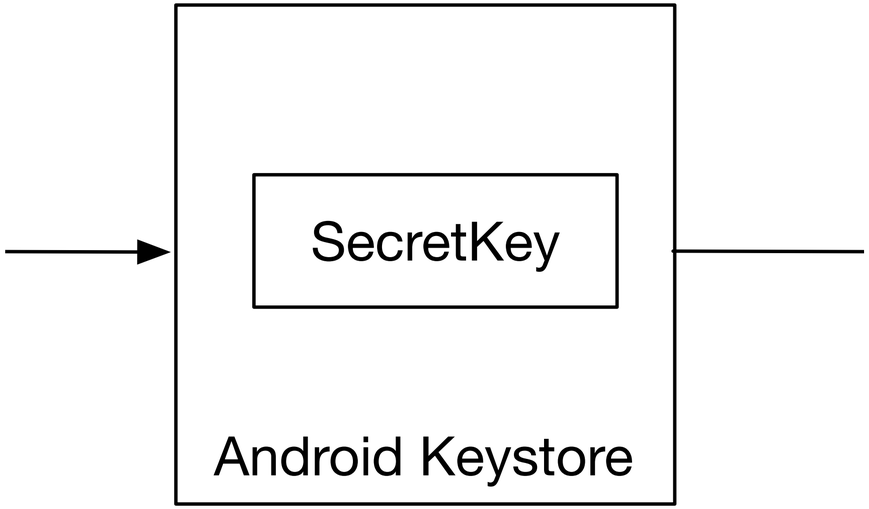
Save the Key (securely!)

Encrypt the Data

KeyStore

…stores keys (and certificates)

AndroidKeyStore



Save the Key (securely!)

- Can store Public Keys, Private Keys, and Certificates
- In our case, all we'll need is a Private Key (symmetric)
- Does Fancy stuff under the hood (TEE, SE, etc)
- Actually a "KeystoreProvider"
- Been called other things in previous versions

Prep the Keystore

```
private static final String ANDROID_KEY_STORE =
"AndroidKeyStore";
```

```
keystore = KeyStore.getInstance(ANDROID_KEY_STORE);
keystore.load(null);
```

KeyStoreHelper.java

Next Up: Creating a Secret Key

```
KeyGenerator keyGenerator = KeyGenerator
    .getInstance(KeyProperties.KEY_ALGORITHM_AES, ANDROID_KEY_STORE);
```

KeyStoreHelper.java

KeyGenParameterSpec

Provides Config for how specifically we want to construct the SecretKey

```
KeyGenParameterSpec.Builder builder =
    new KeyGenParameterSpec.Builder(DEFAULT_KEY,
    KeyProperties.PURPOSE_ENCRYPT | KeyProperties.PURPOSE_DECRYPT)
   .setBlockModes(KeyProperties.BLOCK_MODE_CBC)
   .setEncryptionPaddings(KeyProperties.ENCRYPTION_PADDING_PKCS7);
```

KeyStoreHelper.java

Generate the Key

```
keyGenerator.init(builder.build());
keyGenerator.generateKey();
```

KeyStoreHelper.java

Under the Hood…

```
joshskeen@joshs-MacBook-Pro-3.local:/Users/joshskeen/Desktop/keep-secrets-secure  git:(master*) $ adb shell
generic_x86:/ $ su
generic_x86:/ # cd /data/misc/keystore/user_0
generic_x86:/data/misc/keystore/user_0 # ls
10109_USRSKEY_default_key
generic_x86:/data/misc/keystore/user_0 #
```

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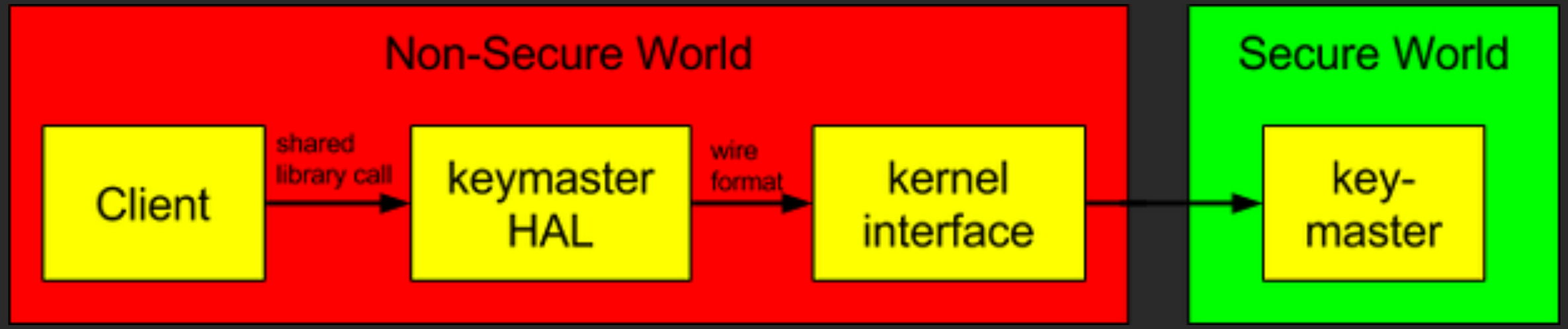
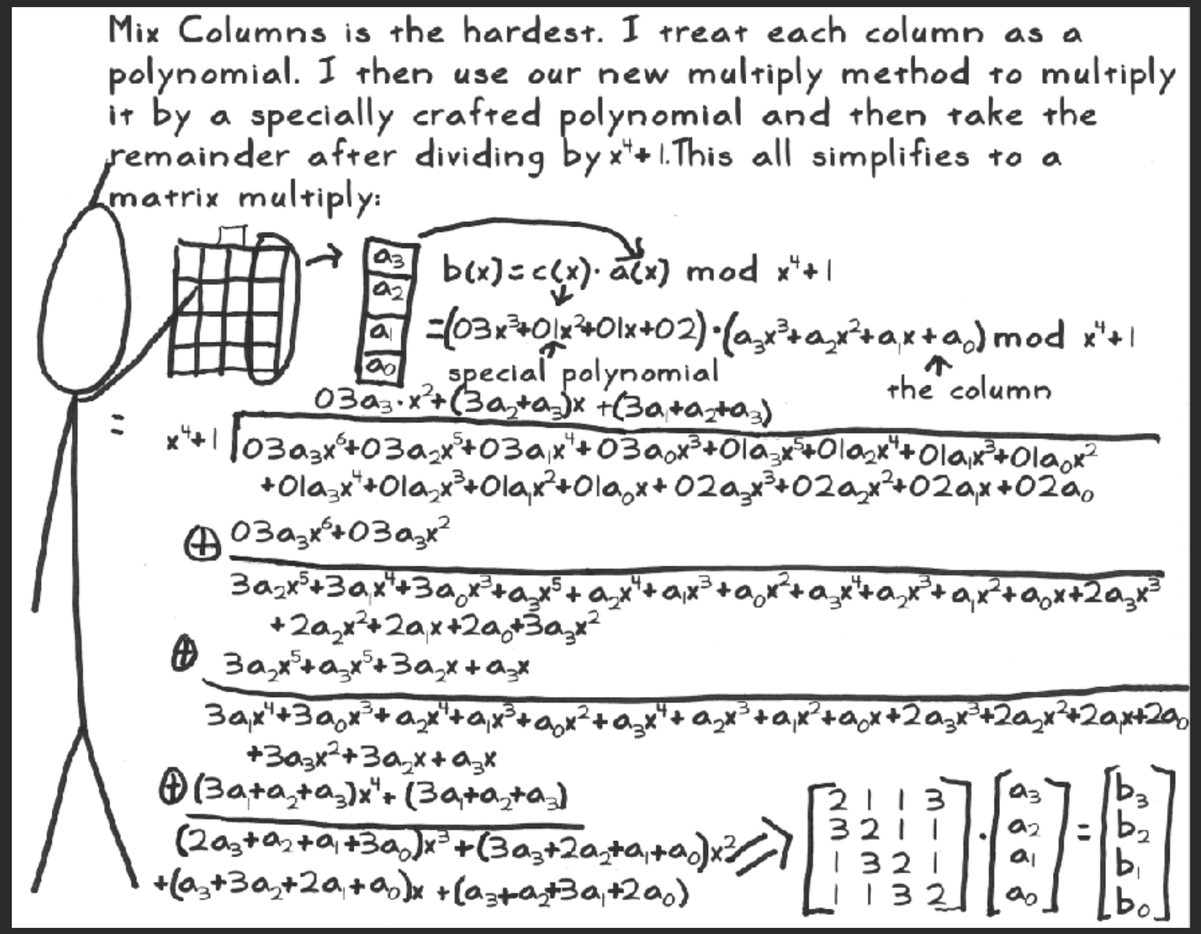
Under the Hood...



AES??



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http://www.moserware.com/2009/09/stick-figure-guide-to-advanced.html

Next Up: Encrypting the Token

Cipher needs a SecretKey

Obtain a Cipher Instance

```
Cipher cipher =
Cipher.getInstance(KeyProperties.KEY_ALGORITHM_AES + "/"
    + KeyProperties.BLOCK_MODE_CBC + "/"
    + KeyProperties.ENCRYPTION_PADDING_PKCS7);
```

CryptoHelper.java

Initializing the Cipher

```
private void initEncryptCipher(Cipher cipher) {
    cipher.init(Cipher.ENCRYPT_MODE,
                keyStoreHelper.getSecretKey());
    sharedPreferencesHelper.saveIV(cipher.getIV());
}
```

CryptoHelper.java

Storing the IV (needed later!)

```
private void initEncryptCipher(Cipher cipher) {
    cipher.init(Cipher.ENCRYPT_MODE,
                keyStoreHelper.getSecretKey());
    sharedPreferencesHelper.saveIV(cipher.getIV());
}
```

CryptoHelper.java

Putting It All Together: doFinal()

```
public void encrypt(String authTokenFromServer) {
    Cipher cipher = getCipher();
    initEncryptCipher(cipher);
    byte[] bytes =
        cipher.doFinal(authTokenFromServer.getBytes());
    sharedPreferencesHelper.saveToken(bytes);
}
```

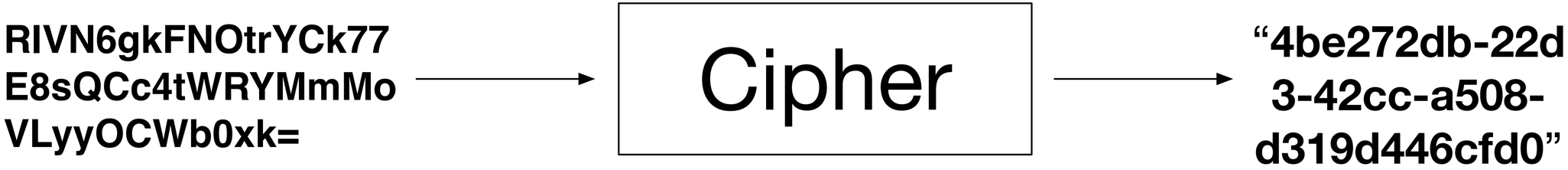
CryptoHelper.java

Saving the Encrypted Token

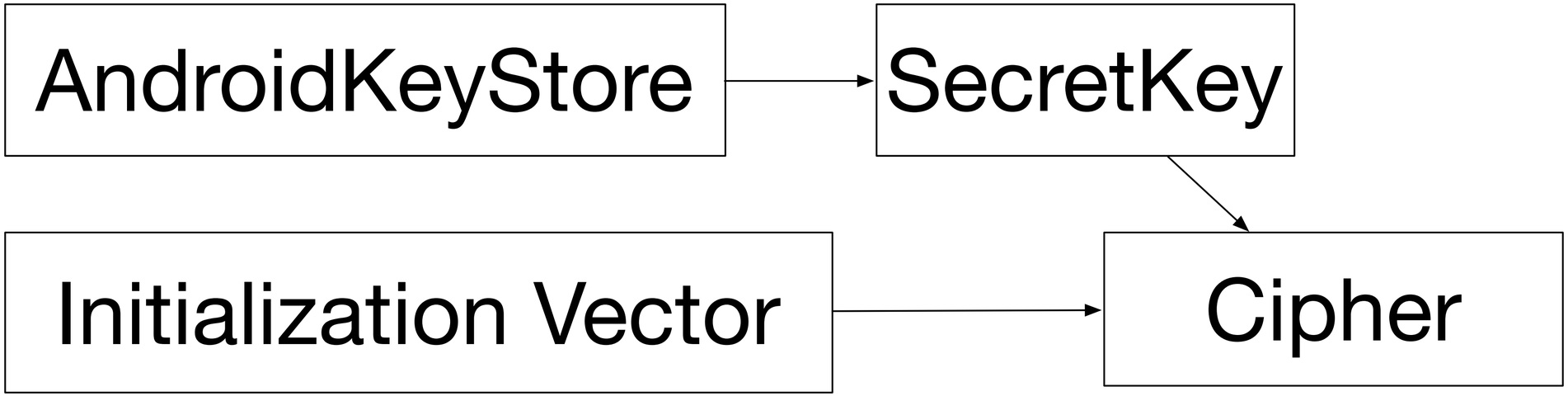
```
public void saveToken(byte[] encryptedToken) {
    String encoded = Base64.encodeString(encryptedToken, Base64.NO_WRAP);
    sharedPreferences
    .edit()
    .putString(SHARED_PREFERENCES_ENCRYPTED_TOKEN, encoded).apply();
}
```

SharedPreferencesHelper.java

Next: Decrypting the Token



Cipher for Decrypt



Decrypt: Retrieve IV

```
byte[] iv = sharedPreferencesHelper.getIV();
IvParameterSpec ivParameterSpec = new IvParameterSpec(iv);
```

CryptoHelper.java

Decrypt: IVParameterSpec

```
byte[] iv = sharedPreferencesHelper.getIV();
IvParameterSpec ivParameterSpec = new IvParameterSpec(iv);
```

CryptoHelper.java

Decrypt: Initialize the Cipher

```
cipher.init(Cipher.DECRYPT_MODE,
            keyStoreHelper.getSecretKey(),
            ivParameterSpec);
```

CryptoHelper.java

Decrypting the Token

```
String textToDecrypt =
    sharedPreferencesHelper.getEncryptedToken();
```

CryptoHelper.java

Decrypting the Token

```
ByteArrayInputStream is =
    new ByteArrayInputStream(Base64.decode(textToDecrypt,
                                           Base64.DEFAULT));
```

CryptoHelper.java

Problem 2: Fingerprint Authentication

FingerprintManager – system service for managing fingerprint reader hardware/software interaction

CryptoObject – verifies the fingerprint authentication occurred and enables or revokes a Cipher object in ENCRYPT or DECRYPT mode

Fingerprint Sensor Technology

- most are using capacitive touch
- old tech = optical – sort of dangerous!
- new tech = ultrasonic

Adding USE_FINGERPRINT Permission

```
<uses-permission android:name="android.permission.USE_FINGERPRINT"/>
```

AndroidManifest.xml

Adding USE_FINGERPRINT Permission

```
requestPermissions(new String[]{Manifest.permission.USE_FINGERPRINT},
                   REQUEST_USE_FINGERPRINT);

@Override
public void onRequestPermissionsResult(int requestCode,
    @NonNull String[] permissions,
    @NonNull int[] grantResults) {
if (requestCode == REQUEST_USE_FINGERPRINT &&
    grantResults[0] == PackageManager.PERMISSION_GRANTED) {
            performFingerprintAuthentication();
        }
    }
}
```

LoginActivity.java

Fingerprint Auth: Check if Available

```
private void performFingerprintAuthentication() {
    if (fingerprintManager.isHardwareDetected() &&
        fingerprintManager.hasEnrolledFingerprints()) {
      //ready to rock. warm up the sensor
    } else {
        //no dice. show an error message, etc
        Timber.e("fingerprint not available");
    }
}
```

LoginActivity.java

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KGPS: Enabling User Auth Required

```
KeyGenParameterSpec.Builder builder = new KeyGenParameterSpec
    .Builder(DEFAULT_KEY, KeyProperties.PURPOSE_ENCRYPT |
    KeyProperties.PURPOSE_DECRYPT)
    .setBlockModes(KeyProperties.BLOCK_MODE_CBC)
    .setEncryptionPaddings(KeyProperties.ENCRYPTION_PADDING_PKCS7)
    .setUserAuthenticationRequired(true);
```

throws an android.security.KeyStoreException if used w/ cipher and user’s not “authed"

KeyStoreHelper.java

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Fingerprint Auth: CryptoObject

```
Cipher cipher = cryptoHelper.getCipher();
cryptoHelper.initDecryptCipher(cipher);

FingerprintManager.CryptoObject cryptoObject =
    new FingerprintManager.CryptoObject(cipher);
```

LoginActivity.java

Fingerprint Manager : Authenticate

```
fingerprintManager.authenticate(cryptoObject, authCallback);
```

LoginActivity.java

Fingerprint Authentication Callbacks

```
private void performFingerprintAuthentication() {
    Cipher cipher = cryptoHelper.getCipher();
    cryptoHelper.initDecryptCipher(cipher);
    FingerprintManager.CryptoObject cryptoObject = new FingerprintManager.CryptoObject(cipher);
    fingerprintManager.authenticate(cryptoObject, null, 0, new FingerprintManager.AuthenticationCallback() {
        @Override
        public void onAuthenticationFailed() {
            super.onAuthenticationFailed();
        }
        @Override
        public void onAuthenticationSucceeded(FingerprintManager.AuthenticationResult result) {
            super.onAuthenticationSucceeded(result);
            //we can now decrypt using our authenticated cipher!
        }
        @Override
        public void onAuthenticationError(int errorCode, CharSequence errString) {
            super.onAuthenticationError(errorCode, errString);
        }
    }, null);
}
```

LoginActivity.java

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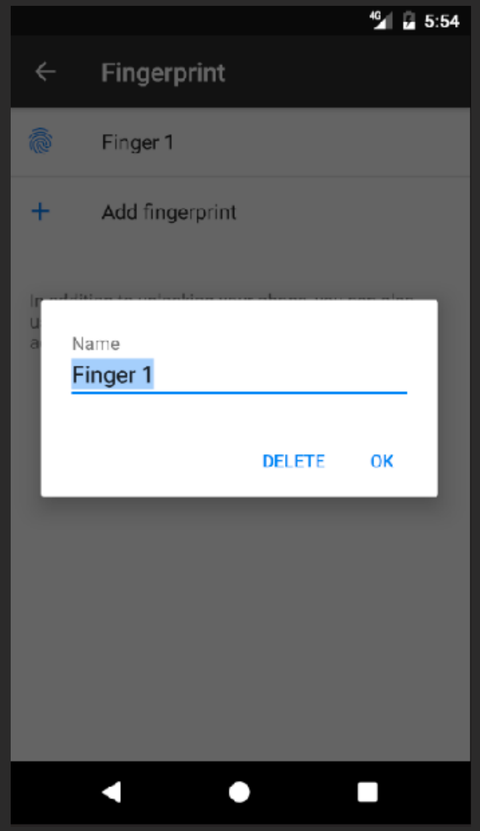
Decrypt, using the Authed Cipher

```
@Override
public void onAuthenticationSucceeded(AuthenticationResult result) {
    super.onAuthenticationSucceeded(result);
    String decryptedToken = cryptoHelper.decrypt(result.getCryptoObject());
    //we can now decrypt using our authenticated cipher
}
```

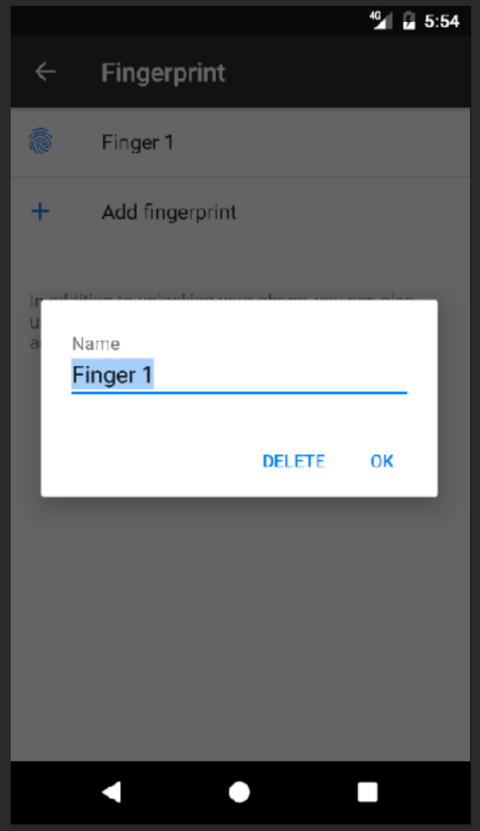
LoginActivity.java

Gotchas : Finger Deleted



?

Gotchas : Finger Deleted



KeyPermanentlyInvalidatedException!

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Further Keystore-Related Tricks

KeyInfo:

```
.isUserAuthenticationRequirementEnforcedBySecureHardware()
.isKeyInsideSecureHardware()
```

SecretKeyGenerator:

```
setUserAuthenticationValidityDurationSeconds()
```

Note about Testing

- robolectric “shadow object” doesn't work with keystore currently
- real integration tests (espresso) may be best option if its important

Final Thoughts

- Good foundation, though with security there's never a "one size fits all" solution
- Additional measures available – Proguard, Dexguard, SafetyNet (is it "security theater?")
- 2FA/MFA
- Big Nerd Ranch Security Courses coming soon! (Android & Web) Q3ish 2017

Resources

- code example: https://github.com/bignerdranch/securebank
- SafetyNet API: https://developer.android.com/training/safetynet/index.html
- Big Nerd Ranch Security Course: http://www.bignerdranch.com
- KeyGenerator : https://developer.android.com/reference/javax/crypto/KeyGenerator.html
- AES explained with stick figures: www.moserware.com/2009/09/stick-figure-guide-to-advanced.html
- IDA https://www.hex-rays.com/products/ida/
- FRIDA https://www.frida.re/docs/android/

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Thanks!

Josh Skeen | josh@bignerdranch.com | @mutexkid

https://github.com/bignerdranch/stockwatcher

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