twitch.tv/dancojocar
youtube.com/dancojocar

Lecture #7
Securing Mobile Apps

Mobile Applications
Fall 2024

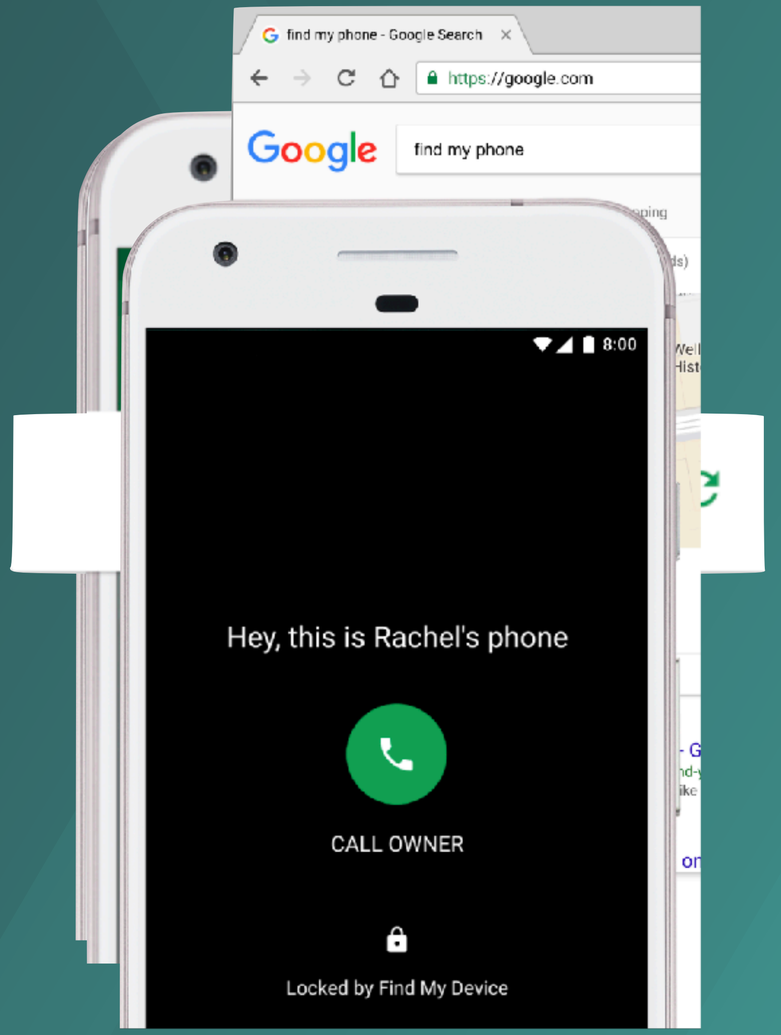
Android Security Strategy

- Google Play Protect
  - Defend agains Internet-borne threats.
  - User experience that offers security CCC (comprehension, control, confidence).
- Platform Engineering
  - Feature dev.
  - OS hardening, leverate HW.
- SDLC - Security Development Life Cycle
  - Vulnerability management.
  - Full cycle.

https://www.android.com/security-center/

Google Play Protect

- Keeping your device safe, 24/7
- Scanning and verifying over 100 billion apps every day
- Securing your device, even if it’s lost
- Helping you surf on the safe side



https://www.android.com/play-protect/

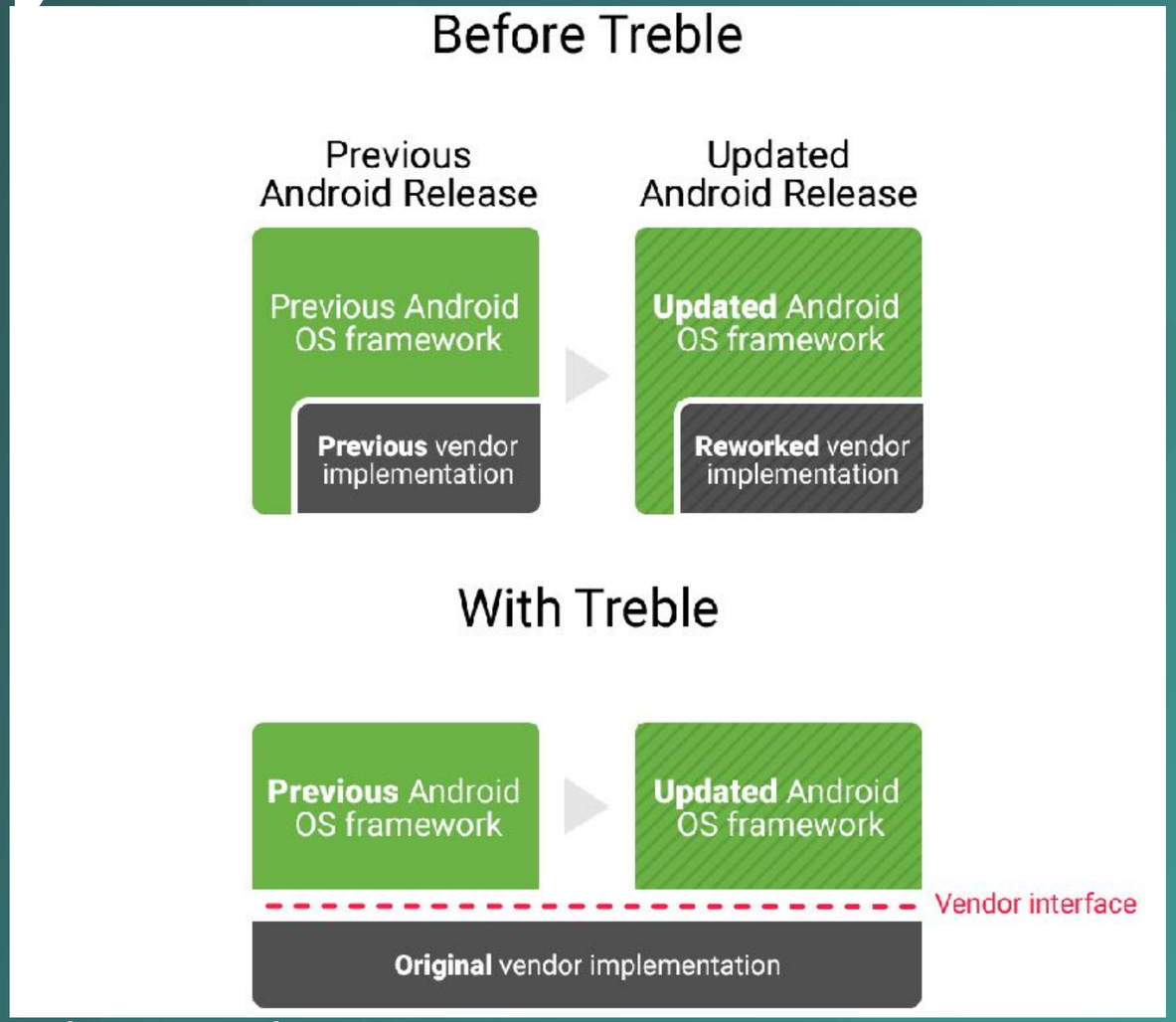
Platform Engineering

- SELinux
  - Allows users and administrators more control over access control.
  - Access can be constrained, as which users and applications can access which resources.
  - Adds finer granularity to access controls.
- Control Flow Integrity
  - Protecting against code reuse attacks.
  - Implementing in the Linux kernel.
- Verify Boot
  - Ensure all executed code comes from a trusted source.

https://source.android.com/security/

Security Development Lifecycle

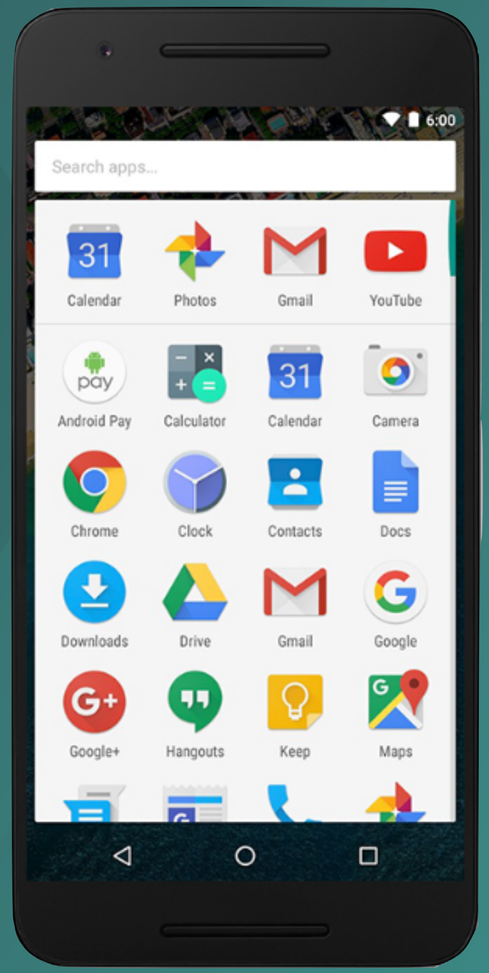
- Testing infrastructure.
- Security patching program.
  - HAL interface definition language (HIDL)
  - Treble: A modular base for Android



https://source.android.com/devices/architecture

Security for Android Developers

- Store data safely.
- Enforce secure communication.
- Update security provider.
- Pay attention to permissions.



Store Data Safely

- Minimize the use of APIs that access sensitive or personal user data.
- Consider using hash or non-reversible form of the data to represent the user's sensitive details.

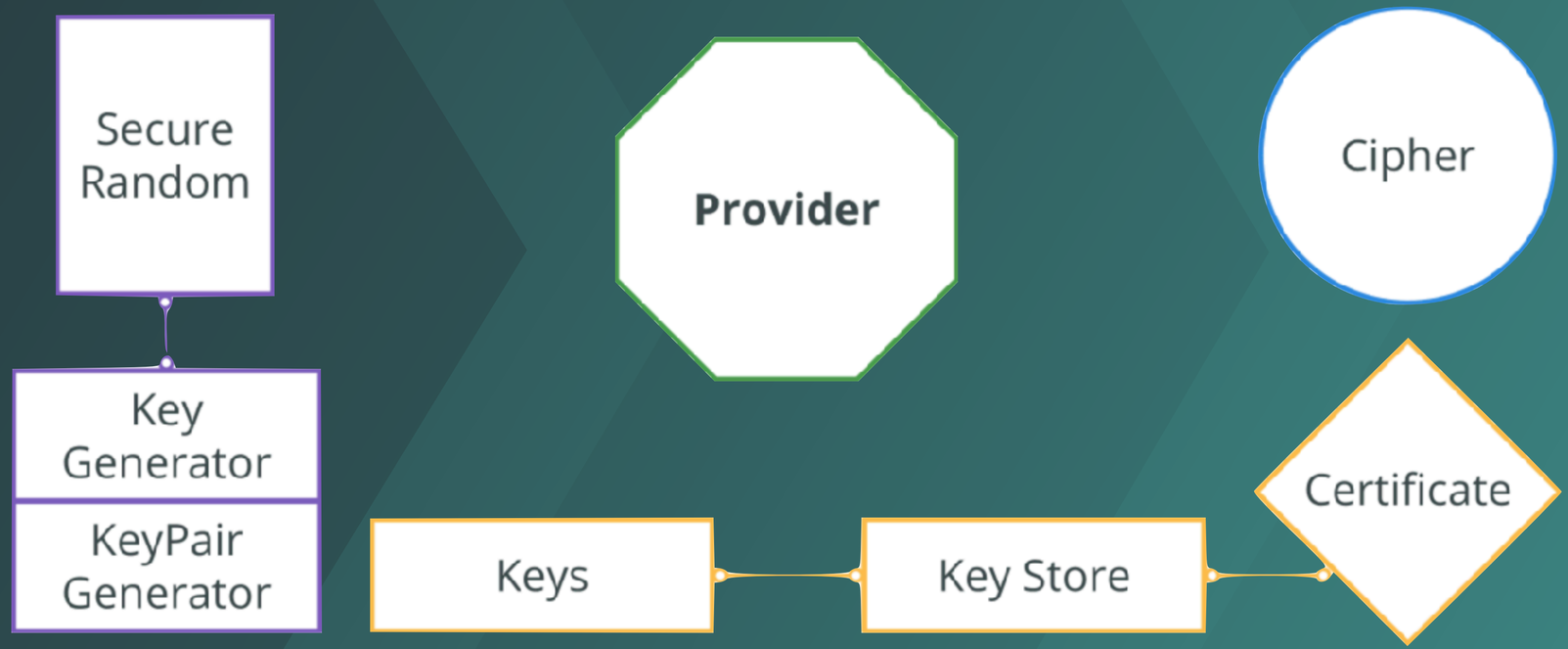
https://developer.android.com/training/articles/security-tips#StoringData

Store Data Safely

- ✔ Internal storage.
  - ✘ MODE_WORLD_WRITEABLE
  - ✘ MODE_WORLD_READABLE
- ✘ External storage.
- ✔ Content providers.

https://developer.android.com/training/articles/security-tips#StoringData

Encrypt Content



docs.oracle.com/javase/8/docs/technotes/guides/security/crypto/CryptoSpec.html

Choose a Key

Key Storage

```
private val keyStore: KeyStore = createAndroidKeyStore()
private fun createAndroidKeyStore(): KeyStore {
  val keyStore = KeyStore.getInstance("AndroidKeyStore")
  keyStore.load(null) //loads parameters
  return keyStore
}
```

Key Generation

```
fun createAndroidKeyStoreAsymmetricKey(alias: String): KeyPair {
  val generator = KeyPairGenerator.getInstance("RSA", "AndroidKeyStore")
  if (SystemServices.hasMarshmallow()) {
    initGeneratorWithKeyGenParameterSpec(generator, alias)
  } else {
    initGeneratorWithKeyPairGeneratorSpec(generator, alias)
  }
  // Generates Key with given spec and saves it to the KeyStore
  return generator.generateKeyPair()
}
```

Choose a Key

Key Initialization

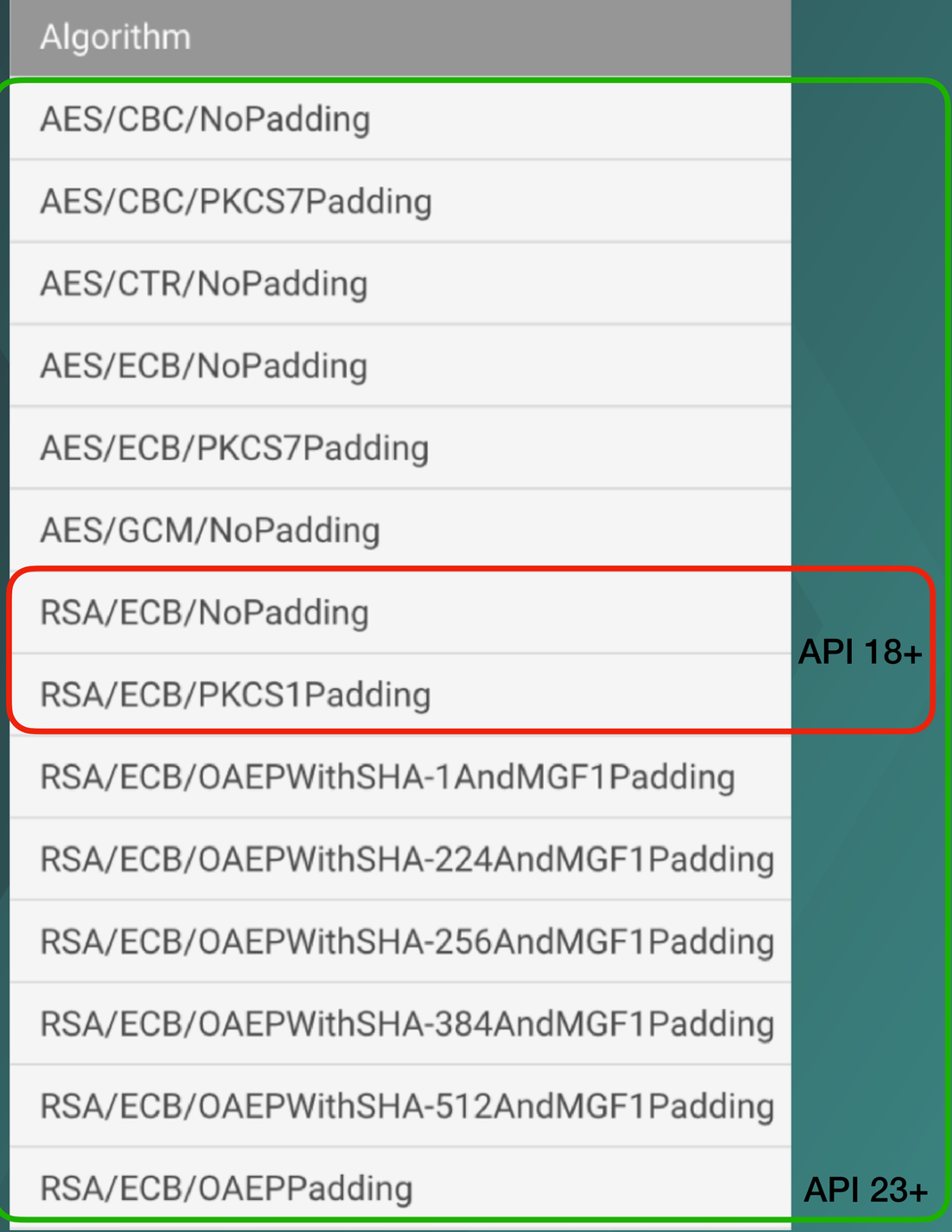
```
@TargetApi(Build.VERSION_CODES.M)
private fun initGeneratorWithKeyGenParameterSpec(
    generator: KeyPairGenerator,
    alias: String) {
  val builder = KeyGenParameterSpec.Builder(
     alias, KeyProperties.PURPOSE_ENCRYPT or KeyProperties.PURPOSE_DECRYPT)
    .setBlockModes(KeyProperties.BLOCK_MODE_ECB)
    .setEncryptionPaddings(KeyProperties.ENCRYPTION_PADDING_RSA_PKCS1)
  generator.initialize(builder.build())
}
```

Key Management

```
fun getAndroidKeyStoreAsymmetricKeyPair(alias: String): KeyPair? {
  val privateKey = keyStore.getKey(alias, null) as PrivateKey?
  val publicKey = keyStore.getCertificate(alias)?.publicKey
  return if (privateKey != null && publicKey != null) {
    KeyPair(publicKey, privateKey)
  } else { null }
}
fun removeAndroidKeyStoreKey(alias: String) = keyStore.deleteEntry(alias)
```

Encrypt & Decrypt

```
companion object {
  var TRANSFORMATION_ASYMMETRIC = "RSA/ECB/PKCS1Padding"
}

val cipher: Cipher = Cipher.getInstance(transformation)


fun encrypt(data: String, key: Key?): String {
  cipher.init(Cipher.ENCRYPT_MODE, key)
  val bytes = cipher.doFinal(data.toByteArray())
  return Base64.encodeToString(bytes, Base64.DEFAULT)
}


fun decrypt(data: String, key: Key?): String {
  cipher.init(Cipher.DECRYPT_MODE, key)
  val encryptedData = Base64.decode(data, Base64.DEFAULT)
  val decodedData = cipher.doFinal(encryptedData)
  return String(decodedData)
}
```


Algorithm
AES/CBC/NoPadding
AES/CBC/PKCS7Padding
AES/CTR/NoPadding
AES/ECB/NoPadding
AES/ECB/PKCS7Padding
AES/GCM/NoPadding
RSA/ECB/NoPadding
RSA/ECB/PKCS1Padding
API 18+
RSA/ECB/OAEPWithSHA-1AndMGF1Padding
RSA/ECB/OAEPWithSHA-224AndMGF1Padding
RSA/ECB/OAEPWithSHA-256AndMGF1Padding
RSA/ECB/OAEPWithSHA-384AndMGF1Padding
RSA/ECB/OAEPWithSHA-512AndMGF1Padding
RSA/ECB/OAEPPadding
API 23+

Encrypt & Decrypt Example

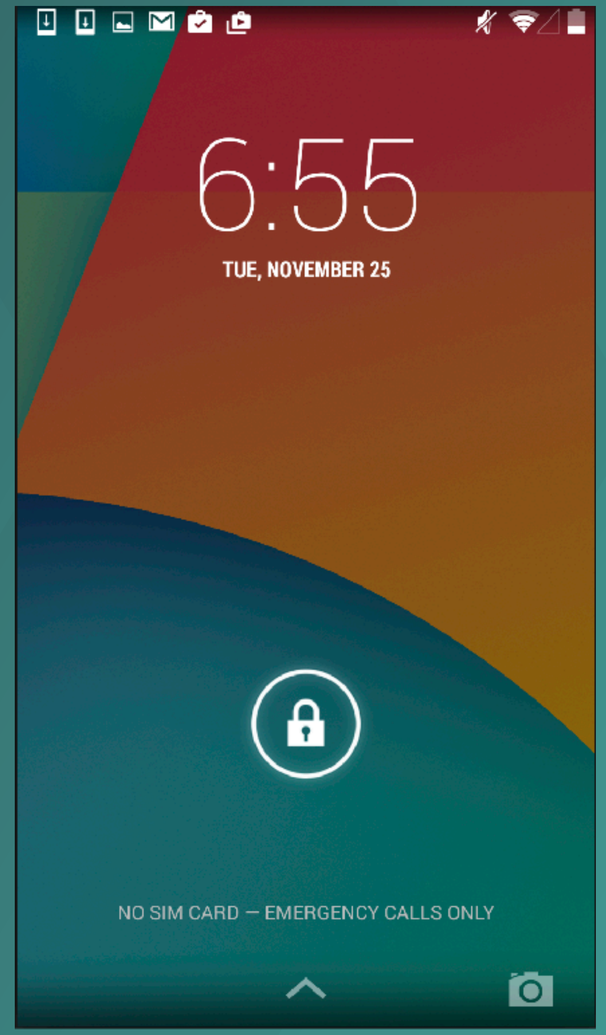
```
var message = "Hello Word"

// Creates Android Key Store and provides manage functions
private val keyStoreWrapper = KeyStoreWrapper(context)

// Create and Save asymmetric key
keyStoreWrapper.createAndroidKeyStoreAsymmetricKey("MASTER_KEY")
```

```
aB9Ce9d5oM0/yloLQikOz8RovWHLmoQf3ovlCiz+D9+0/y7ZDfx6SpPYsKFIK3df079DNVIGVXIW
63CIUrrc7zLPMCCHCnzoeNJMqj2z0mFclluXzr5mCDJYfU/63yPeUpCPuo3y1SfXPPPNYJKhz2pq
TugVE+rWoql9019BwTKtBy80nOE4RDQnMe6M9FWcSv/k6NyFtml9iwwtGVuRGXpSgh9humMWT0Cu
MxzHusdIaRaviY4mQLFS+iIyRC3Riu0OxbkgTWpDs937Vfv3LSslJSo2CvwqFEnMGhkGvMdjtNhJ
vGnpzMYN/rYWt/cer8nreURscXN7o3IR8ZtPkA==
```

```
// Encrypt message with the key, using public key

var encryptedData = cipherWrapper.encrypt(message, masterKey?.public)

// Decrypt message with the key, using private key
var decryptedData = cipherWrapper.decrypt(data, masterKey?.private)
```

Lock Screen

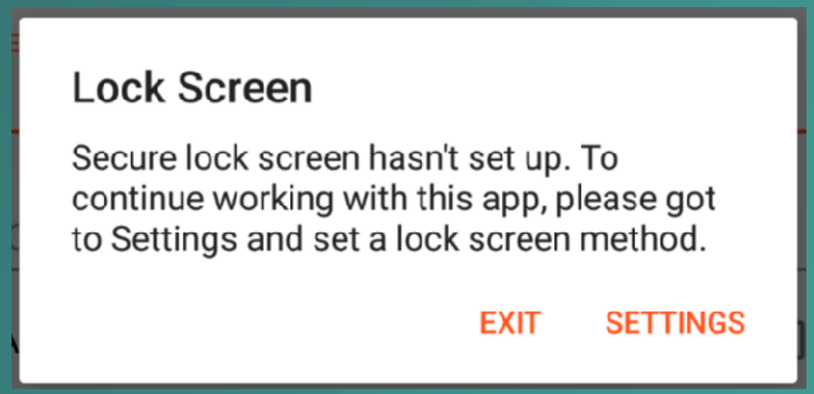
```
private val keyguardManager: KeyguardManager

keyguardManager =
  context.getSystemService(Context.KEYGUARD_SERVICE)

fun isDeviceSecure(): Boolean =
  if (hasMarshmallow()) keyguardManager.isDeviceSecure
  else keyguardManager.isKeyguardSecure

fun hasMarshmallow() =
  Build.VERSION.SDK_INT >= Build.VERSION_CODES.M
```



https://developer.android.com/reference/android/app/KeyguardManager

Prevent the app from starting

```
private var deviceSecurityAlert: AlertDialog? = null

override fun onStart() {
  super.onStart()
  if (!isDeviceSecure()) {
    deviceSecurityAlert = showDeviceSecurityAlert()
  }
}
// Used to block application if no lock screen is setup.
fun showDeviceSecurityAlert(): AlertDialog {
  return AlertDialog.Builder(context)
    .setTitle(R.string.lock_title)
    .setMessage(R.string.lock_body)
    .setPositiveButton(R.string.lock_settings, { _, _ ->
context.openLockScreenSettings() })
    .setNegativeButton(R.string.lock_exit, { _, _ -> System.exit(0) })
    .setCancelable(BuildConfig.DEBUG)
    .show()
}
```



Jetpack Security

- Based on Google Tink (github.com/google/tink).
- Provides abstractions for encrypting Files and SharedPreferences objects.
- Strong security that balances great encryption and good performance.
- Maximum security.

https://developer.android.com/topic/security/data

Setup

```
dependencies {
    implementation "androidx.security:security-crypto:1.0.0"

    // For Identity Credential APIs
    implementation “androidx.security:security-identity-credential:1.0.0-alpha03"
}
```

Read Files

```
val mainKey = MasterKey.Builder(applicationContext)
                       .setKeyScheme(MasterKey.KeyScheme.AES256_GCM).build()

val fileToRead = "my_sensitive_data.txt"
val encryptedFile = EncryptedFile.Builder(applicationContext, File(DIRECTORY, fileToRead),
  mainKey, EncryptedFile.FileEncryptionScheme.AES256_GCM_HKDF_4KB).build()

val inputStream = encryptedFile.openFileInput()
val byteArrayOutputStream = ByteArrayOutputStream()
var nextByte: Int = inputStream.read()
while (nextByte != -1) {
    byteArrayOutputStream.write(nextByte)
    nextByte = inputStream.read()
}

val plaintext: ByteArray = byteArrayOutputStream.toByteArray()
```

Write Files

```
val mainKey = MasterKey.Builder(applicationContext)
        .setKeyScheme(MasterKey.KeyScheme.AES256_GCM)
        .build()

val fileToWrite = "my_sensitive_data.txt"
val encryptedFile = EncryptedFile.Builder(
    applicationContext,
    File(DIRECTORY, fileToWrite),
    mainKey,
    EncryptedFile.FileEncryptionScheme.AES256_GCM_HKDF_4KB
).build()

val fileContent = "MY SUPER-SECRET INFORMATION"
        .toByteArray(StandardCharsets.UTF_8)

encryptedFile.openFileOutput().apply {
    write(fileContent)
    flush()
    close()
}
```

Edit shared preferences

```
val sharedPrefsFile: String = FILE_NAME
val sharedPreferences: SharedPreferences = EncryptedSharedPreferences.create(
        applicationContext,
        sharedPrefsFile,
        mainKey,
        EncryptedSharedPreferences.PrefKeyEncryptionScheme.AES256_SIV,
        EncryptedSharedPreferences.PrefValueEncryptionScheme.AES256_GCM
)

with (sharedPreferences.edit()) {
    // Edit the user's shared preferences...
    apply()
}
```

BiometricPrompt


```
// Create BiometricPrompt instance in onCreate
val biometricPrompt = BiometricPrompt(
    this, // Activity
    ContextCompat.getMainExecutor(this),
    authenticationCallback
)

private val authenticationCallback = object : AuthenticationCallback() {
        override fun onAuthenticationSucceeded(
            result: AuthenticationResult
        ) {
            super.onAuthenticationSucceeded(result)
            // Unlocked -- do work here.
        }
        override fun onAuthenticationError(
            errorCode: Int, errString: CharSequence
        ) {
            super.onAuthenticationError(errorCode, errString)
            // Handle error.
        }
    }
```

```
// To use
val promptInfo = PromptInfo.Builder()
    .setTitle("Unlock?")
    .setDescription("Would you like to unlock this key?")
    .setDeviceCredentialAllowed(true)
    .build()
biometricPrompt.authenticate(promptInfo)
```

Secure Communication

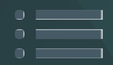
```
// Load CAs from an InputStream
// (could be from a resource or ByteArrayInputStream or ...)
val cf: CertificateFactory = CertificateFactory.getInstance("X.509")
// From https://www.washington.edu/itconnect/security/ca/load-der.crt
val caInput: InputStream = BufferedInputStream(FileInputStream("load-der.crt"))
val ca: X509Certificate = caInput.use {
    cf.generateCertificate(it) as X509Certificate
}
// Create a KeyStore containing our trusted CAs
val keyStoreType = KeyStore.getDefaultType()
val keyStore = KeyStore.getInstance(keyStoreType).apply {
    load(null, null)
    setCertificateEntry("ca", ca)
}
// Create a TrustManager that trusts the CAs inputStream our KeyStore
val tmfAlgorithm: String = TrustManagerFactory.getDefaultAlgorithm()
val tmf: TrustManagerFactory = TrustManagerFactory.getInstance(tmfAlgorithm).apply {
    init(keyStore)
}
// Create an SSLContext that uses our TrustManager
val context: SSLContext = SSLContext.getInstance("TLS").apply {
```

```
val url = URL("https://wikipedia.org")
val urlConnection: URLConnection =
        url.openConnection()
val inputStream: InputStream =
        urlConnection.getInputStream()
copyInputStreamToOutputStream(
        inputStream, System.out)
```

https://developer.android.com/training/articles/security-ssl

SSL


```
// Open SSLSocket directly to gmail.com
val socket: SSLSocket = SSLSocketFactory.getDefault().run {
    createSocket("gmail.com", 443) as SSLSocket
}
val session = socket.session

// Verify that the certificate hostname is for mail.google.com
HttpsURLConnection.getDefaultHostnameVerifier().run {
    if (!verify("mail.google.com", session)) {
        throw SSLHandshakeException("Expected mail.google.com, found ${session.peerPrincipal} ")
    }
}

// At this point SSLSocket performed certificate verification and
// we have performed hostname verification, so it is safe to proceed.

// ... use socket ...

socket.close()
```



Permissions

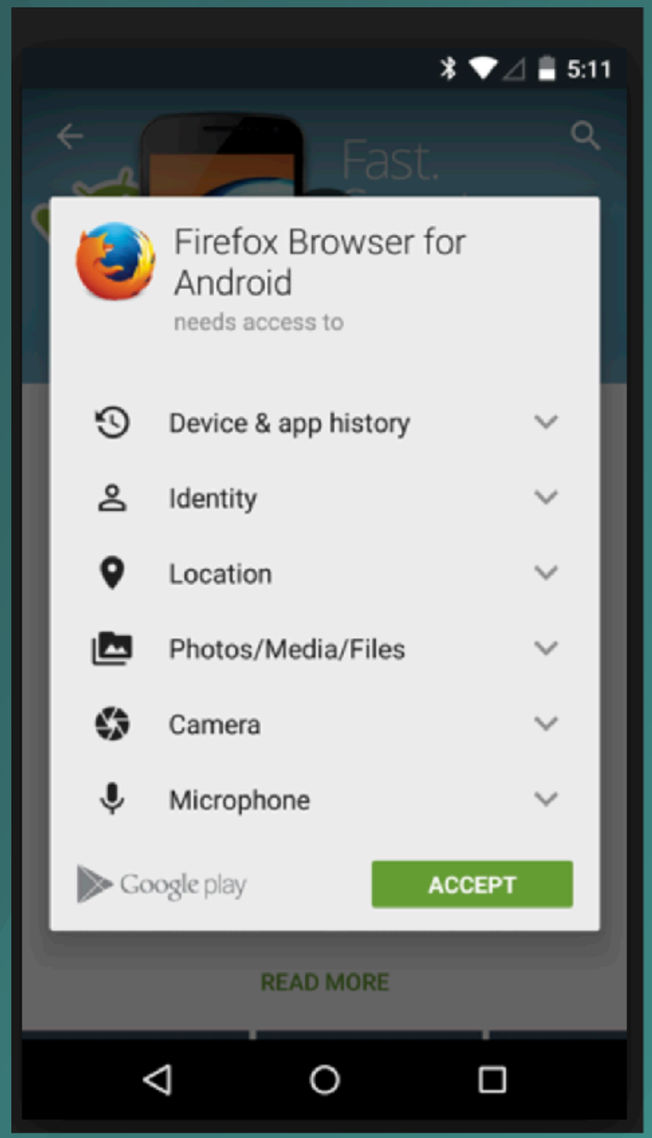
- Only use the permissions necessary for your app to work.
- Pay attention to permissions required by libraries.
- Be transparent.
- Make system accesses explicit.

```
<manifest ...
  package="com.example.snazzyapp">

 <uses-permission
   android:name=
     "android.permission.SEND_SMS"/>
    <!-- other permissions go here -->

 <application ...>
   ...
 </application>
</manifest>
```

Permissions

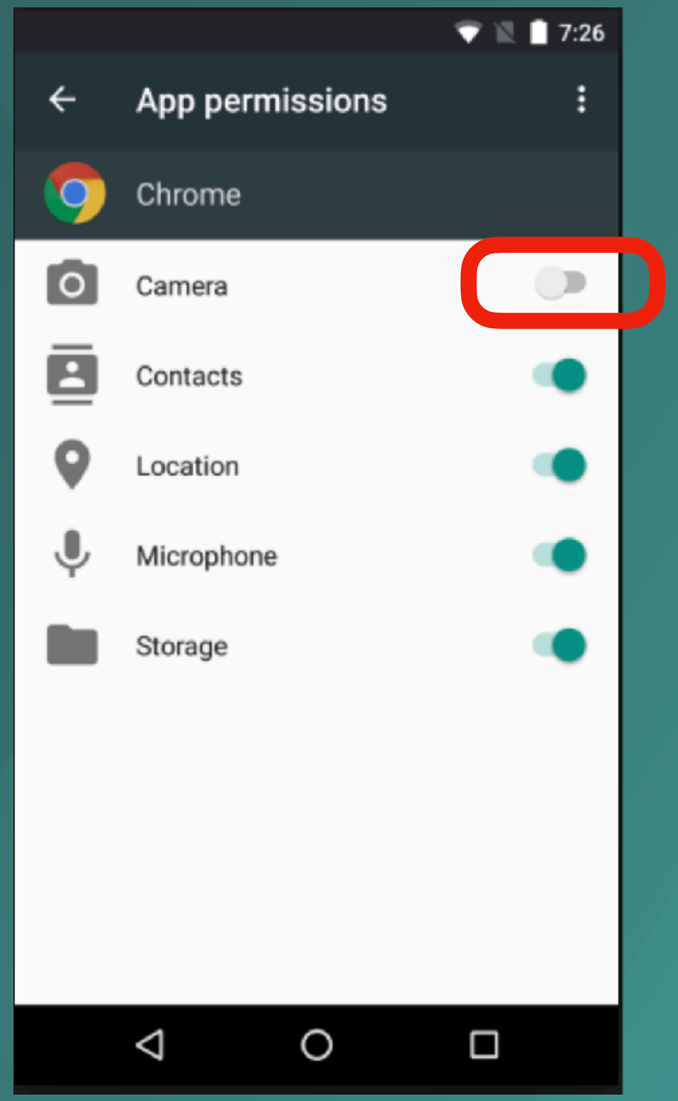
Before: Android 6.0

```
<manifest ...
  package="com.mozilla.firefox">
 ...
 <uses-permission
   android:name=
     "android.permission.CAMERA"/>
 <uses-permission
   android:name=
     "android.permission.MICROPHONE"/>
 ...
 <application ... >
   ...
 </application>
</manifest>
```

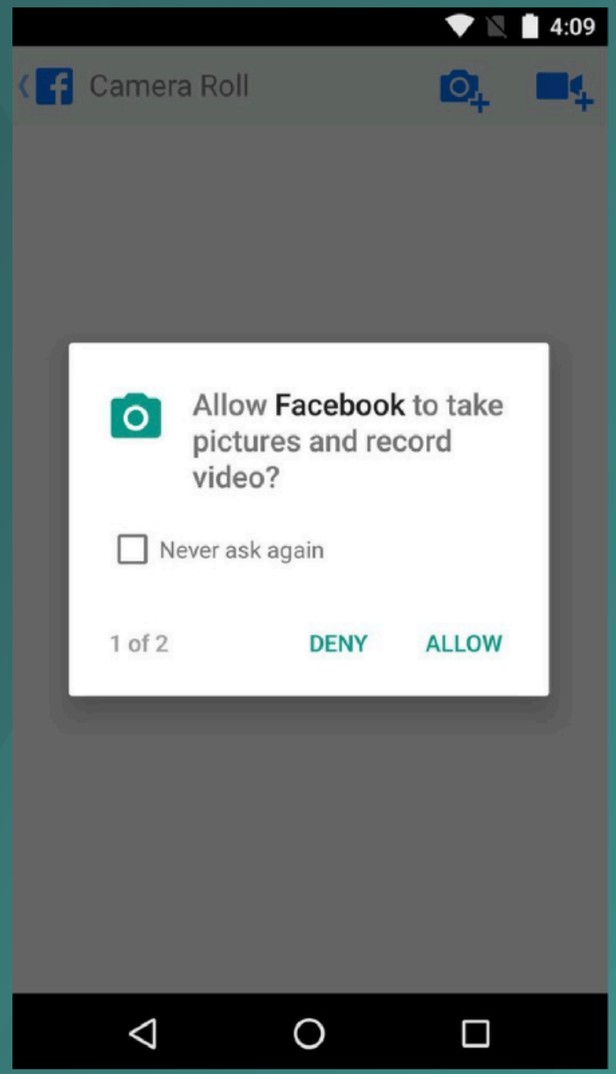


After: Android 6.0

```
if (ContextCompat.checkSelfPermission(
    thisActivity,
    Manifest.permission.CAMERA)
   != PackageManager.PERMISSION_GRANTED) {
  // Permission is not granted
}
```



```
if (ContextCompat.checkSelfPermission(
    thisActivity,
    Manifest.permission.CAMERA)
   != PackageManager.PERMISSION_GRANTED) {
  // Should we show an explanation?
  if (ActivityCompat.
    shouldShowRequestPermissionRationale(
       thisActivity,
       Manifest.permission.CAMERA)) {
     // Show an explanation to the user *asynchronously*
     // -- don't block this thread waiting for user's
     // response! After the user sees the explanation,
     // try again to request the permission.
  } else {
   // No explanation needed,
   // we can request the permission.
   ActivityCompat.requestPermissions(thisActivity,
    arrayOf(Manifest.permission.CAMERA),
    MY_PERMISSIONS_REQUEST_CAMERA)
   // MY_PERMISSIONS_REQUEST_CAMERA is an
   // app-defined int constant.
   // The callback method gets the result of the request.
  }
}
```



https://developer.android.com/training/permissions/requesting

Permissions Request Response

```
override fun onRequestPermissionsResult(requestCode: Int,
  permissions: Array<String>, grantResults: IntArray) {
 when (requestCode) {
  MY_PERMISSIONS_REQUEST_CAMERA -> {
   // If request is cancelled, the result arrays are empty.
   if ((grantResults.isNotEmpty() &&
      grantResults[0] == PackageManager.PERMISSION_GRANTED)) {
    // permission was granted, yay!
    // Do the camera-related task you need to do.
   } else {
    // permission denied, boo!
    // Disable the functionality that depends on this permission.
   }
   return
  }
 // Add other 'when' lines to check for other
  // permissions this app might request.
  else -> {
   // Ignore all other requests.
  }
 }
}
```

Dangerous Permissions

Permission Group	Permissions
CALENDAR	• READ_CALENDAR • WRITE_CALENDAR
CALL_LOG	• READ_CALL_LOG • WRITE_CALL_LOG • PROCESS_OUTGOING_CALLS
CAMERA	• CAMERA
CONTACTS	• READ_CONTACTS • WRITE_CONTACTS • GET_ACCOUNTS
LOCATION	• ACCESS_FINE_LOCATION • ACCESS_COARSE_LOCATION
MICROPHONE	• RECORD_AUDIO
PHONE	• READ_PHONE_STATE • READ_PHONE_NUMBERS • CALL_PHONE • ANSWER_PHONE_CALLS • ADD_VOICEMAIL

OAuth2

- Industry-standard protocol for authorization.
- Focuses on client developer simplicity.
- Specific authorization flows for:
  - Web applications.
  - Desktop applications.
  - Mobile phones.
  - Others, eg: living room devices.

Request an Auth Token

```
<manifest ... >
 <uses-permission
  android:name=
   "android.permission.ACCOUNT_MANAGER" />
 <uses-permission
  android:name=
   "android.permission.INTERNET" />
 ...
</manifest>
```

Get the Auth Token

```
AccountManager am = AccountManager.get(this);
Bundle options = new Bundle();

am.getAuthToken(
 myAccount, // Account retrieved using getAccountsByType()
 "Manage your tasks", // Auth scope
 options, // Authenticator-specific options
 this, // Your activity
 new OnTokenAcquired(), // Callback called when a token
                        // is successfully acquired
 new Handler(new OnError())); // Callback called if an error occurs
```

Get the Auth Token

```
AccountManager am = AccountManager.get(this);
Bundle options = new Bundle();

am.getAuthToken(
 myAccount, // Account retrieved using getAccountsByType()
 "Manage your tasks", // Auth scope
 options, // Authenticator-specific options
 this, // Your activity
 new OnTokenAcquired(), // Callback called when a token
                        // is successfully acquired
 new Handler(new OnError())); // Callback called if an error occurs
```

```
private class OnTokenAcquired
  implements AccountManagerCallback<Bundle> {
 @Override
 public void run(AccountManagerFuture<Bundle> result) {
  // Get the result of the operation from the AccountManagerFuture.
  Bundle bundle = result.getResult();

  // The token is a named value in the bundle. The name of the value
  // is stored in the constant AccountManager.KEY_AUTHTOKEN.
  token = bundle.getString(AccountManager.KEY_AUTHTOKEN);
  ...
 }
}
```

Using the Auth Token

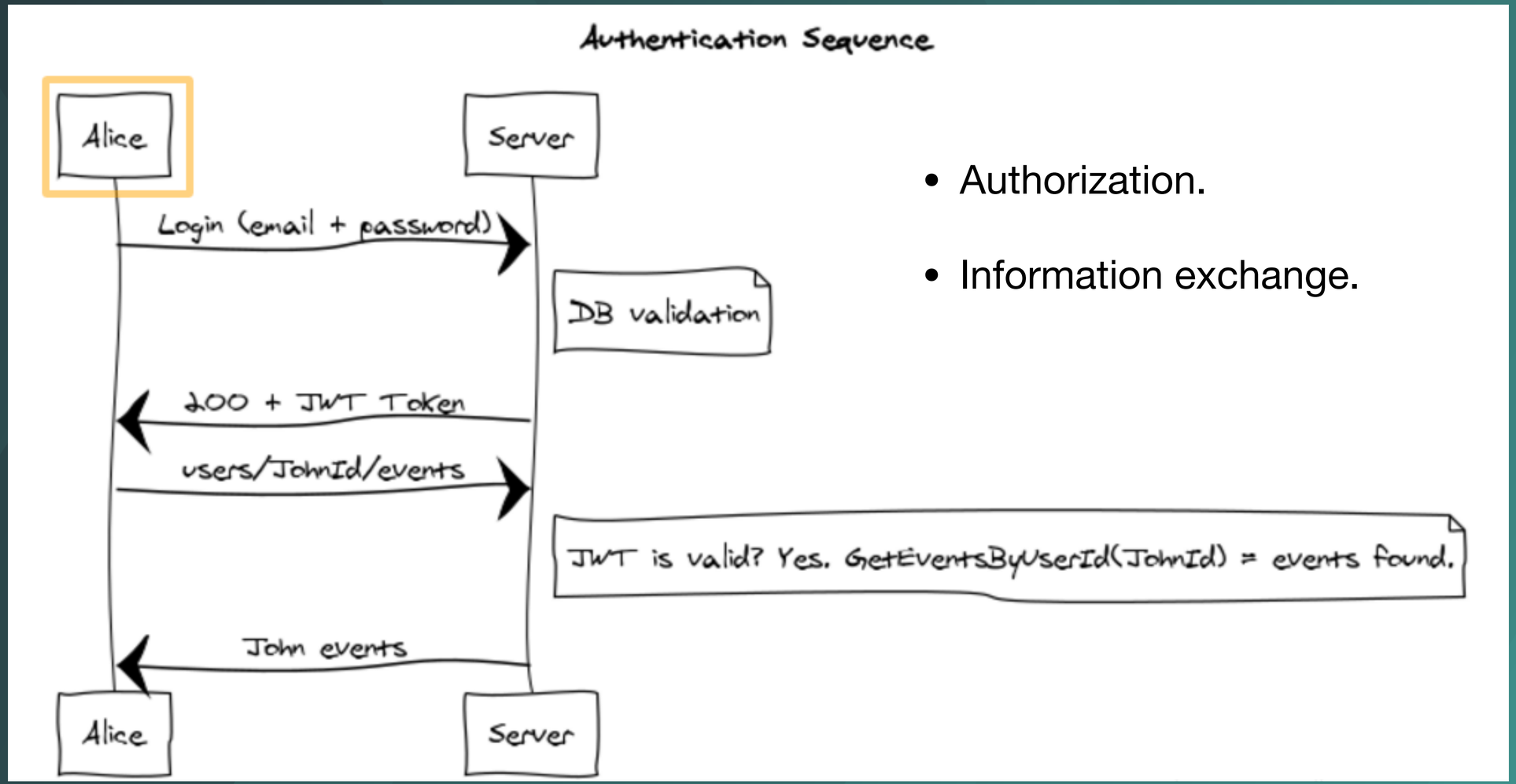

```
URL url = new URL(
 "https://www.googleapis.com/tasks/v1/users/@me/lists?key=" + your_api_key);
URLConnection conn = (HttpURLConnection) url.openConnection();
conn.addRequestProperty("client_id", your client id);
conn.addRequestProperty("client_secret", your client secret);
conn.setRequestProperty("Authorization", "OAuth " + token);
```

https://developer.android.com/training/id-auth/authenticate

JWT (JSON Web Token)

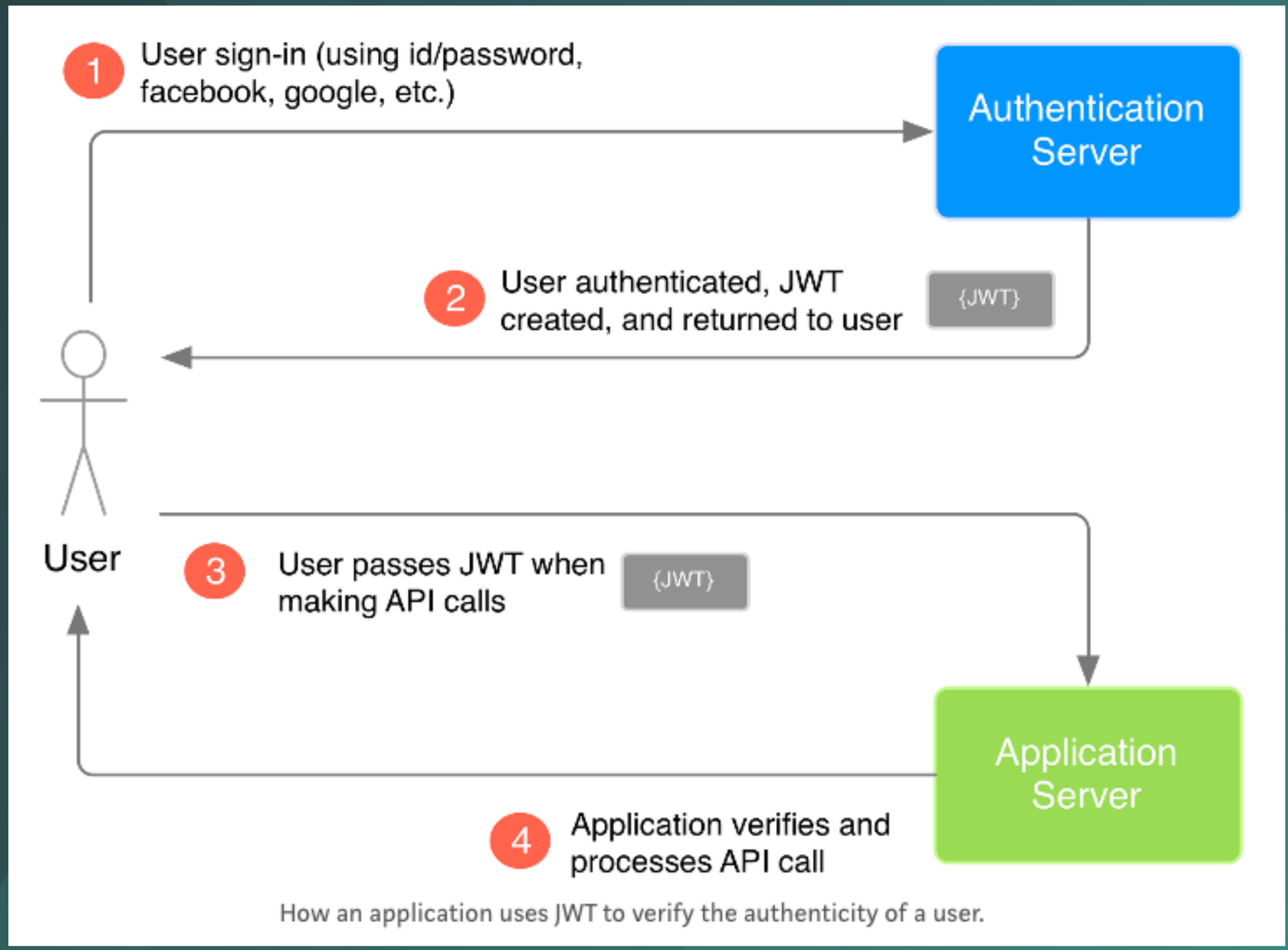
- Open standard, part of RFC 7519.
- Compact.
- Self-contained.
- Secure transmission.
- JSON objects.

JWT - Usage



- Authorization.
- Information exchange.

JWT - Separate Server



How an application uses JWT to verify the authenticity of a user.

JWT - Model

Header:

```
{
  "typ": "JWT",
  "alg": "HS256"
}
```

Payload:

```
{
  "userId": "b08f86af-35da-48f2-8fab-cef3904660bd"
}
```

Signature:

```
// signature algorithm
data = base64urlEncode(header) + "." + base64urlEncode(payload)
hashedData = hash(data, secret)
signature = base64urlEncode(hashedData)
```

Lecture outcomes

- Encrypt/Decrypt user's data.
- Establish secure connections.
- Understand security permissions.
- Using OAuth2.
- Using JWT.