Android Security Mechanisms (2)

Lecture 9

Operating Systems Practical

14 December 2016

OSP
logcat crunch

SSL/TLS

JSSE

Android JSSE Providers

Bibliography

Outline

Secure Communication

- Cryptographic providers for securing communication
- Recommendation: standardized security protocols
- Secure Sockets Layer (SSL) and Transport Layer Security (TLS)
- SSL is the predecesor of TLS

SSL/TLS

- Secure point-to-point communication protocols
- Authentication, message confidentiality and integrity for communication over TCP/IP
- Combination of symmetric and asymmetric encryption for confidentiality and integrity
- Public key certificates for authentication

Cipher Suite

- Cipher suite = set of algorithms for key agreement, authentication, integrity protection and encryption
- Client sends SSL version and list of cipher suites
- Client and server negotiate common cipher suite

Authentication and Encryption

- Authenticate through certificates
  - Usually only server authentication
  - Client authentication is also supported
- Compute shared symmetric key
- Secure communication using symmetric encryption & key

Public Key Certificates

- Binding an identity to a public key
- X.509 certificates
- Signature algorithm
- Validity
- Subject DN
- Issuer DN

Subject Name	
Country	US
State/Province	California
Locality	Mountain View
Organization	Google Inc
Common Name	*.google.com
Issuer Name	
Country	US
Organization	Google Inc
Common Name	Google Internet Authority G2
Serial Number	9085461370495713600
Version	3
Signature Algorithm	SHA-256 with RSA Encryption

Direct Trust

- SSL client communicates with a small number of servers
- Set of trusted server certificates = trust anchors
- Can be self-signed
- A server is trusted if it's certificate is part of the set
- Good control over trusted server
- Hard to update server key and certificate

Private CAs

- Private Certificate Authority (CA) -> trust anchor
- Signs server certificate
- Client trusts any certificate issued by the CA
- Easy to update server key and certificate
- Single point of failure

Public CAs

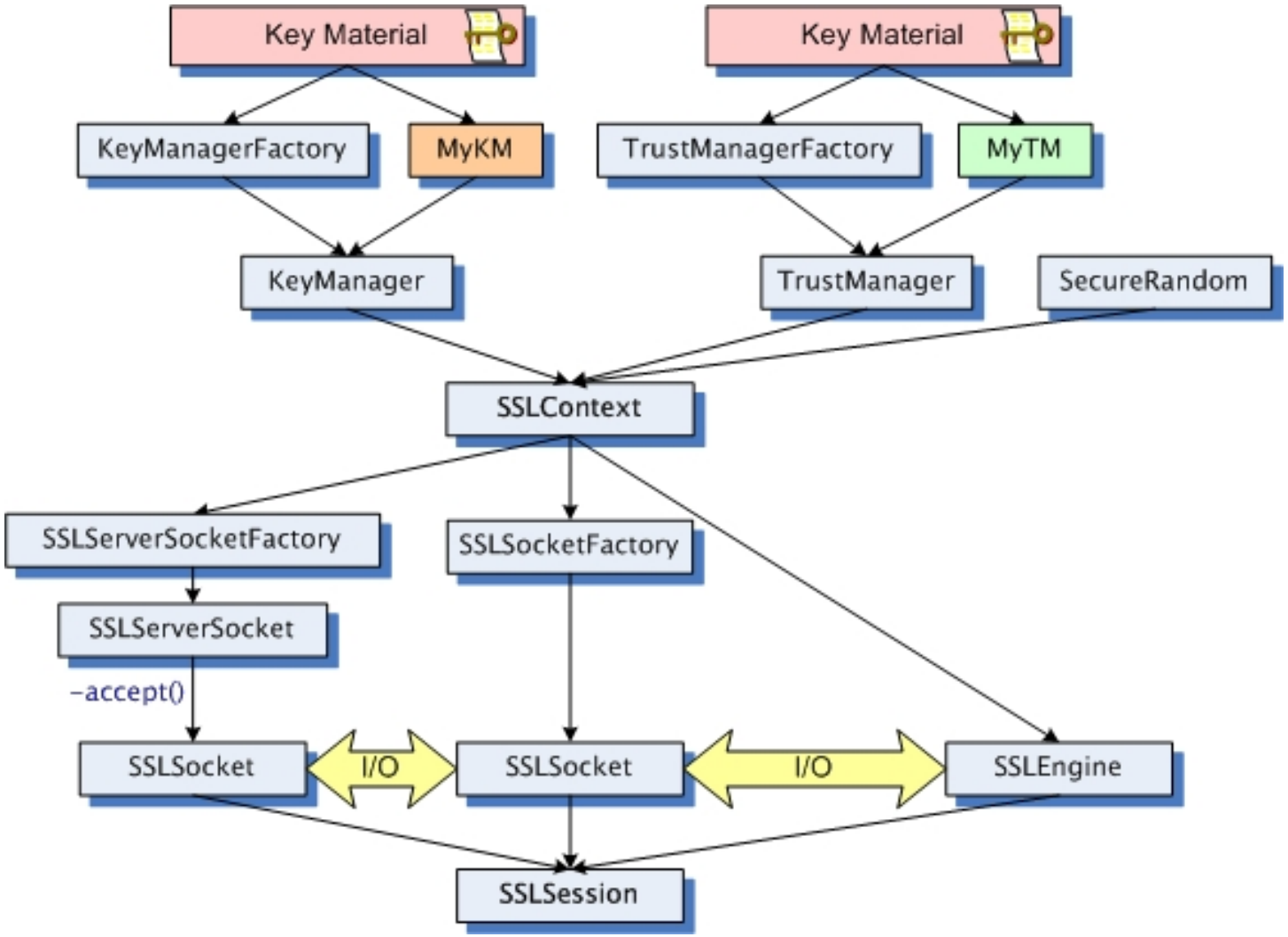
- Public Certificate Authorities (CAs) -> trust anchors
- Client configured with a set of trust anchors
- Web browsers - more than 100 CAs

Outline

Java Secure Socket Extension (JSSE)

- Android provides support for SSL/TLS through JSSE
- `javax.net` and `javax.net.ssl`
- Provides:
  - SSL client and server sockets
  - Socket factories
  - SSLEngine - producing and consuming SSL streams
  - SSLContext - creates socket factories and engines
  - KeyManager, TrustManager and factories
  - HttpsURLConnection

JSSE Classes



Source: http://docs.oracle.com/javase/7/docs/technotes/guides/security/jsse/JSSERefGuide.html

SSLSocket

- `SSLSocket` is created:
  - Through `SSLSocketFactory`
  - Accepting a connection on a `SSLServerSocket`
- `SSLServerSocket` created through `SSLServerSocketFactory`
- `SSLEngine`:
  - Created by `SSLContext`
  - I/O operations handled by the application

SSLContext

- SSL Context obtained in two ways
- 1. `getDefault()` method of `SSLServerSocketFactory` or `SSLSocketFactory`
  - Default context initialized with default KeyManager, default TrustManager and secure random generator
  - Key material from system properties

SSLContext

- 2. `getInstance()` static method of `SSLContext`
  - Context initialized with array of KeyManager, array of TrustManager, secure random generator
  - KeyManager obtained from KeyManagerFactory
  - TrustManager obtained from TrustManagerFactory
  - Factories initialized with KeyStore (key material)

SSLSession

- Established SSL connection -> `SSLSession` object
- Includes identities, cipher suites, etc.
- `SSLSession` used in multiple connections between same entities

TrustManager and KeyManager

- JSSE delegates trust decisions to `TrustManager`
- Delegates authentication key selection to `KeyManager`
- Each `SSLSocket` has access to them through `SSLContext`
- `TrustManager` has a set of trusted CA certificates (trust anchors)
  - A certificate issued by a trusted CA is considered trustworthy

System Trust Store

- Default JSSE `TrustManager` initialized using the system trust store
  - Major commercial and government CA certificates
  - `/system/etc/security/cacerts.bks`

```
TrustManagerFactory tmf = TrustManagerFactory
        .getInstance(TrustManagerFactory.getDefaultAlgorithm());
tmf.init((KeyStore) null);

TrustManager[] tms = tmf.getTrustManagers();
X509TrustManager xtm = (X509TrustManager) tms[0];

for (X509Certificate cert : xtm.getAcceptedIssuers()) {
    String certStr = "S:" + cert.getSubjectDN().getName()
                + "\nI:" + cert.getIssuerDN().getName();
    Log.d(TAG, certStr);
}
```

System Trust Store

- Until Android 4.0,
  - A single file: `/system/etc/security/cacerts.bks`
  - Read-only partition
- From Android 4.0
  - In addition, two directories
  - `/data/misc/keychain/cacerts-added`
  - `/data/misc/keychain/cacerts-removed`
  - Modified only by the system user
  - Add trust anchors through `TrustedCertificateStore` class

Validate Server Certificate

```
TrustManagerFactory tmf = TrustManagerFactory
                                    .getInstance("X509");
tmf.init((KeyStore) null);

TrustManager[] tms = tmf.getTrustManagers();
X509TrustManager xtm = (X509TrustManager) tms[0];

X509Certificate[] certChain = {serverCert};
xtm.checkServerTrusted(certChain, "RSA");
```

- SSLSocket and HttpURLConnection perform similar validations

HttpURLConnection

- Preferred method for connecting to a HTTPS server
- Uses default `SSLSocketFactory` to create secure sockets
- Custom trust store or authentication keys
  - `setDefaultSSLSocketFactory()` or `setSSLSocketFactory()` of `HttpsURLConnection`

Use your own Trust Store

- Use your own trust store instead of the system trust store
  - Load trust store in a `KeyStore` object
  - Obtain `TrustManagerFactory` and initialize it with trust store
  - Load key material in `KeyStore` object (for client authentication)
  - Obtain `KeyManagerFactory` and initailize it with key store
  - Obtain `SSLContext` and initialize it with TrustManager and KeyManager
  - Create `URL` and `HttpURLConnection`
  - Associate `SSLSocketFactory` of `SSLContext` to `HttpURLConnection`

Use your own Trust Store

```
KeyStore trustStore = loadTrustStore();
KeyStore keyStore = loadKeyStore();

TrustManagerFactory tmf = TrustManagerFactory
      .getInstance(TrustManagerFactory.getDefaultAlgorithm());
tmf.init(trustStore);

KeyManagerFactory kmf = KeyManagerFactory
      .getInstance(KeyManagerFactory.getDefaultAlgorithm());
kmf.init(keyStore, KEYSTORE_PASSWORD.toCharArray());

SSLContext sslCtx = SSLContext.getInstance("TLS");
sslCtx.init(kmf.getKeyManagers(), tmf.getTrustManagers(), null);

URL url = new URL("https://myserver.com");
HttpsURLConnection urlConnection = (HttpsURLConnection) url
urlConnection.setSSLSocketFactory(sslCtx.getSocketFactory());
```

Use your own Trust Store

- Generate your trust store using Bouncy Castle and openSSL in comand line
- Trust store file in `/res/raw/`

```
KeyStore localTrustStore = KeyStore.getInstance("BKS");
InputStream in = getResources().openRawResource(
                    R.raw.mytruststore);
localTrustStore.load(in, TRUSTSTORE_PASSWORD.toCharArray());

TrustManagerFactory tmf = TrustManagerFactory
        .getInstance(TrustManagerFactory.getDefaultAlgorithm());
tmf.init(localTrustStore);

SSLContext sslCtx = SSLContext.getInstance("TLS");
sslCtx.init(null, tmf.getTrustManagers(), null);

URL url = new URL("https://myserver.com");
HttpsURLConnection urlConnection = (HttpsURLConnection) url
urlConnection.setSSLSocketFactory(sslCtx.getSocketFactory());
```

Outline

Android JSSE Providers

- JSSE providers implement functionality for engine classes
  - Trust managers, key managers, secure sockets, etc.
  - Developers work with engine classes
- Android includes two JSSE providers:
  - HarmonyJSSE
  - AndroidOpenSSL

Harmony JSSE

- Implemented in Java
- Java sockets, JCA cryptographic classes
- SSLv3, TLSv1
- Deprecated, not actively maintained

AndroidOpenSSL

- Calls to OpenSSL native library (JNI)
- TLSv1.1, TLSv1.2
- Server Name Indication (SNI)
  - SSL clients specify target hostname
  - Server with multiple virtual hosts
  - Used by default by `HttpsURLConnection`
- Both providers share `KeyManager` and `TrustManager` code
- Different SSL socket implementation

Outline

Bibliography

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Keywords

- SSL/TLS
- Trust anchors
- Certificate Authority
- Trust store
- Java Secure Socket Extension
- SSLSocket
- HttpsURLConnection
- AndroidOpenSSL