Introduction to Android Programming

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AGENDA

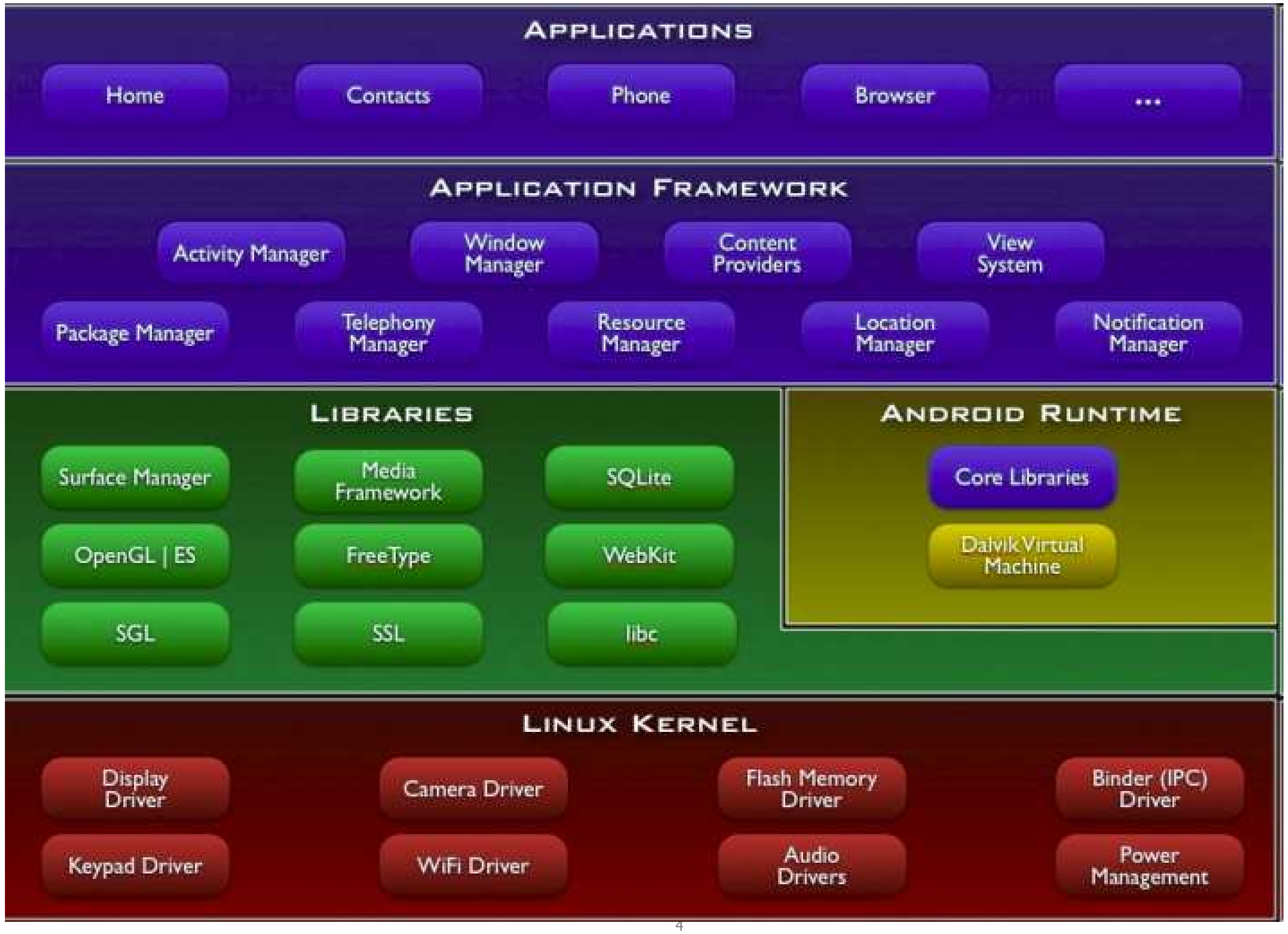
1. Android Basics
2. Eclipse Demo
3. Programming Basics
4. Networking (APIs, C2DM)

Android

- Mobile OS
  - Linux Kernel
  - Open Source (OHA/Google)

- Programming Environment
  - SDK -- compiler, debugger, device emulator
    - Multiplatform dev. support – Windows, Linux, Mac
  - Java Programming: has its own JVM (Dalvik VM) and special bytecode

Architecture

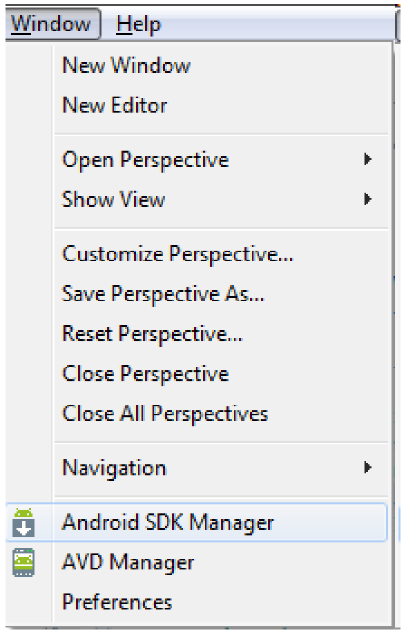


Android Development Process

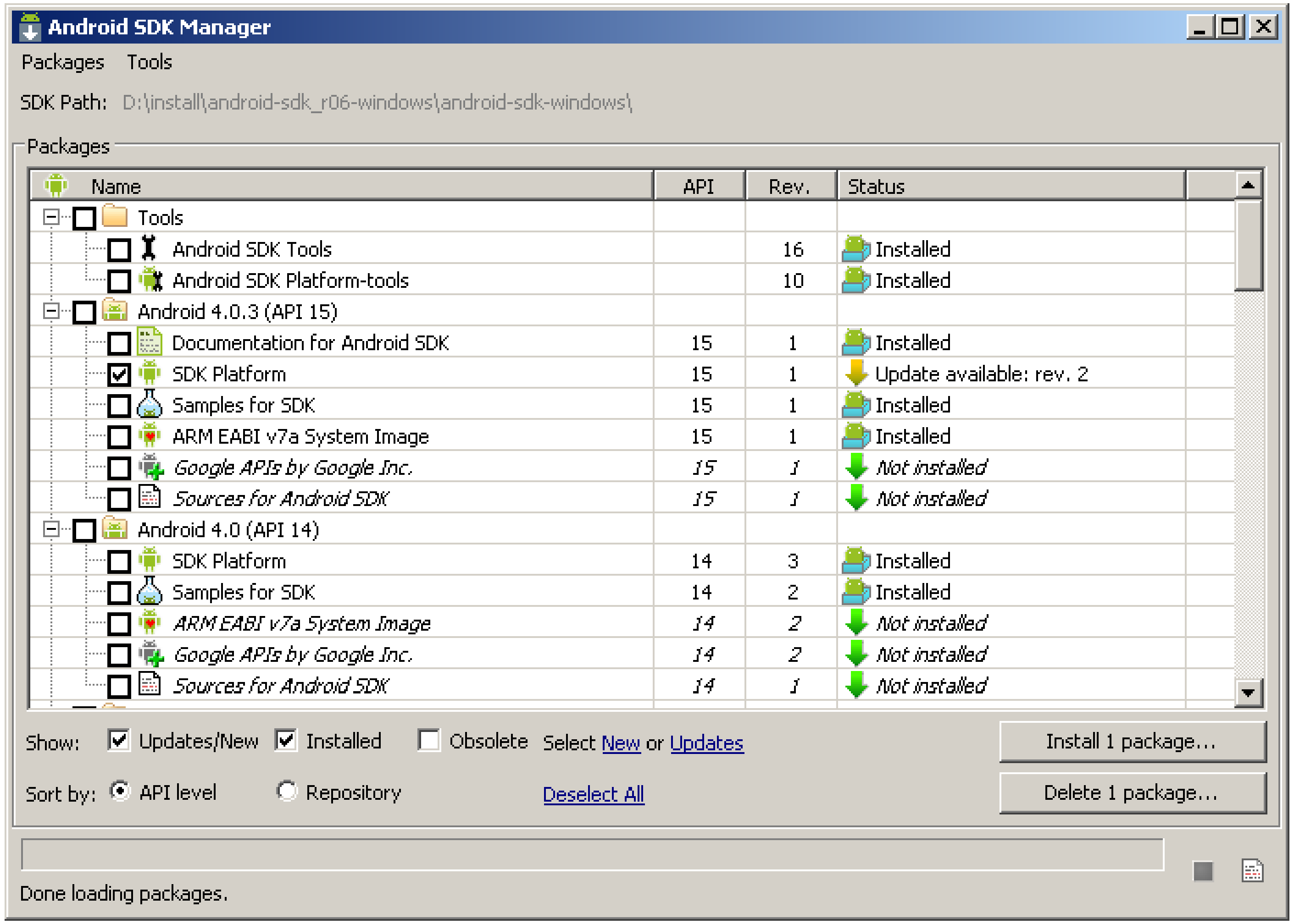
- Setup Dev. Environment (JDK, SDK, Eclipse…)
- Create app.
  - Android Project containing java files + resource files
- Test app.
  - Pack project into debuggable *.apk
  - Install, run and debug on device or emulator
- Publish app. in Android Market
- Get Rich!

Setup SDK within Eclipse (in Windows)

1. Download and Install
   - JDK
   - Eclipse
2. Install and configure Android SDK plugin in Eclipse
   1. Install Android Development Tools (ADT) plugin https://dl-ssl.google.com/android/eclipse/
   2. It will prompt to install the Android SDK
   3. Use Android SDK Manager to install specific versions of Android



Android SDK Manager



Android SDK Manager

Packages Tools

SDK Path: D:\install\android-sdk_r06-windows\android-sdk-windows\

Packages

Name	API	Rev.	Status
☐ Tools			
☐ Android SDK Tools		16	Installed
☐ Android SDK Platform-tools		10	Installed
☐ Android 4.0.3 (API 15)			
☐ Documentation for Android SDK	15	1	Installed
☑ SDK Platform	15	1	Update available: rev. 2
☐ Samples for SDK	15	1	Installed
☐ ARM EABI v7a System Image	15	1	Installed
☐ *Google APIs by Google Inc.*	*15*	*1*	*Not installed*
☐ *Sources for Android SDK*	*15*	*1*	*Not installed*
☐ Android 4.0 (API 14)			
☐ SDK Platform	14	3	Installed
☐ Samples for SDK	14	2	Installed
☐ *ARM EABI v7a System Image*	*14*	*2*	*Not installed*
☐ *Google APIs by Google Inc.*	*14*	*2*	*Not installed*
☐ *Sources for Android SDK*	*14*	*1*	*Not installed*

Show: ☑ Updates/New ☑ Installed ☐ Obsolete Select New or Updates

Sort by: [✓ API level] Repository Deselect All

Install 1 package...

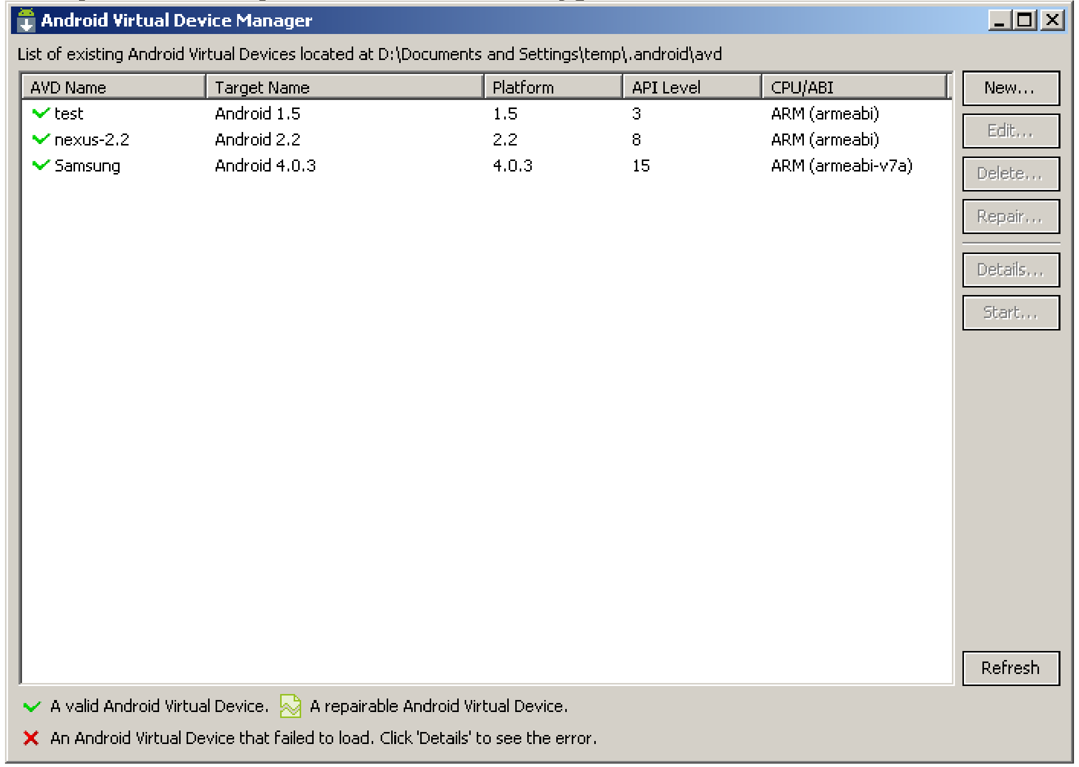
Delete 1 package...

Done loading packages.

Option 1: Use an Emulator

Create an AVD (Android Virtual Device)

- Lets you specify the configuration of a device to be emulated by the **Android** Emulator.
- Create AVD In Eclipse by selecting **Window > AVD Manager**.



List of existing Android Virtual Devices located at D:\Documents and Settings\temp\.android\avd

AVD Name	Target Name	Platform	API Level	CPU/ABI
✓ test	Android 1.5	1.5	3	ARM (armeabi)
✓ nexus-2.2	Android 2.2	2.2	8	ARM (armeabi)
✓ Samsung	Android 4.0.3	4.0.3	15	ARM (armeabi-v7a)

✓ A valid Android Virtual Device. A repairable Android Virtual Device.

✗ An Android Virtual Device that failed to load. Click 'Details' to see the error.

Option 2: Use a device

- Install drivers for device
- Connect device to PC via USB cable
  - Make sure turned on USB debugging (Settings→Application→Development)
  - Also turn on install of non market Apps (Settings→Application→ Unknown Sources)
- Device will be recognized within Eclipse (DDMS view)

Continue after Eclipse Demo

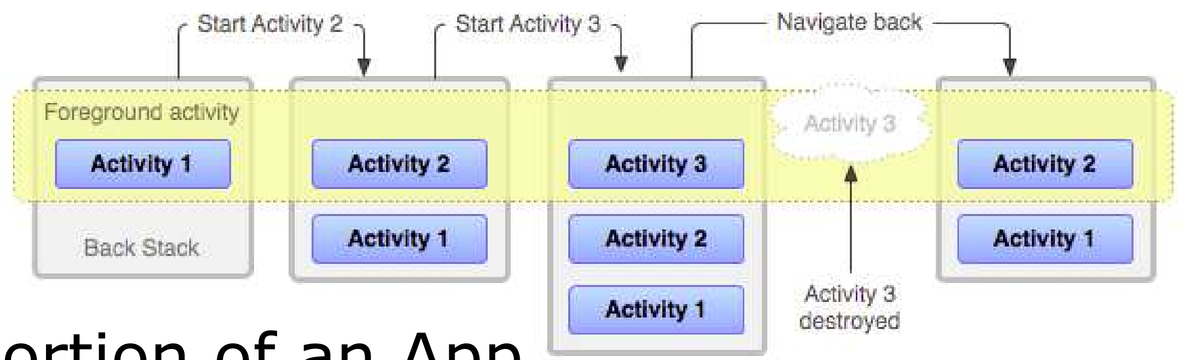
Android App

- Runs in its own Virtual Machine & process
  - Isolation among apps
- Typically an app cannot directly access other apps data
- Is composed of basic “components”
- App components can be activated individually
  - Android starts the app process when any of its component needs to be executed

Android App Components

Basic Components	Description
Activity	Deals with UI aspects. Typically corresponds to a single screen
Service	Background tasks (e.g. play music in background while user is web surfing) that typically have no UI.
BroadCastReciever	Can receive messages (e.g. “Low Battery”) from system/apps and act upon them.
ContentProvider	Provide an interface to app data. Lets apps share data with each other

Activities



- UI portion of an App
- One activity typically corresponds to a single screen of an app (but can also be faceless)
- Conceptually laid out as a stack
  - The Activity on top of the stack is visible/in foreground
  - Background activities are stopped but state is retained
  - Back button resumes previous Activity in the stack
- HOME button moves app and its activities in background

Activity Example

MyActivity.java

```
import android.app.Activity;
import android.os.Bundle;

public class MyActivity extends Activity
{
  /** Called when the activity is first created. */
  @Override
  public void onCreate(Bundle savedInstanceState)
  {
      super.onCreate(savedInstanceState);
      setContentView(R.layout.main);
  }
}
// savedInstance holds any data that may have been saved for the activity just before it got
      killed by the system (e.g. to save memory) the last time
```

AndroidManifest.xml

```
<activity android:name=".MyActivity"
                  android:label="@string/app_name">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
</activity>
```

Views

- Views are building blocks of Activities/UI
  - TextView, EditText, ListView, ImageView, MapView, WebView…

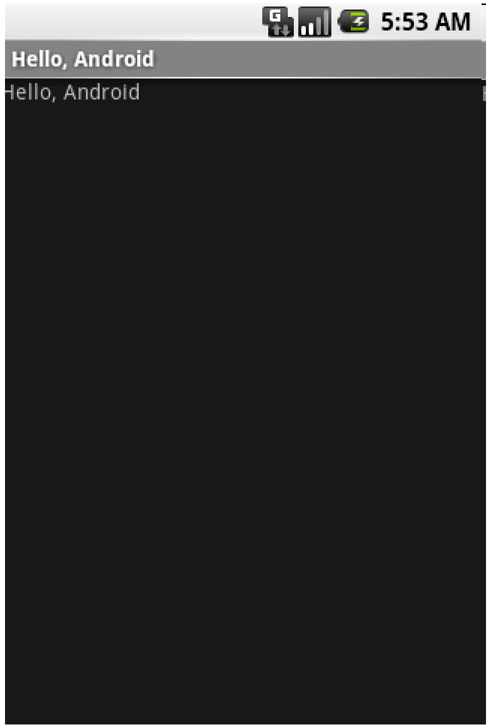
main.xml

```
<TextView
     xmlns:android="http://schemas.android.com/apk/re
     s/android"
       android:layout_width="fill_parent"
       android:layout_height="wrap_content"
       android:text="@string/hello"
</TextView>
```

XML-based UI layout file

MyActivity.java

```
public class MyActivity extends Activity
{
public void onCreate(Bundle savedInstanceState)
  {
     super.onCreate(savedInstanceState);
     setContentView(R.layout.main);
  }
}
```



5:53 AM

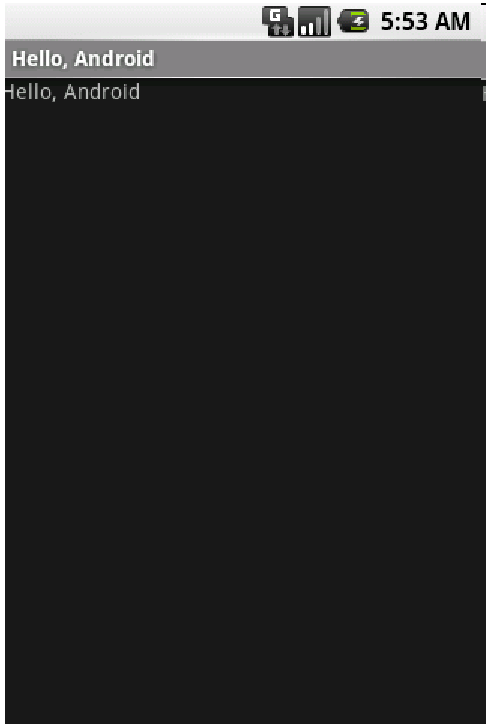
Hello, Android

Hello, Android

Views Continued

- Views can also be created using “programmatic" UI layout

```
MyActivity.java
public class MyActivity extends Activity
{
public void onCreate(Bundle savedInstanceState)
  {
      super.onCreate(savedInstanceState);
     // setContentView(R.layout.main);
      TextView tv = new TextView(this);
      tv.setText("Hello, Android");
      setContentView(tv);

  }
}
```



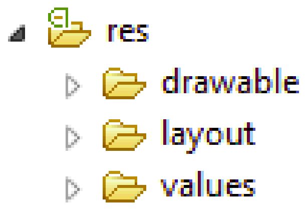
Hello, Android

Layouts

- Controls how Views are laid out:
  - LinearLayout : single row or column
  - TableLayout : rows and columns
  - RelativeLayout : relative to other Views

MyActivity.java

```
public class MyActivity extends Activity
{
public void onCreate(…)
  {
     ….
     setContentView(R.layout.main);
  }
}
```



```
res
  drawable
  layout
  values
```

main.xml

```
<LinearLayout
      xmlns:android="http://schemas.android.com/apk/res/andr
      oid"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:orientation="vertical" >

    <TextView
        android:layout_width="fill_parent"
        android:layout_height="wrap_content"
        android:text="@string/hello1" />

    <TextView
        android:layout_width="fill_parent"
        android:layout_height="wrap_content"
        android:text="@string/hello2" />

</LinearLayout>
```

Services

- Faceless components that typically run in the background
  - music player, network download, etc.
- Services can be started in two ways
  - A component can start the service by calling *startService()*
  - A component can call *bindService()* to create the service
- Service started using *startService()* remains running until explicitly stopped
- Service started using *bindService()* runs as long as the component that created it is still “bound” to it.
- The Android system can force-stop a service when memory is low
  - However “foreground” services are almost never killed.
  - If the system kills a service, it restarts it as soon as resources become available again

Service Example

ExampleService.java
```
 public class ExampleService extends IntentService {

   // Called from the default worker thread. Service stopped when method returns
  @Override
  protected void onHandleIntent(Intent intent) {
      // Do some work here, like download a file.
    }
  }
```

AndroidManifest.xml
```
<manifest ... >
  ...
  <application ... >
      <service android:name=".ExampleService" />
      ...
  </application>
</manifest>
```

Caller.java
```
Intent msgIntent = new Intent(this, ExampleService.class);
startService(msgIntent);
```

Broadcast Receivers

- Components designed to respond to broadcast messages (called Intents)
- Can receive broadcast messages from the system. For example when:
  - A new phone call comes in
  - There is a change in the battery level or cellID
- Can receive messages broadcast by Applications
  - Apps can also define new broadcast messages

Broadcast Receiver Example

PhoneCallReceiver.java

```
 public class PhoneCallReceiver extends BroadcastReceiver {
     @Override
     public void onReceive(Context context, Intent intent) {
               Bundle extras = intent.getExtras();
               if (extras != null) {
                        String state = extras.getString(TelephonyManager.EXTRA_STATE);
                        if (state.equals(TelephonyManager.EXTRA_STATE_RINGING)) {
                              String phoneNumber =
               extras.getString(TelephonyManager.EXTRA_INCOMING_NUMBER);
                              Log.w("DEBUG", phoneNumber);
                              }
               }
     }
}
```

AndroidManifest.xml

```
      <application android:icon="@drawable/icon" android:label="@string/app_name">


               <receiver android:name="PhoneCallReceiver">
                              <intent-filter>
                                    <action android:name="android.intent.action.PHONE_STATE"></action>
                              </intent-filter>
               </receiver>
      </application>
      <uses-permission android:name="android.permission.READ_PHONE_STATE"></uses-permission>
```

ContentProvider

- Enables sharing of data across applications
  - address book, photo gallery, etc.

- Provides uniform APIs for:
  - Query, delete, update, and insert rows
  - Content is represented by URI and MIME type

ContentProvider Example

BooksContentProvider.java

```
public class BooksContentProvider extends ContentProvider {
        @Override
        public int delete(Uri arg0, String arg1, String[] arg2) {………………..}

        @Override
        public String getType(Uri uri) {…………………….}

        @Override
        public Uri insert(Uri uri, ContentValues values) {………………………..}

        @Override
        public boolean onCreate() {…………………………….}

        @Override
        public Cursor query(Uri uri, String[] projection, String selection, String[] selectionArgs, String sortOrder)
            {…………………………………..}

        @Override
        public int update(Uri uri, ContentValues values, String selection, String[] selectionArgs) {……………..}
}
```

AndroidManifest.xml

```
<provider android:name="edu.columbia.BooksContentProvider" android:authorities="books"/>
```

CallingApp.java

```
Uri empsUri=Uri.parse("content://books");
Cursor cursor=getContentResolver().query(empsUri, null, null, null, null);
```

Intent

- Intent are messages used for activating components
- Intent Object:
  - Helps identify the receiving component(s)
  - May contain action to be taken and data to act on
  - Serve as notification for a system event (e.g. new call)
- Intents can be:
  - Explicit: Specify receiving component (java class)
  - Implicit: Specify action/data. Components registered for the action/data pair can receive the Intent
    - Register via ***IntentFilters*** in AndroidManifest.xml
    - BroadCastRecievers can also register programmatically

Explicit Intent Example

ExampleService.java

```
 public class ExampleService extends IntentService {

   // Called from the default worker thread. Service stopped when method returns
  @Override
  protected void onHandleIntent(Intent intent) {
      // Do some work here, like download a file.
    }
  }
```

AndroidManifest.xml

```
<manifest ... >
  ...
  <application ... >
      <service android:name=".ExampleService" />
      ...
  </application>
</manifest>
```

Caller.java

```
Intent msgIntent = new Intent(this, ExampleService.class);
startService(msgIntent);
```

Implicit Intent Example

AndroidManifest.xml

```
<activity android:name="MyBrowserActivitiy" android:label="@string/app_name">
  <intent-filter>
     <action android:name="android.intent.action.VIEW" />
     <category android:name="android.intent.category.DEFAULT" />
     <data android:scheme="http"/>
  </intent-filter>
</activity>
```

Caller.java

```
intent = new Intent(Intent.ACTION_VIEW, Uri.parse("http://www.google.com"));
startActivity(intent);
```

Networking

Net APIs

- Standard java networking APIs
- Two HTTP clients: HttpURLConnection and Apache HTTP Client.

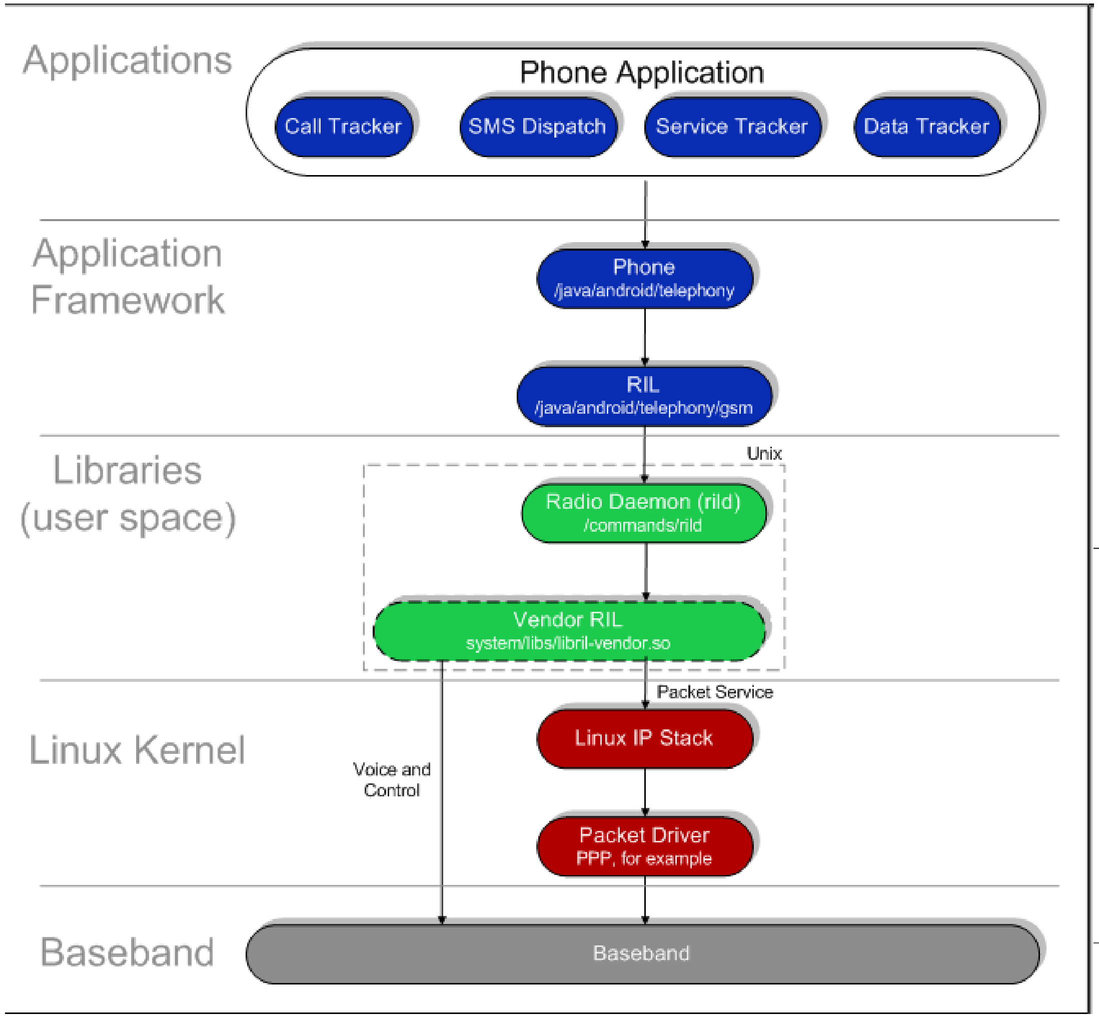
```
import java.net.Socket;

 Socket socket;
   try {
          socket = new Socket(hostName, port);
   }
   catch (IOException e) {
       System.out.println(e);
   }
```

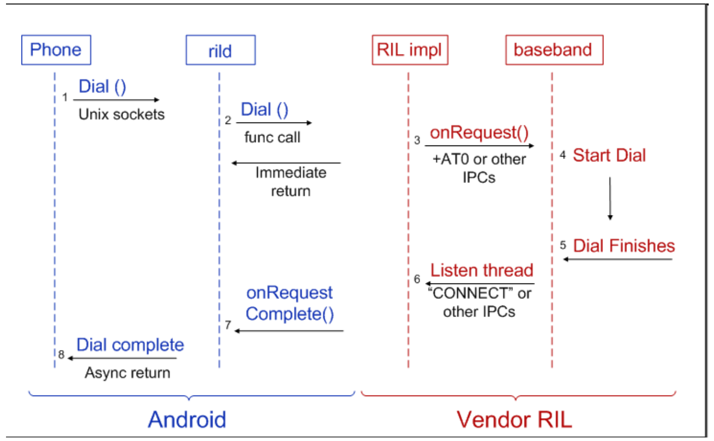
```
import org.apache.http.HttpResponse;
import org.apache.http.client.HttpClient;
import org.apache.http.client.methods.HttpGet;
import org.apache.http.impl.client.DefaultHttpClient;

   HttpClient client = new DefaultHttpClient();
        HttpGet request = new HttpGet(url);
        try{
            HttpResponse response = client.execute(request);
      }catch(Exception ex){
                  System.out.println(ex);
      }
```

Telephony APIs (android.telephony)

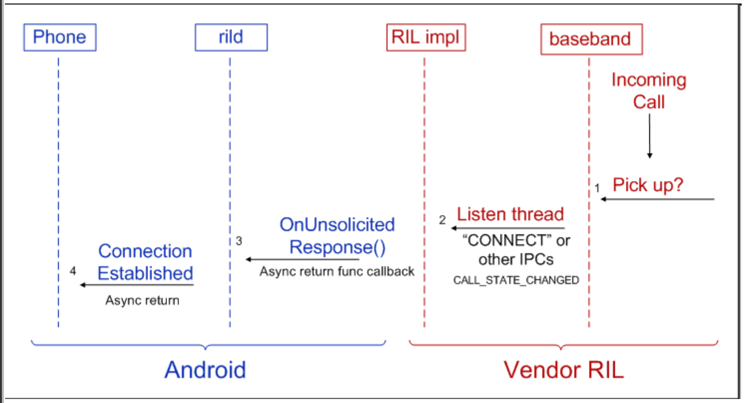
- Send and receive SMS
- Get mobile network info (network type, operator..)
- Get current value of network parameters (cellID, signal strength, SNR, roaming state ..)
- Monitor state changes (cellID, signal strength, SNR, call state, connectivity..)
- Get current device state (connected, idle, active)
- Get device parameters (IMSI, IMEI, device type)

Android Telephony Deep Dive





Solicited command – call flow



Unsolicited command – call flow

Ref: http://www.netmite.com/android/mydroid/development/pdk/docs/telephony.html

WiFi APIs (android.net.wifi)

- Get WiFi state (on or off). Turn WiFi on or off.
- Get list of configured networks. Modify attributes of individual entries
- Currently active network. Disconnect from WiFi
- Initiate scan for WiFi APs
- Receive list of WiFi APs (e.g. SSIDs) from a scan
- Connect to a particular WiFi AP
- Get current state (e.g. RSSI, connection state)
- Intents broadcast upon any sort of change in WiFi state

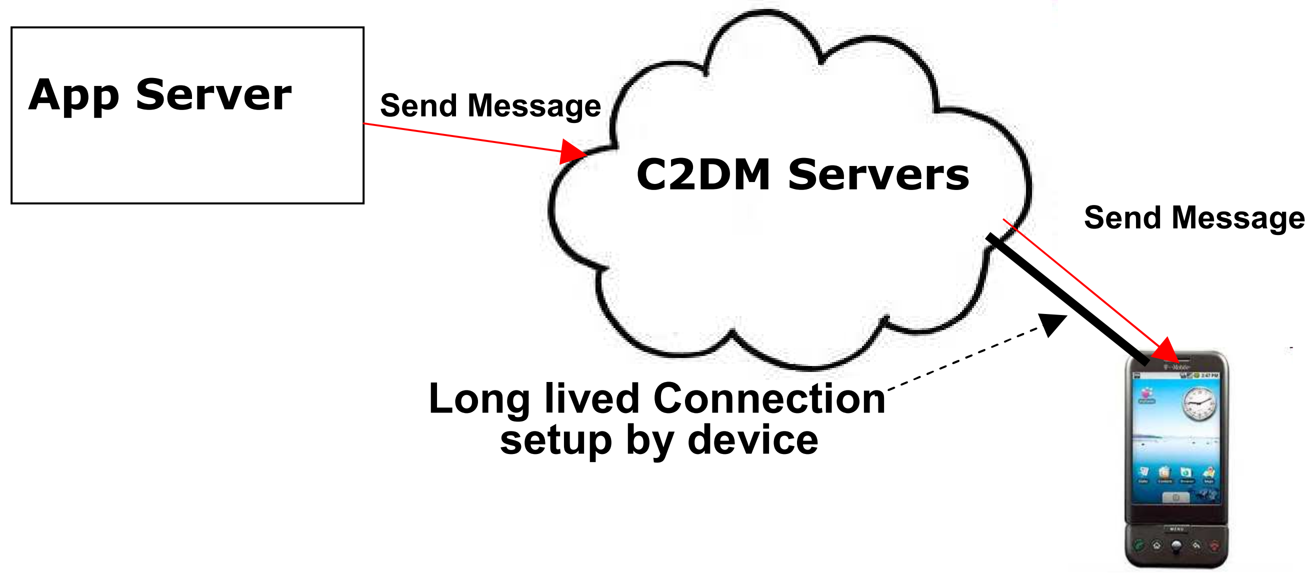
Cloud to Device Messaging

- Various mechanisms to keep an app in synch with changes in the server (cloud)
  - Polling: App periodically polls the servers for changes
  - Push: Servers push changes to app
- Polling can be inefficient if server data changes infrequently
  - Unnecessary Battery drain and network (signaling and data) overhead
- Several apps polling independently without coordination can also be inefficient
  - High battery drain and radio signaling every time the device moves from “idle” to “radio connected” state

Push Notifications

- Network firewalls prevent servers from directly sending messages to mobile devices
- Alternative is to have the device initiate the connection
  - Maintain a connection between device and cloud
  - “Push” cloud updates to apps on the device via this connection
  - Optimize this connection to minimize bandwidth and battery consumption
    - E.g. by adjusting the frequency of keep-alive messages
- This is the principal behind Android’s Cloud to Device Messaging (C2DM)
  - Available since Android 2.2

C2DM



- Device maintains a connection to Android Marketplace
- App Server sends message to C2DM servers (e.g. via http post)
  - Message size limited to 1024 bytes
- C2DM servers forward the message to app on the device
  - If device is not online then will wait until device comes online
  - Message sent to app via a Broadcast Intent (app has to register for it)
- Message notifies that there is an update for the app. It may trigger the App to contact the server

Using C2DM

1. Sign up for a C2DM account with Google (http://code.google.com/android/c2dm/signup.html)
2. Setup AndroidManifest
   - BroadcastReciever that will receive C2DM messages
   - Permissions to register and receive C2DM messages
3. Register with C2DM in the app
4. Handle registration and other messages from C2DM in the app
   - Registration response contains a registration id which the App Server needs to be able to send C2DM messages to the device

Manifest file for using C2DM

AndroidManifest.xml

```
    <permission
     android:name=" edu.columbia.permission.C2D_MESSAGE"
     android:protectionLevel="signature" />

  <uses-permission android:name="edu.columbia.permission.C2D_MESSAGE" />
  <uses-permission android:name="com.google.android.c2dm.permission.RECEIVE" />
  <uses-permission android:name="android.permission.INTERNET" />

    <receiver android:name=".MyC2DMReceiver"
    android:permission="com.google.android.c2dm.permission.SEND">
      <!-- Receive the actual message -->
      <intent-filter>
        <action android:name="com.google.android.c2dm.intent.RECEIVE" />
        <category android:name="edu.columbia" />
      </intent-filter>
      <!-- Receive the registration id -->
      <intent-filter>
        <action android:name="com.google.android.c2dm.intent.REGISTRATION" />
        <category android:name="edu.columbia" />
      </intent-filter>
    </receiver>
```

Registering with C2DM (device side)

Register.java

```
    Intent intent = new Intent("com.google.android.c2dm.intent.REGISTER");
    intent.putExtra("app",PendingIntent.getBroadcast(this, 0, new Intent(), 0));
    intent.putExtra("sender", EmailUsedToRegisterWithC2DM);
    startService(intent);
```

- In main activity send the register call
- Include the email used to register with C2DM.
- PendingIntent gives C2DM info about the app (via the **this** pointer)
- The service asynchronously registers with C2DM
- Will receive "com.google.android.c2dm.intent.REGISTRATION" intent upon successful registration

Handle messages from C2DM

MyC2DMReceiver.java

```
public class MyC2DMReceiver extends BroadcastReceiver {

@Override
public void onReceive(Context context, Intent intent) {

        if (intent.getAction().equals("com.google.android.c2dm.intent.REGISTRATION")) {
      String registrationId = intent.getStringExtra("registration_id");
      handleRegistration(…………);
   } else if (intent.getAction().equals("com.google.android.c2dm.intent.RECEIVE")) {
      handleMessage(……………);
   }
 }
```

- From the Registration response a registration id is obtained and is sent to the App Server
- App Server needs the registration ID to send C2DM messages to the app

References

- SDK http://developer.android.com/sdk/index.html
- APIs http://developer.android.com/reference/packages.html
- Basics
  - http://developer.android.com/guide/index.html
  - http://developer.android.com/resources/index.html
  - http://www.vogella.de/android.html
- C2DM http://code.google.com/android/c2dm/