Android SDK

Lecture 2

Operating Systems Practical

12 October 2016

Outline

Android Manifest

- `AndroidManifest.xml` file
- In the root of an app's directory
- Describes application components and resources
  - Application name and Java package name (unique)
  - Activities, Services, Broadcast Receivers, Content Providers
  - Main(default) activity
  - Permissions
  - Libraries
  - Target/Minimum API level

Permissions

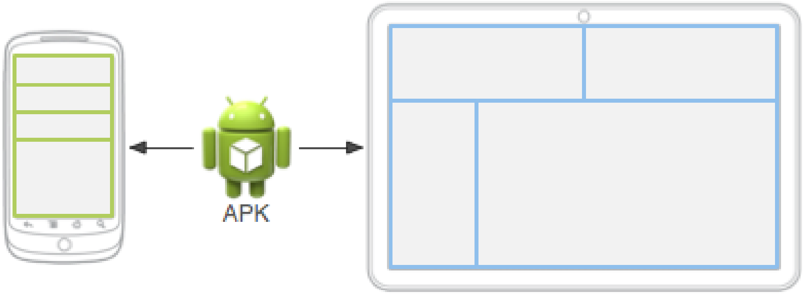
- Request access to resources and APIs for the application
- Provide security through sandboxing
- Declared in the Manifest
  - `<uses-permission android:name="android.permission.INTERNET" />`
- Control who can access your components and resources
  - Start Activity, start/bind Service, send broadcasts, access data in Content Providers

  -
    ```
    <activity android:name=".ExampleActivity"
        android.permission="com.example.perm.START">
        ...
    </activity>
    ```
  - URI permissions

Resources

- res/ directory
- Each resource type in a different subdirectory
  - Specific name
  - drawable/, layout/, values/, menu/, xml/, etc.
- Different configurations may require different resources
  - Bigger screen -> different layout
  - Different language -> different strings
  - Subdirectory for each alternative set of resources
  - <resources_name>-<config_qualifier>
  - drawable-hdpi/ for High Density Screens
  - Resource chosen at runtime based on device configuration
- An ID is generated for each resource name in gen/

Resources - Different Configurations



Source: http://developer.android.com

Layouts

- Resources from `res/layouts/`
- Describe the UI of an activity or part of the UI
- UI elements
  - Button, TextView, etc.
- `res/layout/filename.xml`
  - `filename` is used as resource ID
  - `R.layout.filename`
  - `R.java` includes all resource IDs
- Can be edited as xml or using graphical tools

Layouts - Example

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res
/android"
              android:layout_width="match_parent"
              android:layout_height="match_parent"
              android:orientation="vertical" >
    <TextView android:id="@+id/text"
              android:layout_width="wrap_content"
              android:layout_height="wrap_content"
              android:text="Hello, I am a TextView" />
    <Button android:id="@+id/button"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:text="Hello, I am a Button" />
</LinearLayout>
```

```
public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main_activity);
}
```

Drawables

- Resources from `res/drawables/`
- Element that can be drawn on the screen
- Can be images (.png, .jpg, or .gif) or xmls
- xmls describe how an UI element reacts to input (pressed, focused)
- xmls point to images
- Visual feedback for interaction

Outline

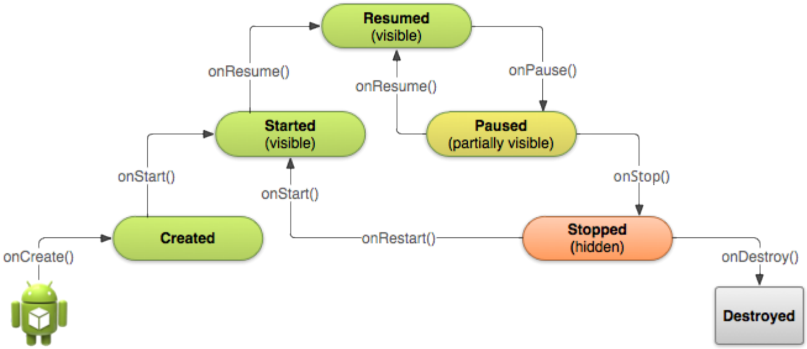
Activity

- Application component
- User interface window, provide user interaction
- Require a layout
- Can only draw and change UI from the Looper thread
  - Computationally intensive or wait based tasks on separate threads
- An application may include multiple activities
  - Only one is the main activity
  - Activities can start each other -> the previous one is stopped
  - Activity stack ("*back stack*")
  - Back -> activity destroyed and previous one resumed

Activity Declaration in Manifest

```
<manifest ... >
  <application ... >
      <activity android:name=".ExampleActivity" />
      ...
  </application ... >
  ...
</manifest >
```

Activity Lifecycle



Source: http://developer.android.com

Activity Lifecycle Callbacks

```
public class ExampleActivity extends Activity {
    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        // The activity is being created.
    }
    @Override
    protected void onStart() {
        super.onStart();
        // The activity is about to become visible.
    }
    @Override
    protected void onResume() {
        super.onResume();
        // The activity has become visible (it is now "resumed").
    }
[...]
```

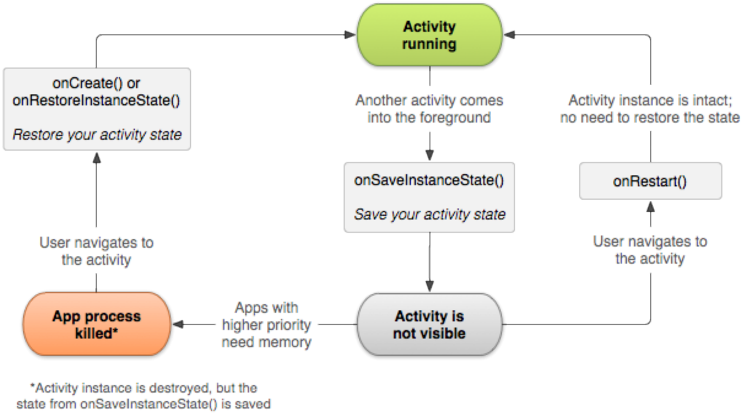
Activity Lifecycle Callbacks (2)

```
[...]
    @Override
    protected void onPause() {
        super.onPause();
        // Another activity is taking focus (this activity is
        // about to be "paused").
    }
    @Override
    protected void onStop() {
        super.onStop();
        // The activity is no longer visible (is now "stopped")
    }
    @Override
    protected void onDestroy() {
        super.onDestroy();
        // The activity is about to be destroyed.
    }
}
```

Activity Lifecycle

- Activities can be killed after `onPause()`, `onStop()` in low memory situations
  - The activity state (objects) are lost
  - Can preserve state by saving objects
  - User interaction can be saved and restored
  - `onSaveInstanceState()` callback
    - Save information in a `Bundle`
  - `onCreate()`, `onRestoreInstanceState()`
    - Restore the activity state
  - Threads can be stopped graciously
    - In `onPause()` threads should be signaled to stop

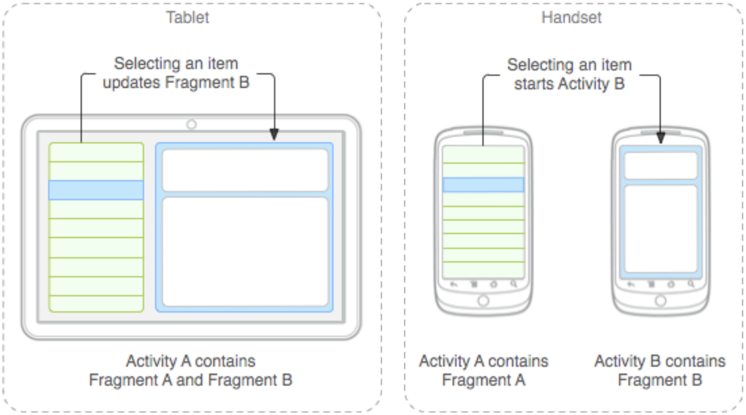
Save Activity State


Activity running
onCreate() or onRestoreInstanceState()
Restore your activity state
Another activity comes into the foreground
onSaveInstanceState()
Save your activity state
Activity instance is intact; no need to restore the state
onRestart()
User navigates to the activity
User navigates to the activity
App process killed*
Apps with higher priority need memory
Activity is not visible
*Activity instance is destroyed, but the state from onSaveInstanceState() is saved

Source: http://developer.android.com

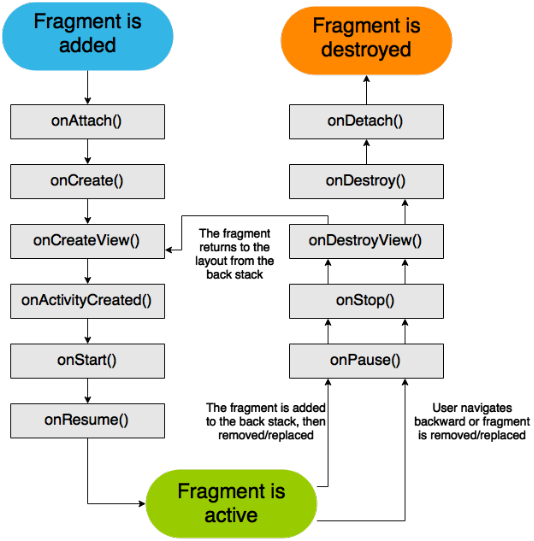
- Represent portions of UI in an Activity
- Can be combined to build a multi-pane UI
  - Same code, different layout for phone / tablet
- Can be reused in multiple Activities

Fragments


Tablet
Selecting an item updates Fragment B
Activity A contains Fragment A and Fragment B
Handset
Selecting an item starts Activity B
Activity A contains Fragment A
Activity B contains Fragment B

Source: http://developer.android.com

Fragment Lifecycle



Source: http://developer.android.com

- UI is a hierarchy of views
- `View`: rectangular space, provides user interaction
- Buttons, Lists, Images, TextViews, EditTexts
- Callbacks for actions
  - `onTouch()`, `onClick()`, `onLongClick()`
- A `ViewGroup` is a container for other Views or ViewGroups
- View / ViewGroup classes can be extended to create complex views
- Adapters allows for more complex data types to be displayed

Outline

Services

- Perform operations in the background
- Do not provide a UI
- Continue to run even if another application is in foreground
- Able to perform network transactions, file I/O operations, interact with content providers, etc.
- Run in the main thread of the hosting process
  - A separate thread should be created if the service performs CPU intensive or blocking operations
- Start using Intents
- Private service

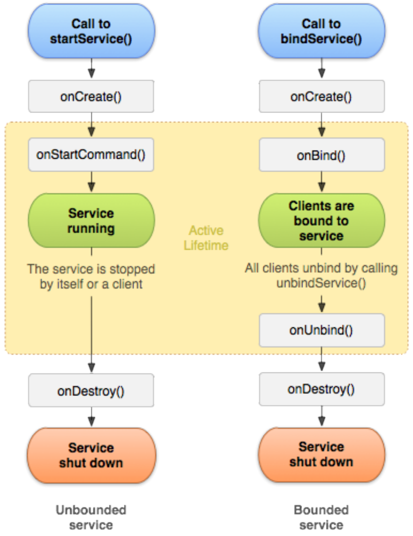
Service Declaration in Manifest

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

Types of services

- Started
  - An application component calls `startService()`
  - Performs a single operation, then stops itself and does not return a result to the caller
  - Runs even if the caller component is destroyed
- Bound
  - An application component binds to it by calling `bindService()`
  - Provides a client-server interface - send requests, return results
  - Runs as long as the application component is bound to it
  - Check for null service
  - Multiple components can bind to a service at once
  - Service destroyed after all components unbind

Service Lifecycle



Source: http://developer.android.com

Service Lifecycle Callbacks

```
public class ExampleService extends Service {
    int mStartMode;           // indicates how to behave
                              // if the service is killed
    IBinder mBinder;          // interface for clients that bind
    boolean mAllowRebind;     // indicates whether onRebind
                              // should be used
    @Override
    public void onCreate() {
        // The service is being created
    }
    @Override
    public int onStartCommand(Intent intent, int flags,
                                                int startId) {
        // The service is starting,
        // due to a call to startService()
        return mStartMode;
    }
[...]
```

Service Lifecycle Callbacks (2)

```
[...]
    @Override
    public IBinder onBind(Intent intent) {
        // A client is binding to the service with bindService()
        return mBinder;
    }
    @Override
    public boolean onUnbind(Intent intent) {
        // All clients have unbound with unbindService()
        return mAllowRebind;
    }
    @Override
    public void onRebind(Intent intent) {
        // A client is binding to the service with bindService(),
        // after onUnbind() has already been called
    }
    @Override
    public void onDestroy() {
        // The service is no longer used and is being destroyed
    }
}
```

Outline

Intent

- An object used for delivering a message
- Includes: target, action and data
- Intent filters
  - Declare the types of intents that a component can receive
  - Specified in the manifest - `<intent-filter>`
  - `<action>`, `<data>`

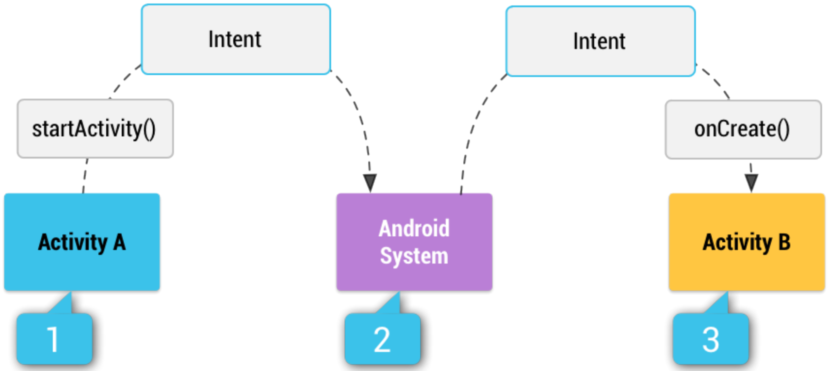
Intents - Use Cases

- Starting an activity
  - Pass Intent to `startActivity()` or `startActivityForResult()`
- Starting or binding a service
  - Pass Intent to `startService()` or `bindService()`
- Delivering a broadcast message
  - Pass Intent to `sendBroadcast()`, `sendOrderedBroadcast()`, or `sendStickyBroadcast()`

Types of Intents

- Explicit intents
  - Specify exactly which component to start (the class name)
  - Typically used to start components in your own app
  - Will be delivered even if there is no intent filter declared
- Implicit intents
  - Do not specify the exact component
  - Declare a general action to be performed
  - The Android system finds the appropriate component
  - Compares the intent to the intent filters in the manifest of the apps
  - Multiple components that match the intent
  - Intent filters are mandatory

Implicit Intents



Source: http://developer.android.com

Implicit Intents - Example

```
// Create the text message with a string
Intent sendIntent = new Intent();
sendIntent.setAction(Intent.ACTION_SEND);
sendIntent.putExtra(Intent.EXTRA_TEXT, textMessage);
sendIntent.setType("text/plain");

// Verify that the intent will resolve to an activity
if (sendIntent.resolveActivity(getPackageManager()) != null) {
    startActivity(sendIntent);
}
```

Intent Filter - Example

```
<activity android:name=".ExampleActivity">
    <intent-filter>
        <action android:name="android.intent.action.SEND" />
        <category android:name="android.intent.category.DEFAULT" /
        <data android:mimeType="text/plain" />
    </intent-filter>
</activity>
```

Outline

Broadcast Receiver

- Responds to system-wide broadcast announcements
- The system generates many broadcasts
  - Example: battery is low, screen has turned off, etc.
- Apps can generate broadcasts - send an announcement for other apps
- No UI, may create a notification in the status bar to alert the user
- The receiver lets other components perform the work based on the event

Broadcast Receiver

- Each broadcast is delivered as an *Intent*
  - Intent passed to `startBroadcast()` or `startOrderedBroadcast()`
- Local broadcasts using *LocalBroadcastManager*
  - More efficient
  - Data does not leave the app
  - Other apps cannot send the broadcast - no security holes
- Register a receiver in two ways
  - Statically in the manifest using the <`receiver`> tag
  - Dynamically using `Context.registerReceiver()`

Types of Broadcasts

- Normal broadcasts
  - Completely Asynchronous
  - All receivers run in an undefined order
  - `sendBroadcast()`
- Ordered broadcasts
  - Delivered to one receiver at a time
  - Each receiver executes and may propagate the result to the next or abort the broadcast
  - The order is determined using the `android:priority` in the `<intent-filter>` of the receiver
  - `sendOrderedBroadcast()`

Broadcast Receiver Declaration in Manifest

```
<manifest ... >
  <uses-permission android:name=
                "android.permission.RECEIVE_BOOT_COMPLETED" />
  <application ... >
    <receiver android:name="ExampleReceiver" >
      <intent-filter>
        <action android:name=
                "android.intent.action.BOOT_COMPLETED" />
      </intent-filter>
    </receiver>
      ...
  </application ... >
   ...
</manifest >
```

Broadcast Receiver Example

```
public class ExampleReceiver extends BroadcastReceiver {
        @Override
        public void onReceive(Context context, Intent intent) {
                Intent intent = new Intent(context,
                                                ExampleService.class);
                context.startService(intent);
        }
}
```

Outline

Content Provider

- Provides access to a repository of data
- System Content Providers
- To access a provider you have to request specific permissions (in the manifest)
  - `<uses-permission android:name="android.permission.READ_USER_DICTIONARY">`
- Two ways of storing data
  - File data - audio, video, photos
  - Structured data - database, array, etc.
    - Form compatible with tables of rows and columns
    - Usually a SQLite database

Content Provider

- Interface for accessing data in one process from another process
  - Provider and client
  - The application that owns the data includes the provider
  - The client application owns the client
- Access data using a *ContentResolver* client object
  - Its methods provide CRUD (create, retrieve, update, delete) functions
  - Calls the methods with the same name in the *ContentProvider* object

Content URIs

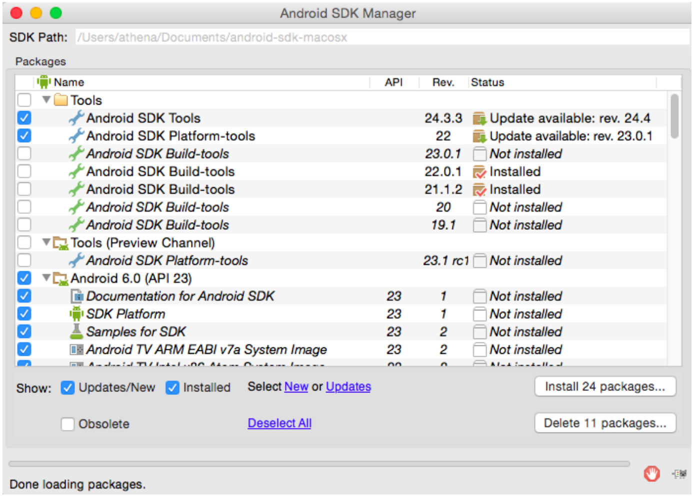
- Identify data in the provider
- Include a symbolic name for the provider (*authority*) and a name for the table (*path*)
  - Example: `content://user_dictionary/words`
  - The *ContentResolver* uses the *authority* for identifying the provider
  - From a system table with all known providers
  - The *ContentResolver* sends a query to the provider
  - The *ContentProvider* uses the *path* to identify the table

Content Provider - Example

```
mCursor = getContentResolver().query(
    UserDictionary.Words.CONTENT_URI,
    mProjection,
    mSelectionClause,
    mSelectionArgs,
    mSortOrder);
[...]
mNewUri = getContentResolver().insert(
    UserDictionary.Word.CONTENT_URI,
    mNewValues);
[...]
mRowsUpdated = getContentResolver().update(
    UserDictionary.Words.CONTENT_URI,
    mUpdateValues,
    mSelectionClause,
    mSelectionArgs);
```

Outline

- Android SDK Manager
  - Download SDK packages, samples, emulator images, tools



Android SDK Manager

SDK Path: /Users/athena/Documents/android-sdk-macosx

Packages

	Name	API	Rev.	Status
☐	Tools			
✓	Android SDK Tools		24.3.3	Update available: rev. 24.4
✓	Android SDK Platform-tools		22	Update available: rev. 23.0.1
☐	*Android SDK Build-tools*		*23.0.1*	*Not installed*
☐	Android SDK Build-tools		22.0.1	Installed
☐	Android SDK Build-tools		21.1.2	Installed
☐	*Android SDK Build-tools*		*20*	*Not installed*
☐	*Android SDK Build-tools*		*19.1*	*Not installed*
☐	Tools (Preview Channel)			
☐	*Android SDK Platform-tools*		*23.1 rc1*	*Not installed*
✓	Android 6.0 (API 23)			
✓	*Documentation for Android SDK*	*23*	*1*	*Not installed*
✓	*SDK Platform*	*23*	*1*	*Not installed*
✓	*Samples for SDK*	*23*	*2*	*Not installed*
✓	*Android TV ARM EABI v7a System Image*	*23*	*2*	*Not installed*

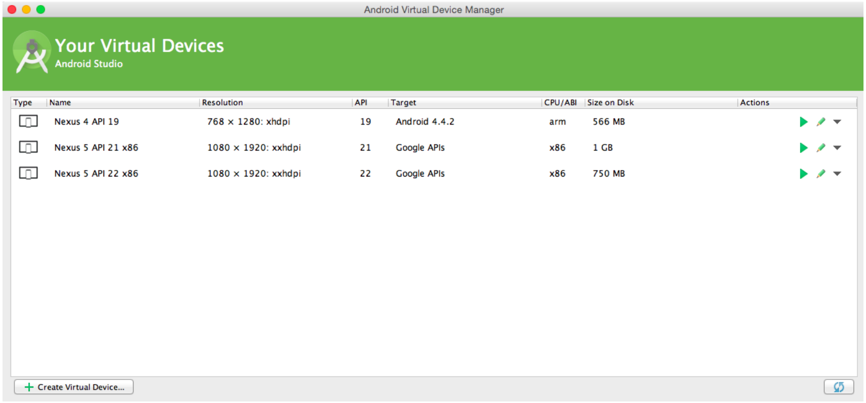
Show: [✓ Updates/New] [✓ Installed] Select New or Updates — Install 24 packages...

☐ Obsolete — Deselect All — Delete 11 packages...

Done loading packages.

AVD Manager

- AVD Manager
  - Manages Android Virtual Devices (for emulator)
- Emulator
  - Virtual mobile devices running on a PC



Type	Name	Resolution	API	Target	CPU/ABI	Size on Disk	Actions
	Nexus 4 API 19	768 × 1280: xhdpi	19	Android 4.4.2	arm	566 MB	
	Nexus 5 API 21 x86	1080 × 1920: xxhdpi	21	Google APIs	x86	1 GB	
	Nexus 5 API 22 x86	1080 × 1920: xxhdpi	22	Google APIs	x86	750 MB	

SDK Tools

- Dalvik Debug Monitor Server (`ddms`)
  - Debugging tool
  - Port forwarding, screen capture, call and SMS spoofing, location spoofing, etc.
- Android Debug Bridge (`adb`)
  - Communication between the development tools and (virtual) device
- `dx`
  - Generates the `classes.dex` file from several `.class` files

SDK Tools

- Android Interface Definition Language (`aidl`)
  - To allow clients from another application to access your service
  - Generates interfaces and stubs that are used by the Binder
- Android Asset Packaging Tool (`aapt`)
  - Create, update and view Zip-compatible archives (zip, apk, jar)
  - Compile resources into binary assets (XML files, etc.)
- `dexdump`
  - Disassembler tool
  - Obtain the Dalvik bytecode from `classes.dex`

Android Debug Bridge

- Three components
  - Client: runs on the development machine
  - Server: background process on the development machine
  - Daemon: background process on the (virtual) device
- Copy files
- Install applications
- Debug
- Shell on the (virtual) device

Emulator

- QEMU
- Screen, Keyboard, Network, Audio, GPS, Radio
- Can be accelerated through virtualization
  - x86 System Image
  - Intel Hardware Accelerated Execution Manager (HAXM) on Windows
  - KVM on Linux
- GPU accelerated

- http://developer.android.com/guide/topics/manifest/manifest-intro.html
- http://developer.android.com/guide/topics/resources/overview.html
- http://developer.android.com/guide/components/activities.html
- http://developer.android.com/guide/components/services.html
- http://developer.android.com/guide/topics/providers/content-providers.html
- http://developer.android.com/guide/components/intents-filters.html
- http://developer.android.com/tools/help/index.html

Keywords

- Manifest file
- Permissions
- Resources
- Layouts
- Drawables
- Activity
- Service
- Intent
- Broadcast Receiver
- Content Provider
- Content URI
- Tools