EMBEDDED SYSTEMS PROGRAMMING 2016-17

Application Basics

APPLICATIONS

- Application components (e.g., UI elements) are **objects** instantiated from the platform's frameworks

- Applications are **event driven**
  (⇒there are callbacks, delegates, notifications...)

- Many use **design patterns**
  (e.g., delegation, model-view-controller, ...)

APPLICATIONS AND IDES

Integrated Development Environments (**IDEs**) simplify application development by

- automatically setting up a default application environment and creating skeleton code every time a new application component is added,
- allowing the programmer to design the UI in a graphical way,
- pointing out errors and bad practices in the source code,
- simplifying the refactoring process

Nonetheless, a lot of details must be managed by hand

APPLICATION RESOURCES

- **Resources**: non-code files that are part of an application
  - Images, sounds, videos
  - The application icon
  - The application preferences
  - And more

EMBEDDED APPS (1/2)

Mobile apps behave differently from PC applications

- Only **one app is visible at a time** to interact with the user. The operating system manages the switch from one application to another
- The visible app has **no windows**
- **Apps not interacting with the user are scheduled differently**

EMBEDDED APPS (2/2)

- The operating system may decide to **terminate apps not interacting with the user** so as to free up resources

- The **lifecycle** of apps is **optimized for the embedded setting**

- **No page file**

ANDROID: USER VS. SYSTEM

- **System apps do not use special APIs**: they have to go through the same public APIs available to user-developed applications

- Android can be told to make **your application replace a standard application**. For instance, a user-programmed keyboard may replace the system-provided keyboard

- This open, modular design is unique to Android

ANDROID: ADDING USER APPS

- Adding applications is done through Android **APK** (.apk) **packages**.

  An APK package is a binary archive containing compiled bytecode, non-compiled resources such as images, and other informations for installing the application

- Every APK should be digitally signed. However, it is not mandatory that the signature is validated by a CA

THE BUILD PROCESS (1/2)

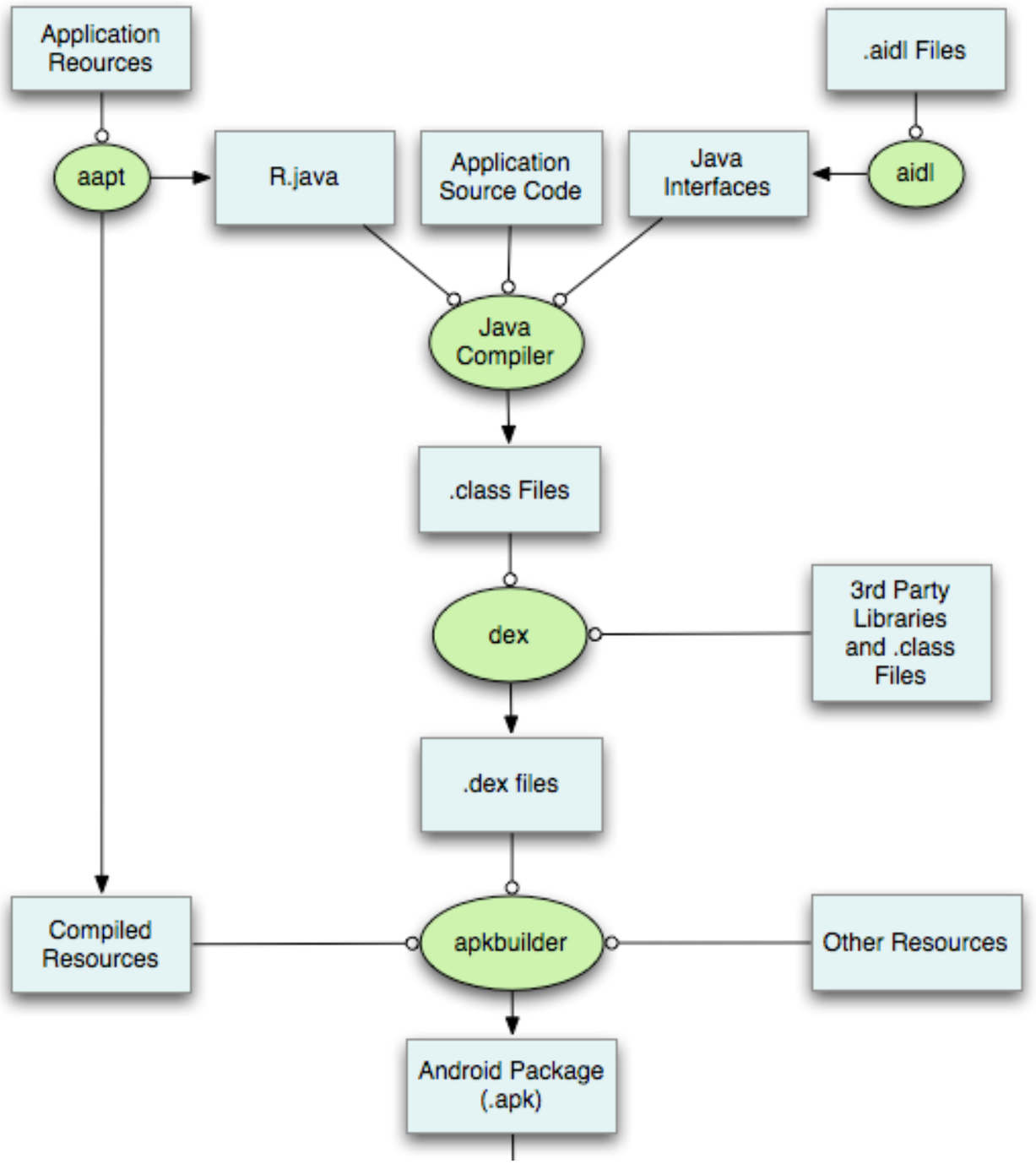


Image from developer.android.com

THE BUILD PROCESS (2/2)

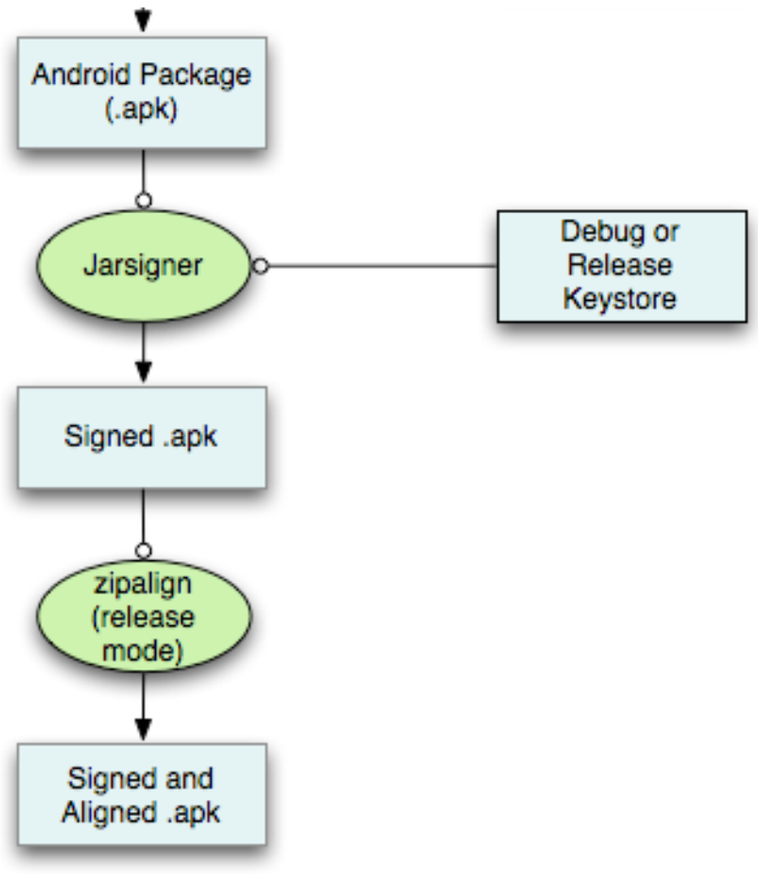


Image from developer.android.com

ANDROID: APP TYPES

- **Applications**: take over the whole screen*.
  Example: Android's standard web browser

- **Widgets**: take a small, fixed portion of the home screen. Example: Android's standard clock.
  (Note: *UI widgets* are a different thing!)

* Android 7.0 introduced support for displaying multiple apps at the same time

APPLICATION ISOLATION

- Each application runs in **its own Linux process** with **its own user ID**.
  The Linux OS ensures that applications cannot access privileged OS components or hamper one another's memory and data

- Each application runs in **its own copy of the VM**.
  Malfunctions cannot propagate from one application to another

- Applications communicate through content providers

APP COMPONENTS

- **Activity**: a single screen with a user interface
- **Service**: performs (in the *background*) long-running operations (e.g., music playback). No user interface
- **Content provider**: encapsulates data that needs to be shared between applications. No user interface
- **Broadcast receiver**: responds to system-wide broadcast events (e.g., “battery low!”). No user interface

- Four classes are available, one for each type of component

ABOUT COMPONENTS

- An application is a mixture of components, each with a **distinct lifecycle**

- Any application can ask Android to start another application's component (e.g., the "take a shot" activity of the camera application)

- No "first" component, no application entry point (although a "main activity" exists)

INTENTS

- Activities, services and broadcast receivers are activated by **intents**

- **Intent: asynchronous message that requests an action**

- An intent may **request** a specific component or **just a type of component**: in the latter case, it is the system's task to bind the intent to an available component that performs the required action

ACTIVITIES VS. APPLICATIONS

- **Activity: a single, focused thing that the user can do**
- Example: an activity to edit a text-only note
- **Application: contains activities** (and other components)
- Example: a notepad application has an activity to edit a note and another activity to manage a list of notes

ACTIVITY LIFECYCLE (1/2)

An activity passes through the following states.

- **Active** (aka running): visible, receiving user input
- **Paused**: partially visible, not receiving user input (e.g., an alert dialog is above it)
- **Stopped**: not visible
- **Destroyed**: removed from memory by Android

Callback methods allow an activity to perform actions on state transitions

ACTIVITY LIFECYCLE (2/2)

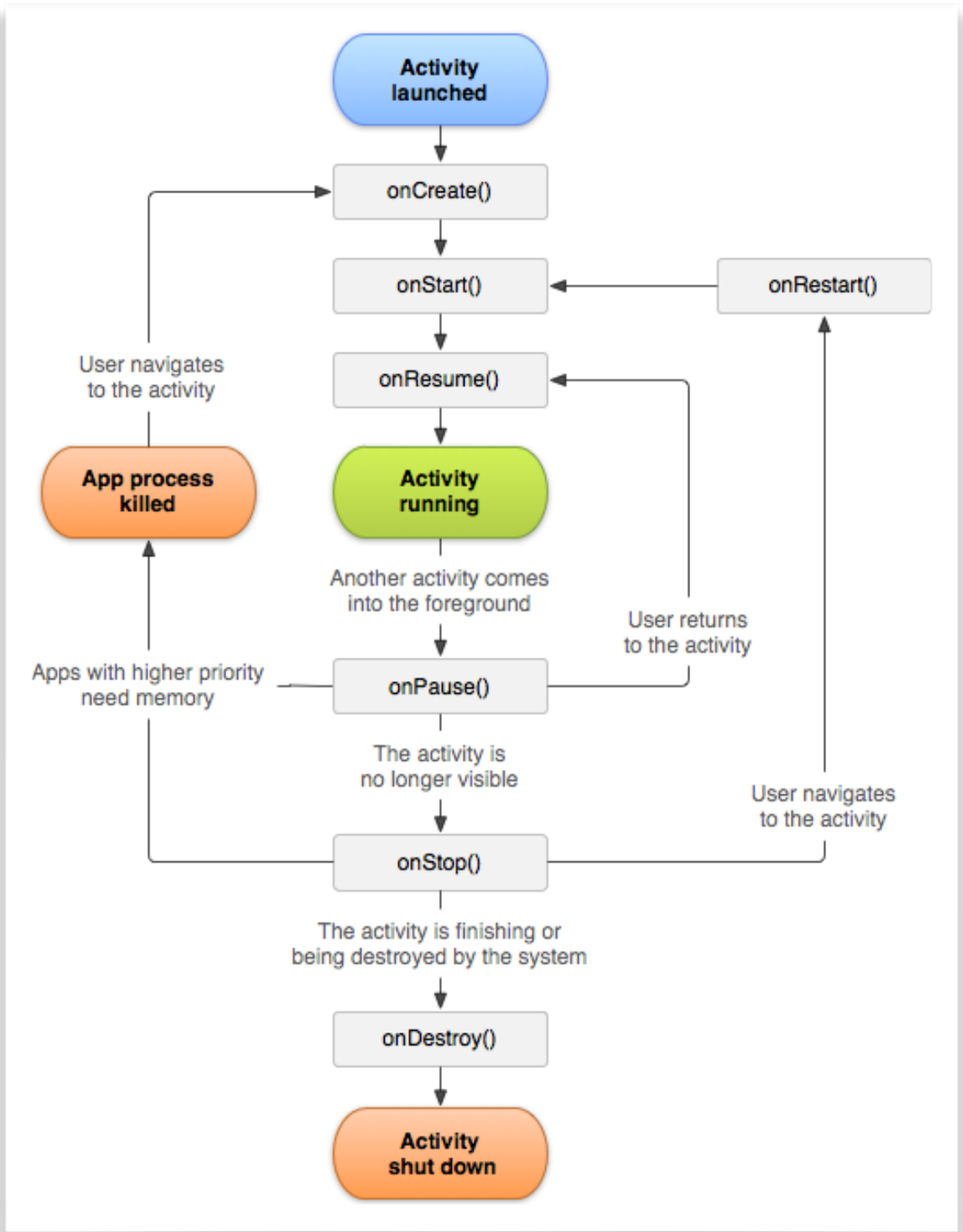


Image from developer.android.com

State transitions are a consequence of **user** or **system** decisions.

An activity cannot avoid state transitions: it can only manage them by undertaking appropriate actions

CALLBACK METHODS

- **`onCreate()`**
  Called when the activity is first created
- **`onStart()`**
  Called when the activity is becoming visible to the user
- **`onResume()`**
  Called when the activity will start interacting with the user
- **`onPause()`**
  Called when the system is about to start resuming a previous activity
- **`onStop()`**
  Called when the activity is no longer visible to the user
- **`onRestart()`**
  Called after the activity has been stopped, prior to it being started again
- **`onDestroy()`**
  Last method to be called before the activity is destroyed

APPLICATION TERMINATION

- Any activity that is not running may be terminated by Android **at any time** to free up resources

- **The `onStop()` and `onDestroy()` methods are not guaranteed to be called: only `onPause()` is**

Morale: save your state
every time your activity is paused

ORIENTATION CHANGE

Any change between portrait and landscape mode will cause an activity to be

- **paused**, then
- **stopped**, then
- **destroyed**,

then a new instance of the activity will be created

Once again: **save your state**
every time your activity is **paused**

BACK STACK

- Android's Activity Manager arranges activities in a stack (the **back stack**) according to the order in which they were opened

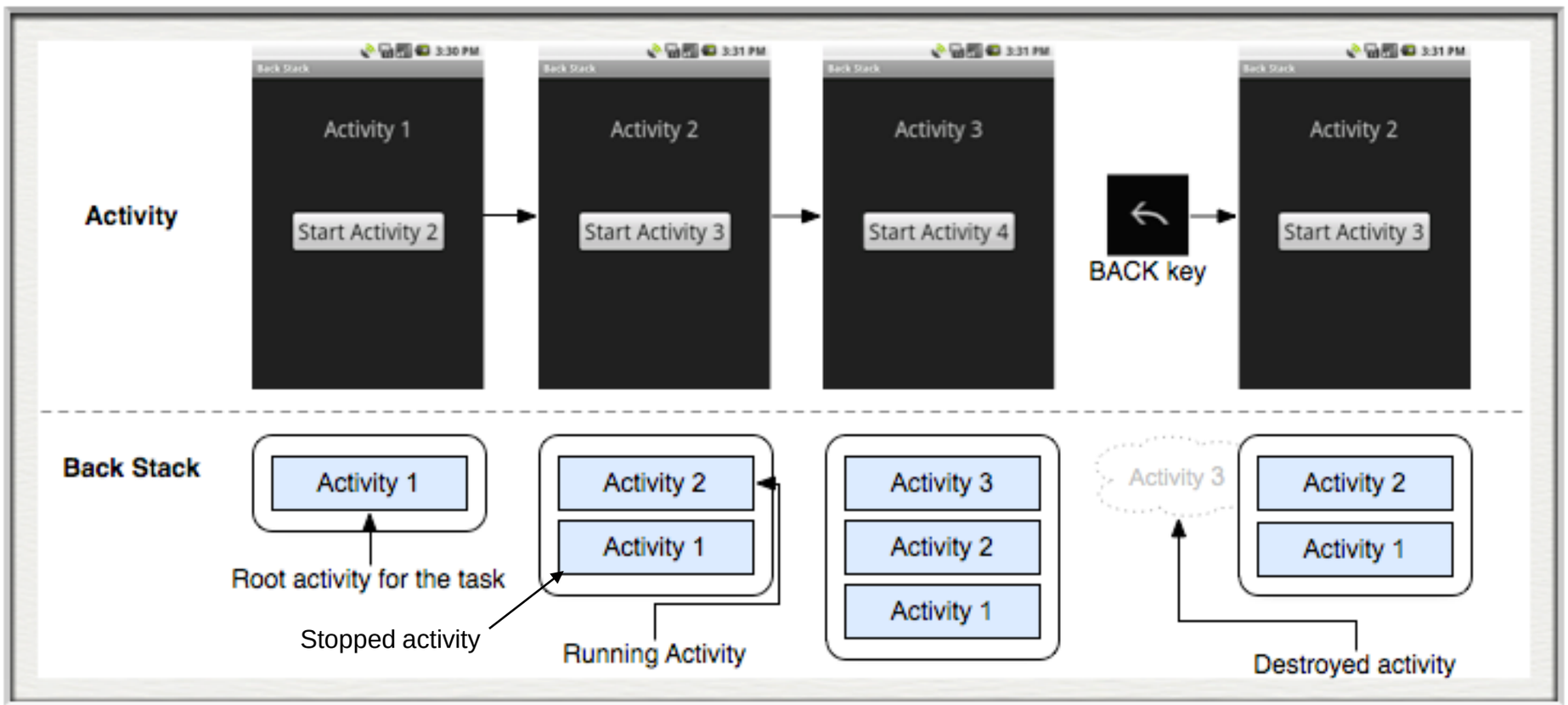


Image from developer.android.com

TASKS

- **Task**: set of related activities
  (i.e., the first activity in the task called all the others)

- A task is moved to the background as a whole -- and all its activities stopped -- if the user starts a new, unrelated task (e.g., by tapping the "Home" button and launching a new application)

- Different instances of the same activity can be present in different tasks

THE MANIFEST FILE

The **manifest** (AndroidManifest.xml) of an application

- declares the components of the app
- declares hardware (e.g., specific displays) and software features (e.g., additional API libraries) required by the app
- lists any user permissions required by the app

THE BUILD.GRADLE FILE

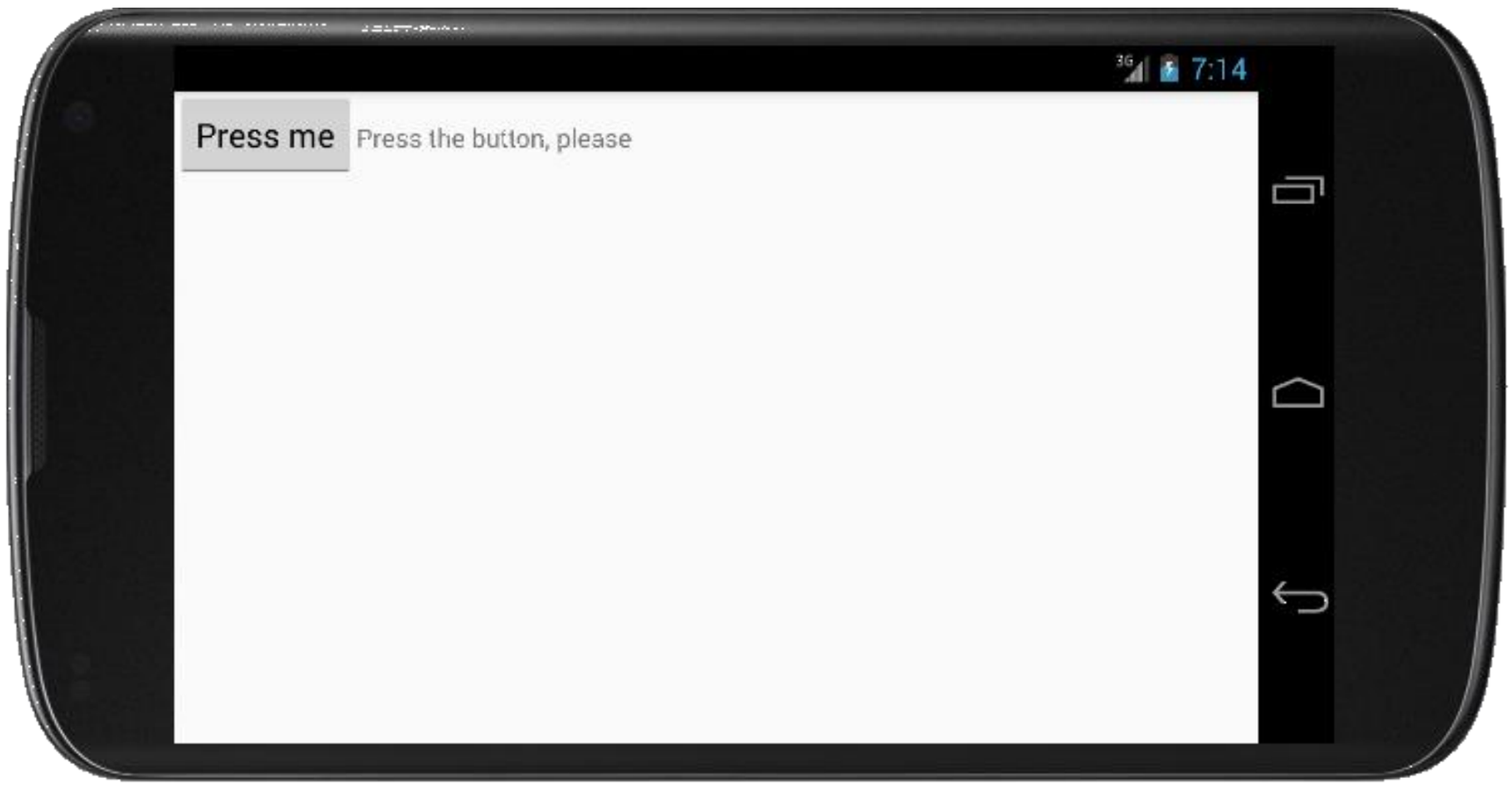
- Not part of the APK package
- Contains information about the tools, and the Android version, required to build and run the app

```
android {
    compileSdkVersion 23
    buildToolsVersion "23.0.2"

    defaultConfig {
        applicationId "it.unipd.dei.esp1516.hellowithbutton"
        minSdkVersion 15
        targetSdkVersion 23
        versionCode 1
        versionName "1.0"
    }
    buildTypes {
        release {
            minifyEnabled false
            proguardFiles getDefaultProguardFile('proguard-android.txt'), 'proguard-rules.pro'
        }
    }
}
```

THE FIRST ANDROID APP

- The application shows a button and a string of text
- When the button is pressed, the text changes



APPLICATION CLASSES

- **`View`**: base class for user interface components (both widgets and layouts)

- **`ViewGroup`**: base class for layouts and views containers. Extends `View`

- **`Activity`**: base class for activities

- **`LinearLayout`**: arranges its children in a single row (default) or column. Extends `ViewGroup`

- **`Button`**, **`TextView`**: UI widgets. Extend `View`

HELLOWITHBUTTON.JAVA (1/2)

```
package it.unipd.dei.esp1516.hellowithbutton;

import android.os.Bundle;
import android.app.Activity;
import android.view.View;
import android.widget.TextView;
import android.widget.Button;
import android.widget.LinearLayout;

public class HelloWithButton extends Activity
{
    /** Called when the activity is first created. */
    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);

        // Create the TextView
        final TextView tv = new TextView(this);
        tv.setText("Press the button, please");

        // Create the Button
        Button bu = new Button(this);
        bu.setText("Press me");
…
```

HELLOWITHBUTTON.JAVA (2/2)

```
…
        // Set the action to be performed when the button is pressed
        bu.setOnClickListener(new View.OnClickListener() {
            public void onClick(View v) {
                // Perform action on click
                tv.setText("Good job!");
            }
        });

        // Create the layout
        LinearLayout myLayout = new LinearLayout(this);

        // Add the UI elements to the layout
        myLayout.addView(bu);
        myLayout.addView(tv);

        // Display the layout
        setContentView(myLayout);
    }
}
```

STRINGS.XML

- Automatically generated by Android Studio when the app module is created in the project

```
<resources>
    <string name="app_name">HelloWithButton</string>
</resources>
```

ANDROIDMANIFEST.XML

- Automatically generated from properties that the programmer specifies via Android Studio

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    package="it.unipd.dei.esp1516.hellowithbutton">

    <application
        android:allowBackup="false"
        android:icon="@mipmap/ic_launcher"
        android:label="@string/app_name"
        android:supportsRtl="true"
        android:theme="@style/AppTheme"
        tools:ignore="GoogleAppIndexingWarning">
        <activity android:name=".HelloWithButton">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
    </application>

</manifest>
```

APP'S BUILD.GRADLE

- Automatically generated from properties that the programmer specifies via Android Studio

```
apply plugin: 'com.android.application'

android {
    compileSdkVersion 23
    buildToolsVersion "23.0.2"

    defaultConfig {
        applicationId "it.unipd.dei.esp1516.hellowithbutton"
        minSdkVersion 15
        targetSdkVersion 23
        versionCode 1
        versionName "1.0"
    }
    buildTypes {
        release {
            minifyEnabled false
            proguardFiles getDefaultProguardFile('proguard-android.txt'), 'proguard-rules.pro'
        }
    }
}

dependencies {
    compile fileTree(dir: 'libs', include: ['*.jar'])
    testCompile 'junit:junit:4.12'
    compile 'com.android.support:appcompat-v7:23.1.1'
}
```

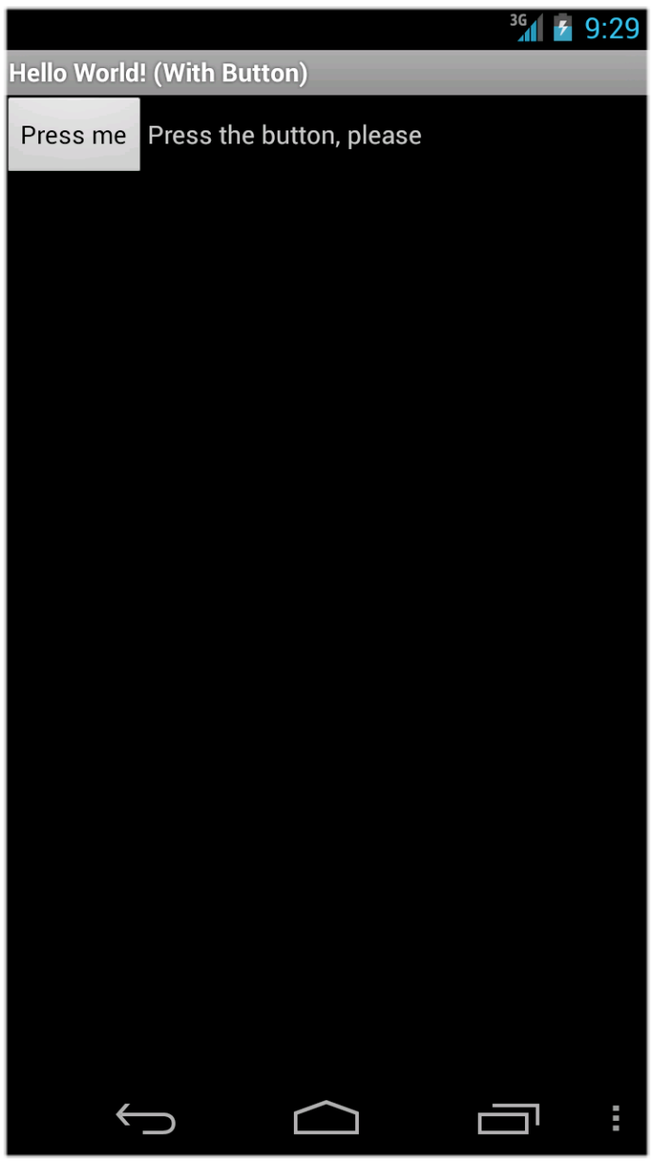
SDK VERSION

- **`minSdkVersion`** (integer)
  Minimum API Level required for the app to run.
  If not properly set, the app will crash at runtime as soon as it accesses an unsupported API

- **`targetSdkVersion`** (integer)
  API level against whom the app has been tested. The app is still able to run on lower API levels, down to `minSdkVersion`.
  If not set, it is assumed equal to `minSdkVersion`.

- **`maxSdkVersion`** (integer)
  Maximum API Level on which the app can run.
  Declaring this attribute is not recommended: new versions of Android are designed to be backward-compatible

<USES-SDK>: EXAMPLE



`targetSdkVersion`=8,
Android 4.2.2 (API Level 17)

`targetSdkVersion`=17,
Android 4.2.2 (API Level 17)

API LEVEL

- The **API Level** is an integer that identifies the set of APIs supported by a given version of Android
- Examples:
  - Android 2.2 ↔ API Level 8
  - Android 2.3 ↔ API Level 9
  - Android 2.3.3, 2.3.4, ... ↔ API Level 10
  - Android 4.0.3, 4.0.4 ↔ API Level 15
- To sum things up, each Android release is identified by a Platform Version (e.g., 2.2), an API Level (e.g., 8) and a Version Code (e.g., “Froyo”)

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