Introduction to Android

Ambient intelligence

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Politecnico di Torino, 2018/2019

Some slides and figures are taken from the
Mobile Application Development (MAD) course

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Disclaimer

- This is only a quick introduction:
  - It is not complete (only scrapes the surface)
  - Only superficial notions are provided

It is a **guide** to **self-learning** and **self-documentation**

ONLINE DOCUMENTATION:
https://developer.android.com/guide/

Summary

- Short history
- Platform
- Application Fundamentals
- Application Lifecycle
- Tools

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ANDROID HISTORY

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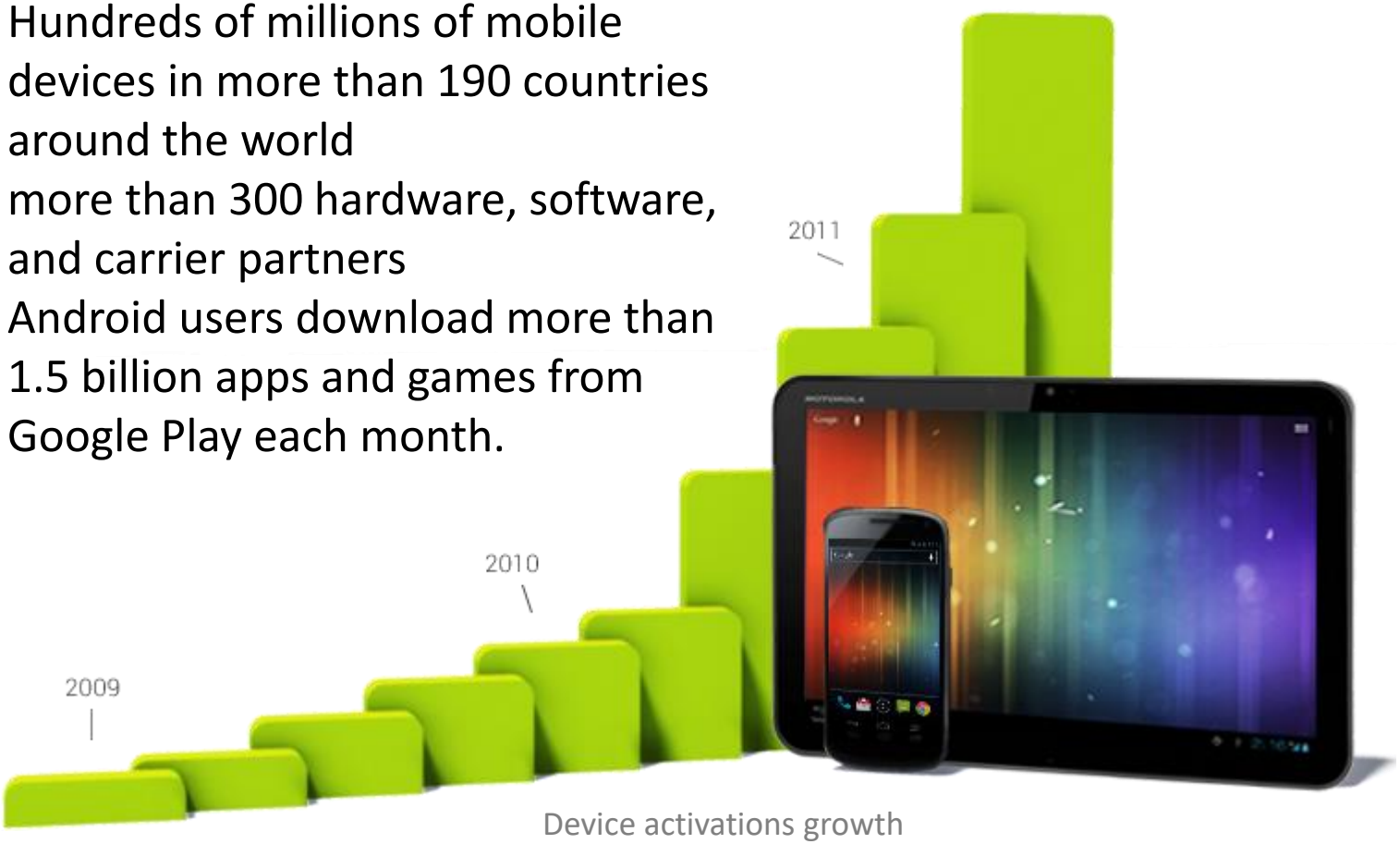
History

- Originally created by Andy Rubin
- Acquired by Google Inc. in 2005
- Now it is maintained by the Open Handset Alliance (OHA) (since 2007)
- Several stable releases since then

Market share

- Hundreds of millions of mobile devices in more than 190 countries around the world
- more than 300 hardware, software, and carrier partners
- Android users download more than 1.5 billion apps and games from Google Play each month.



Device activations growth

Versions

Version	Codename	API	Distribution
2.3.3 - 2.3.7	Gingerbread	10	0.3%
4.0.3 - 4.0.4	Ice Cream Sandwich	15	0.3%
4.1.x	Jelly Bean	16	1.2%
4.2.x		17	1.5%
4.3		18	0.5%
4.4	KitKat	19	6.9%
5.0	Lollipop	21	3.0%
5.1		22	11.5%
6.0	Marshmallow	23	16.9%
7.0	Nougat	24	11.4%
7.1		25	7.8%
8.0	Oreo	26	12.9%
8.1		27	15.4%
9	Pie	28	10.4%

https://developer.android.com/about/dashboards/index.html

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THE ANDROID PLATFORM

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Android Platform

- Android is “an open source software stack for a wide range of mobile devices and a corresponding open source project led by Google.”[1]
- It is composed of:
  - an operating system
  - a software platform for creating apps and games

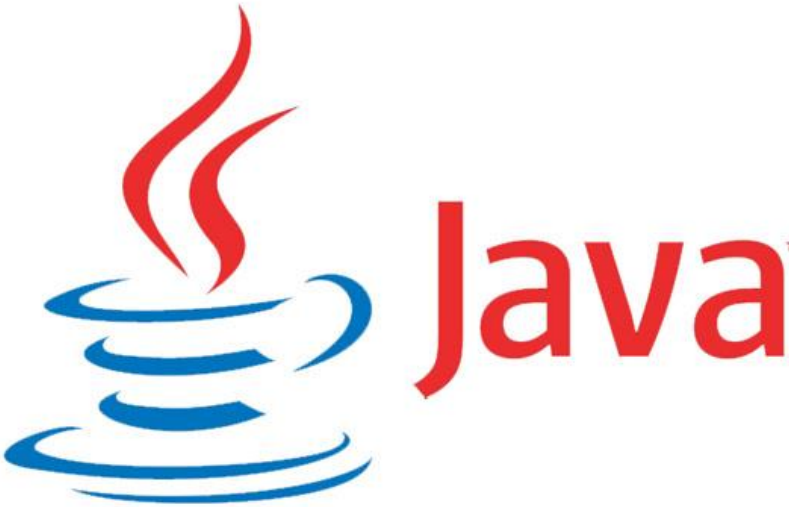
[1] *https://source.android.com/*

Android Platform

- Development Tools are free:
  - Android applications are (mostly) written in Java programming language (6 or higher)
  - Alternatively, a C++ API is available
- There is no distinction between native and third-party applications
  - All the applications use the same Software Development Kit (SDK)
  - All the applications can access the underlying hardware

Java

- General-purpose computer-programming language
  - Concurrent
  - Class-based
  - Object-oriented
  - Portable



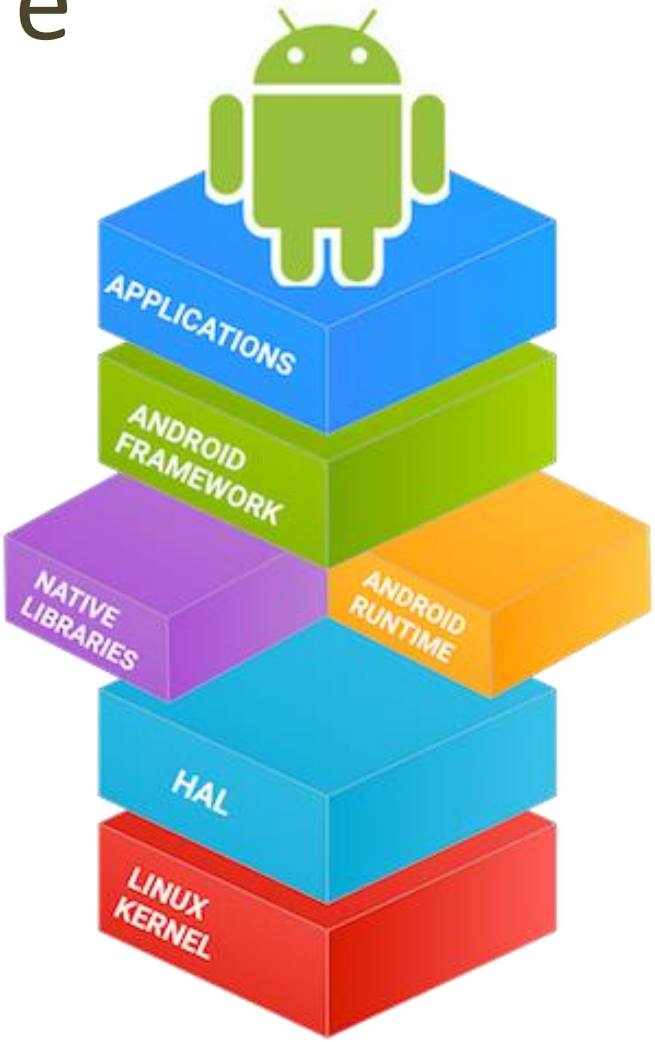
Java

- Java applications are typically compiled to bytecode that can run on any Java virtual machine (**JVM**) regardless of computer architecture
- Java bytecode instructions are analogous to machine code, but they are intended to be executed by a virtual machine (**VM**) written specifically for the host hardware.

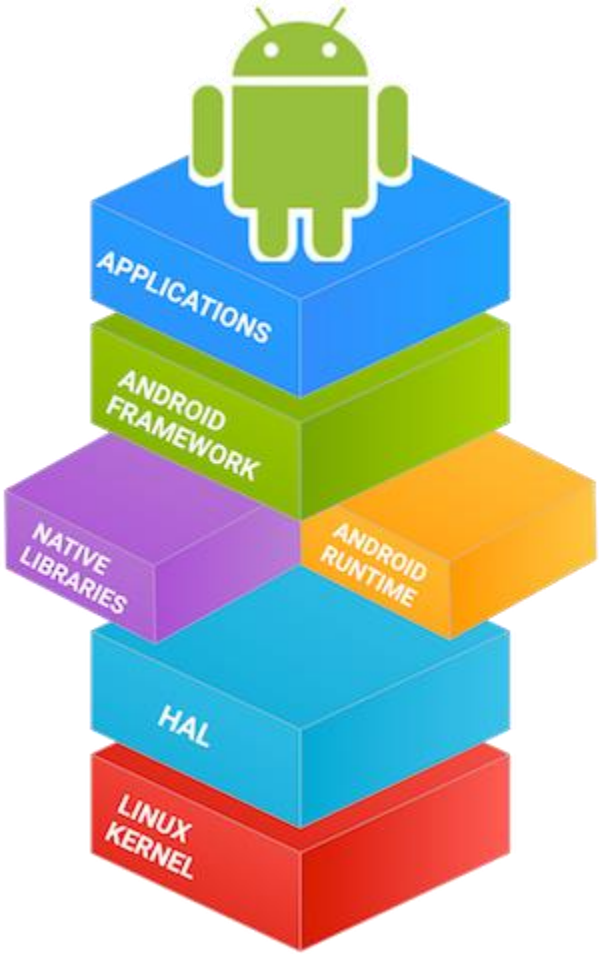
Android Architecture

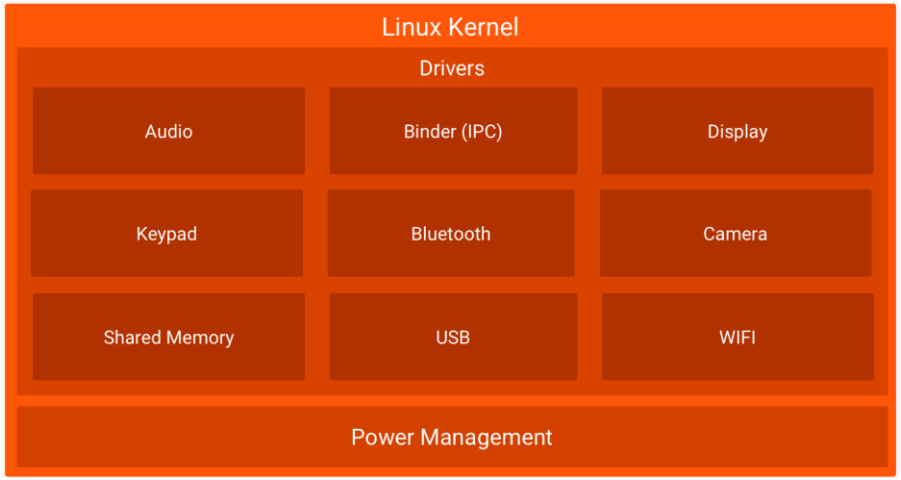
- Android is composed of an operating system and a software platform for creating apps and games
  - Android includes a set of minimal applications (browser, email client)
    - These basic features can be easily included in other applications
- Android has been designed to be robust
  - It is based on the Linux Operating System Kernel
  - Every Android application runs in its own process, with its own instance of the virtual machine

Architecture



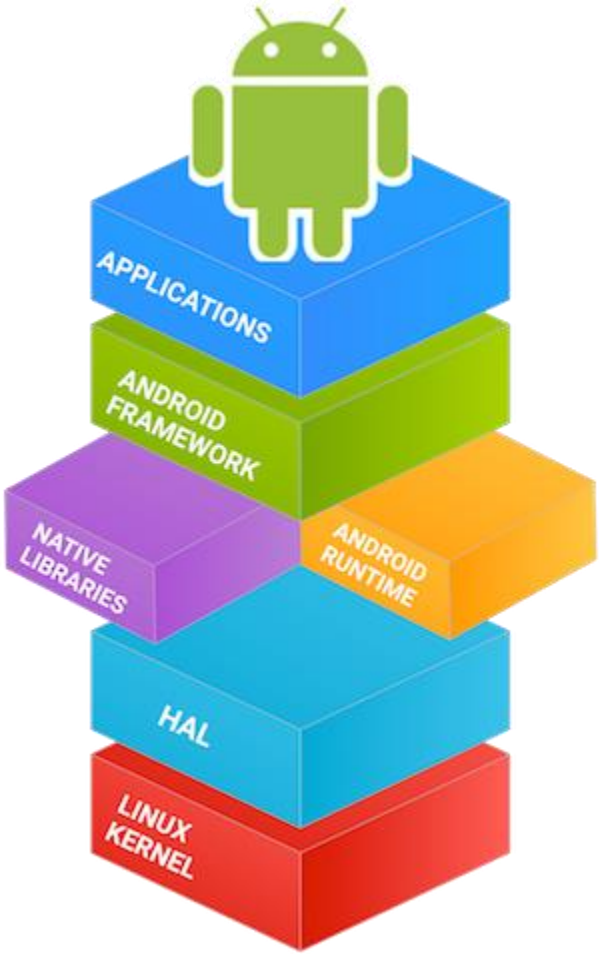
Architecture

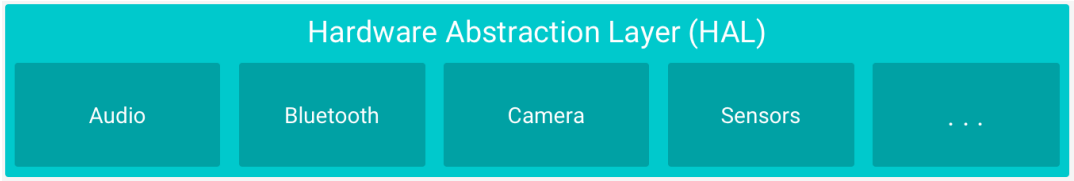




- Android is based on the Linux Kernel:
  - takes advantage of the Linux Kernel key security features
  - allows device manufacturers to develop hardware drivers for a well-known kernel

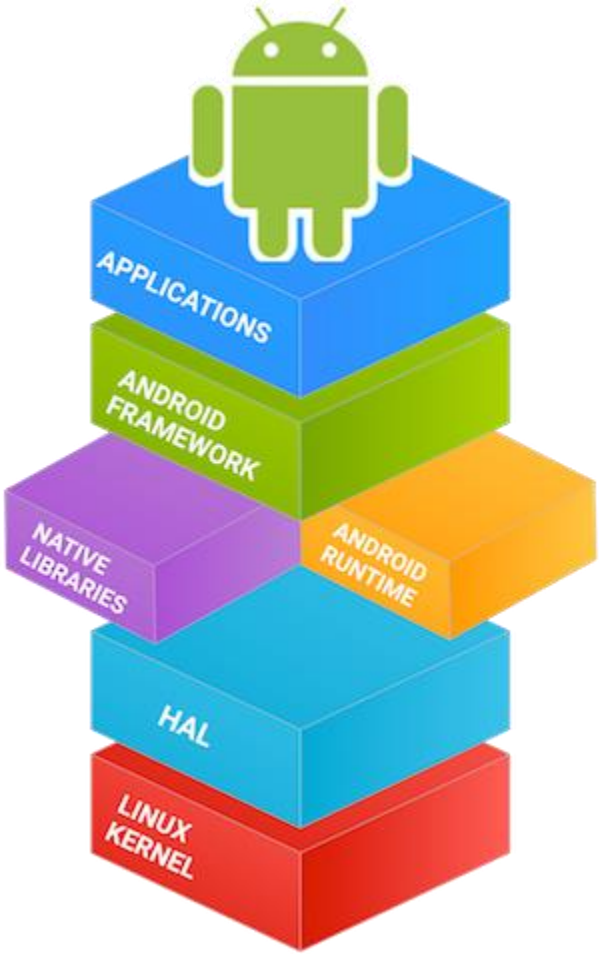
Architecture

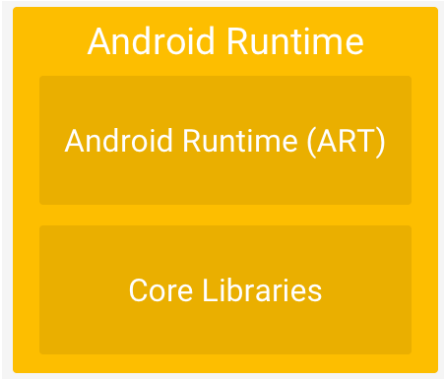




- Provides standard interfaces that expose device hardware capabilities to the higher-level Java API framework.
- It consists of multiple library modules that implement interfaces for specific type of hardware components (e.g., camera, Bluetooth …)

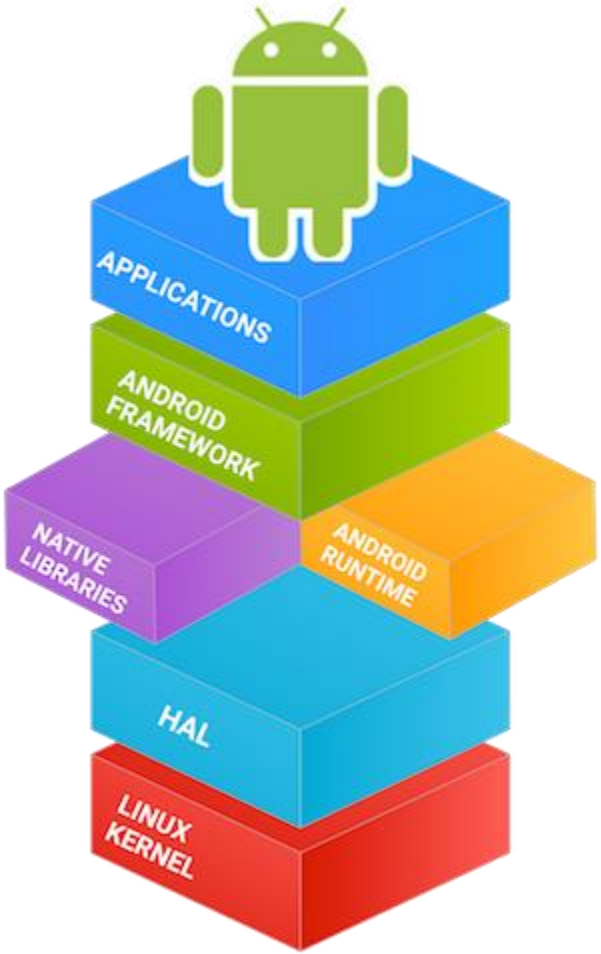
Architecture

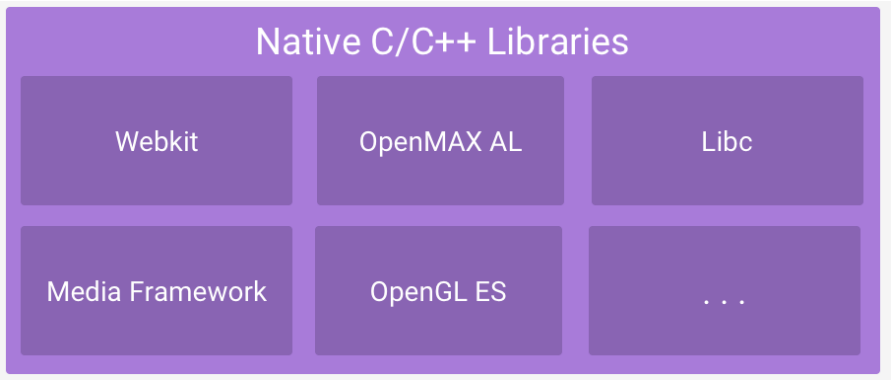




- ART is an application runtime environment (prior to Android 5.0, Dalvik used instead of ART)
- It is written to run multiple virtual machines, one for each running application
- Each app runs in its own process within its own instance of the Android Runtime (ART)

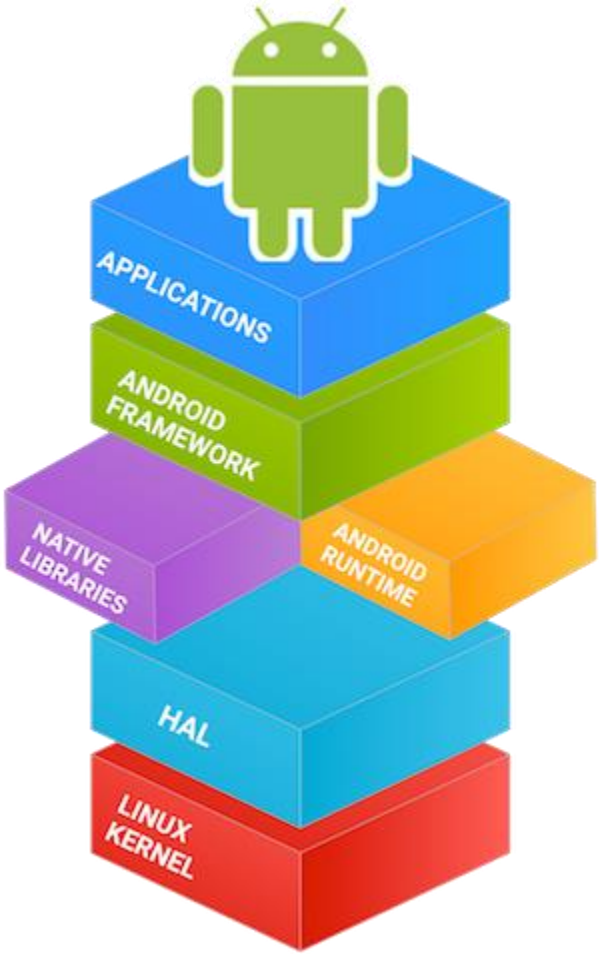
Architecture

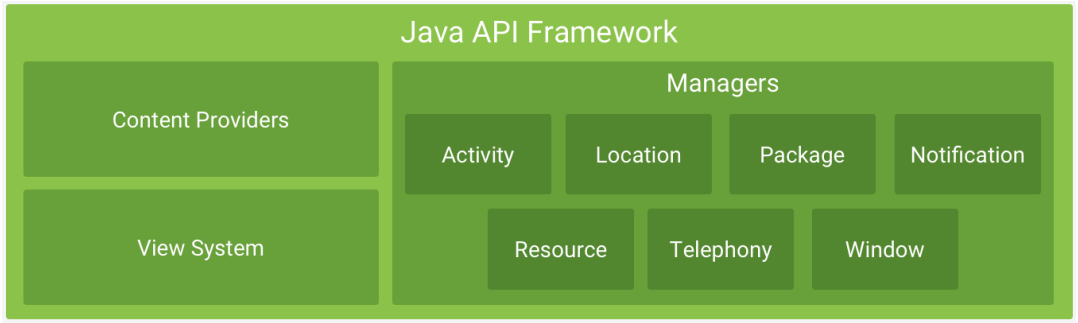




- Many core Android system components and services, (e.g., ART and HAL), are built from native code that require native libraries written in C and C++
- If you want to develop your app using C or C++, you can use the Android NDK

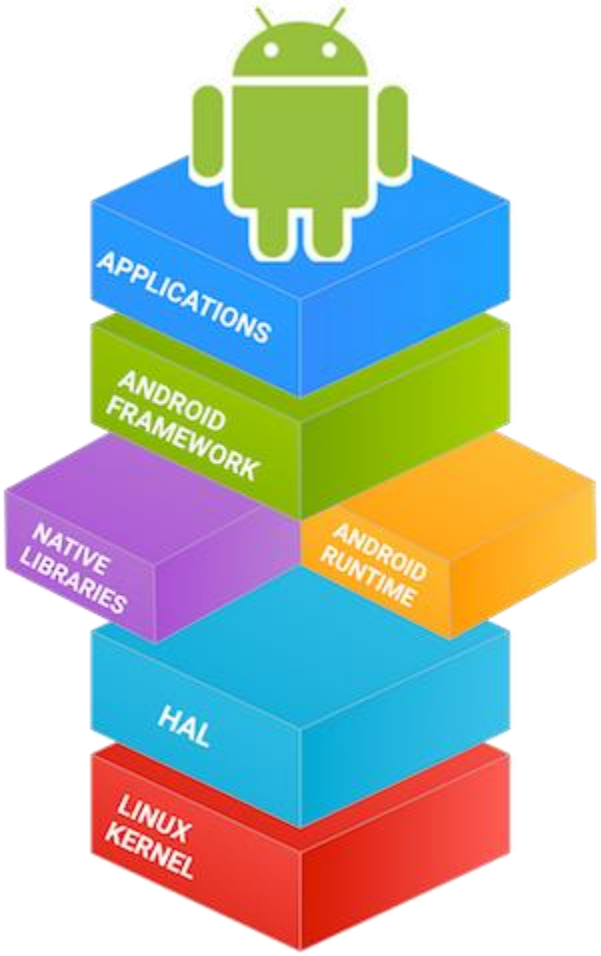
Architecture

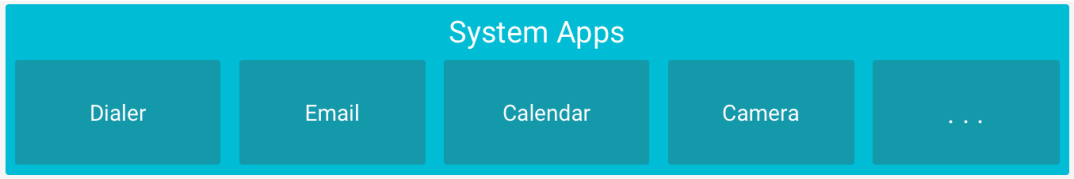




- The entire feature-set of the Android OS is available through Java APIs
- These APIs form the building blocks needed to create Android apps

Architecture





- Android comes with a set of core apps
- Android doesn't make any distinction between native and third-party applications

Security

- Every application runs with its own user
  - Once the application is installed, the operating system creates a new user profile associated with it
  - Filesystem permissions ensure that one user cannot alter or read another user's files
- Every application must declare which shared resources will use
  - For example, making phone calls, using the camera or other sensors
  - Android will block applications which try to use not declared resources
- Every application also requires the permission to access the user's private data
  - Such as preferences, user location, user contacts, …
  - If the permission is not granted, the installation fails

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APPLICATION FUNDAMENTALS

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- The Android SDK exposes a set of APIs, which allows the access to the underlying hardware
  - No distinction between "native applications" and "third-party applications"
  - Every application, if equipped with the appropriate permissions, can use them
- Android includes a set of minimal applications such as a browser, and an email client
  - Third-party provided applications can integrate, extend or even replace them
- The main programming language is Java
  - But it is possible to develop applications using C++, as well

Application Structure

- Conceptually, an application consists of a set of data and code designed to perform a given set of tasks

- Android applications do not have a single entry point, as it happens in other operating systems
  - Each application consists of one or more components, activated by the operating system, at its own will

Application Structure

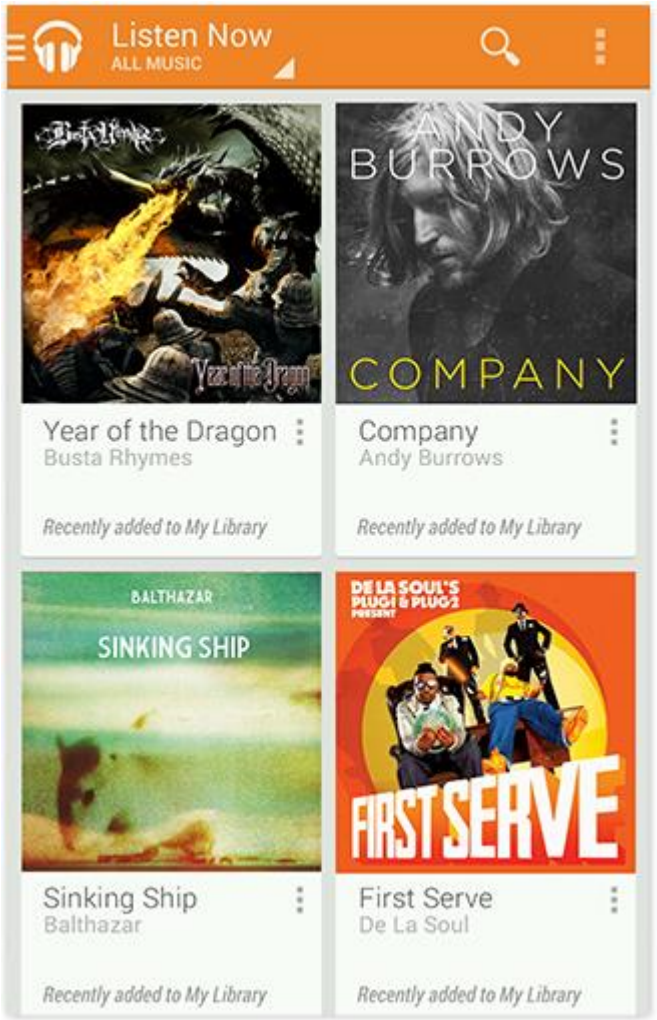
- Each component takes care of a specific interaction with the operating system and/or the user
  - Component creation, operation, and destruction follow a well defined life-cycle

Application Structure

- Each application consists of one or more of the following components:
  - Activity
  - Service
  - Content Provider
  - Broadcast Receiver

Activity

- An activity is a software component that:
  - Has a Graphical User Interface
  - Can perform a task inside the application
- An application is composed by one or more activities. An email app might have the following activities
  - one that shows a list of new emails;
  - one to compose an email;
  - one for reading emails.



Service

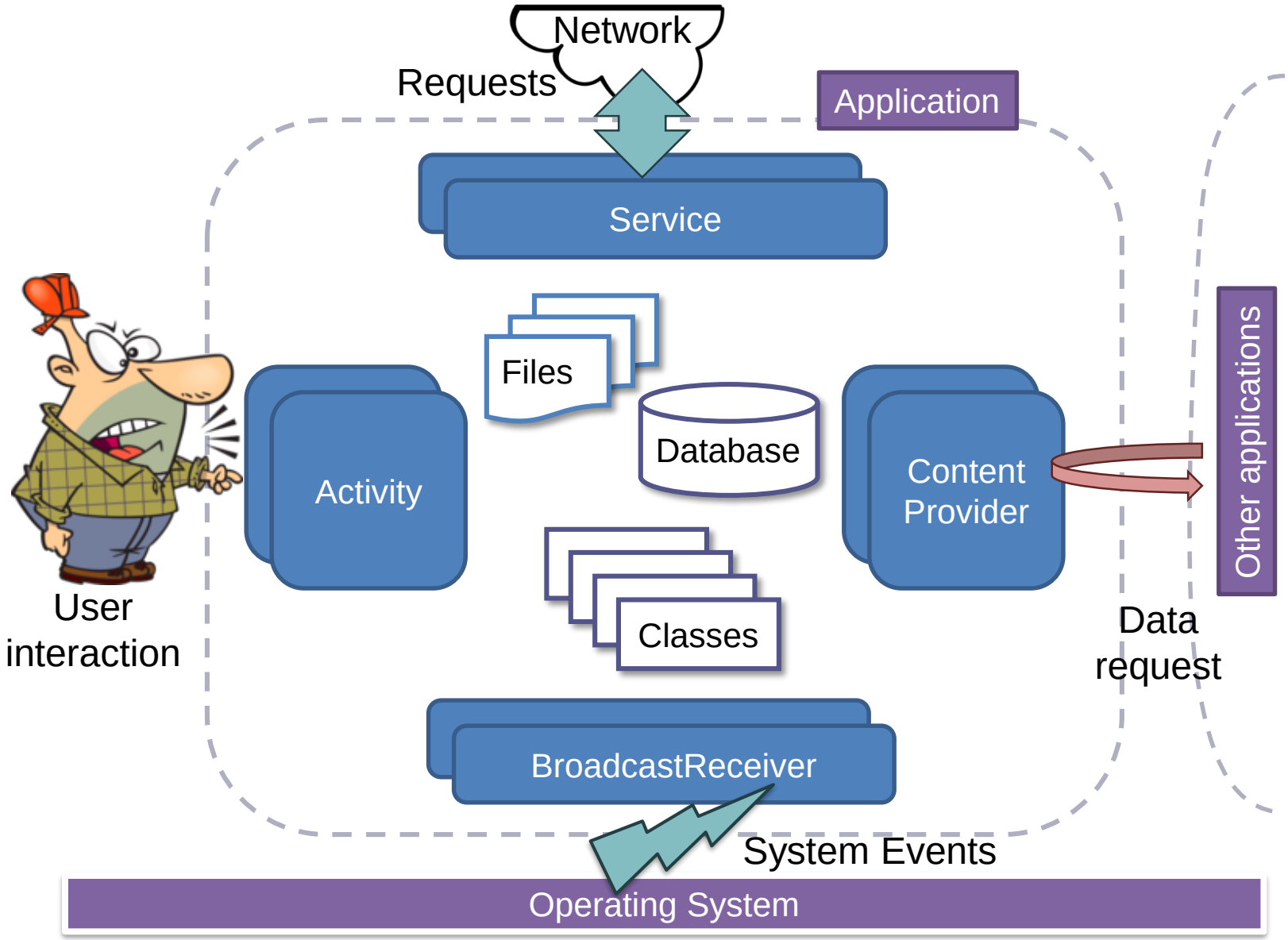
- A service is a component that can run in the background
  - It does not provide a user interface
- Usually services are used to perform long tasks
  - A service could play music while the user is using another application
  - A service could gather network data without blocking the user interaction with another activity

Content provider

- A content provider manages a shared set of app data
  - Data can be stored in the file system, in an SQLite database, on the web, or in any other persistent storage location the app can access
  - It implements a set of standard methods that allow other applications to fetch and to store data handled by the current application
  - Other applications do not call its method directly, but they interact via a content

Broadcasts

- A Broadcast Receiver is a component which “waits” for messages
  - Some messages are created by the Operating System
    - For example, whenever the display is turned off, when the battery is low …
  - Applications can produce messages, too
    - For example, when a data transfer is completed
- A broadcast receiver does not have a Graphical User Interface, but it can generate notifications in the status bar
  - To notify the user that a particular message is detected


Network
Requests
Application
Service
Files
Database
Activity
Content Provider
Other applications
User interaction
Classes
Data request
BroadcastReceiver
System Events
Operating System

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APPLICATION LIFECYCLE

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Application Lifecycle

- The functionality provided by an application are defined by its **manifest file**
  - It is an XML document that “signs a sort of contract” between the application and the execution environment
  - It lists all the single components that compose the application, the requested permissions and their configurations information

Application Lifecycle

- When an external event occurs, based on its type and on the components declared in the manifest file, Android creates a new process
  - Its owner is the one that was created when the application was installed
- For each application in execution, Android instantiates in its process a single object of class android.app.Application
  - It is possible to specify a subclass of it in the manifest file
  - This object can be used to store global information shared by all the app components

Application Lifecycle

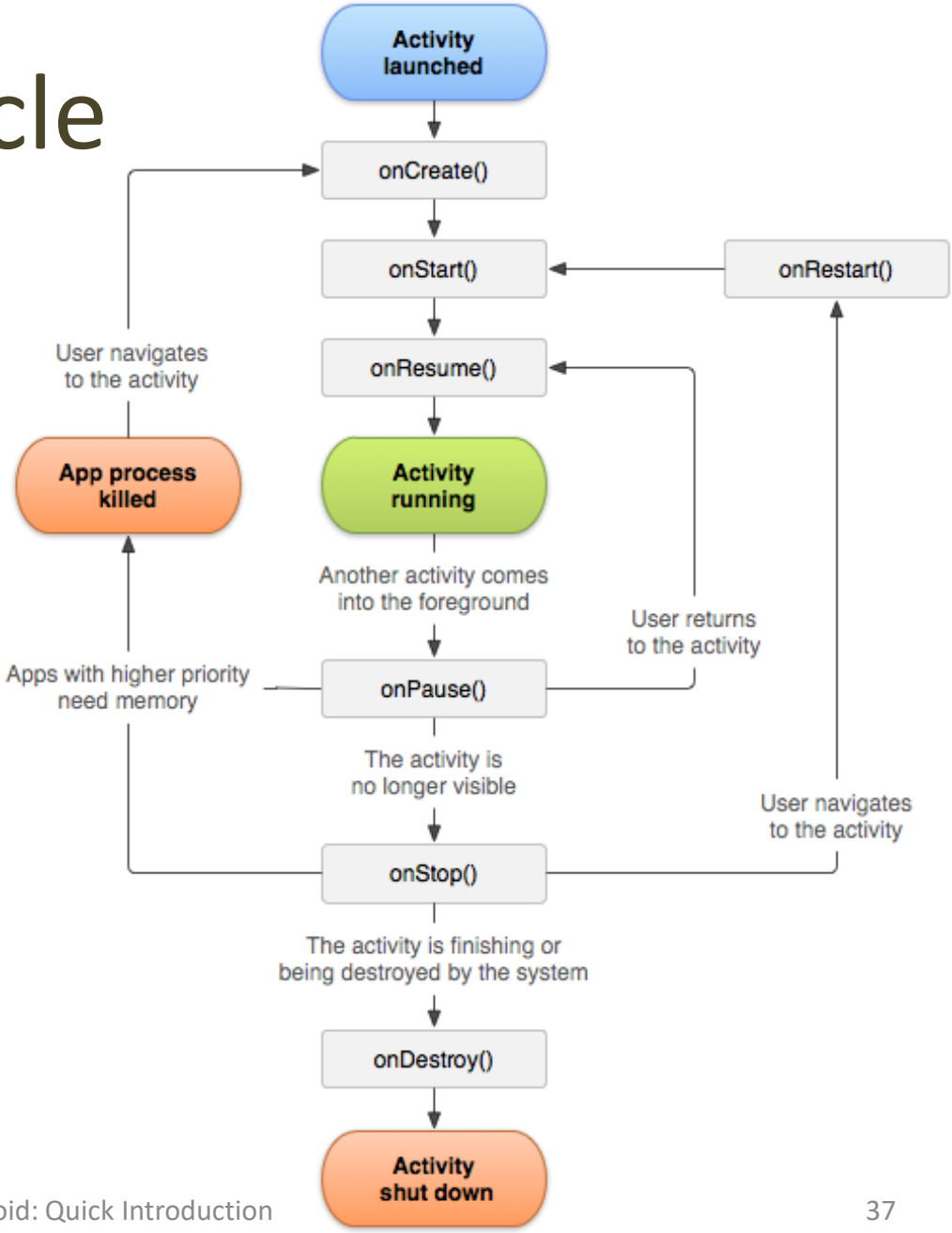
- Android notifies the application object with the evolving status of the ongoing elaboration
  - void onCreate()
  - void onConfigurationChanged(…)
  - void onLowMemory()
  - void onTerminate()

Application Lifecycle

- Once the application object has been created and initially notified of the beginning of the process, Android instantiates the **main** activity
- The activity receives some initial events:
  - void onCreate()
  - void onStart()
  - void onResume()
- The application object stays in memory as long as there are active components
  - The application object is removed from the memory when all the components end their lifecycle

Activity - Lifecycle

- As a user navigates through, out of, and back to an app, the Activity instances in this app transit through **different states**



Intents

- To instantiate components, Android uses **intents**
- An intent defines an action to be performed and a set of data on which to operate
  - The operating system finds and instantiates the corresponding components that can handle the required action
- Intents can be **implicit** or **explicit**

Implicit Intents

- They consist of several parts, the most important of which are
  - The **action**, a unique string describing what is requested or what has happened
  - The **data** to operate upon, typically expressed as a URI
  - The **category**, one or more strings containing additional information about the kind of component that should handle the intent

Implicit Intents and Manifest File

- All the components exported by an application are listed in its manifest file
  - Together with zero or more intent-filters
- Each filter describes a capability of the component, a set of intents that the component is willing to receive
  - Listing fields corresponding to the action, data, and category fields of an Intent object

Implicit Intents and Manifest File

- When an intent is delivered, Android tries to match it against all filters, in order to detect which component should be activated
  - Filters are also used to learn something about the component itself: the launcher is populated with all activities that have filters reporting action MAIN and category LAUNCHER

```
<manifest
    xmlns:android="http://schemas.android.com/apk/res/android"
    package="com.mycompany.myapplication"
    android:versionCode="1"
    android:versionName="1.0" >
    <uses-sdk
        android:minSdkVersion="11"
        android:targetSdkVersion="15" />

    <application
        android:icon="@drawable/ic_launcher"
        android:label="@string/app_name"
        android:theme="@style/AppTheme" >

        <activity
            android:name=".MainActivity"
            android:label="@string/title_main_activity" >
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER”/>
            </intent-filter>
        </activity>

    </application>
</manifest>
```

Explicit Intents

- An explicit intent is one that you use to launch a specific app component, such as a particular activity or service
- You can create and send to Android explicit intents from your code
- Typically, you have to specify the context of your app, and the Java class of the component you are interested in

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DEVELOPING FOR ANDROID: TOOLS

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Environment setup

- The most convenient tool for developers today is Android Studio
  - http://developer.android.com/sdk/index.html
- Android Studio offers
  - A rich code editor
  - Several code templates and integration with GitHub
  - Instant preview for many different devices
  - Dependency support and build automation via Gradle

Environment Setup

- Beside an IDE, the Android SDK need to be installed
  - Automatically done by the Android Studio installer
- Android SDK consists of a bunch of programs broadly divided into SDK tools and platform tools

SDK Tools

- Set of tools for debugging and testing, and other utilities that are required to develop an app
  - Installed in folder <sdk>/tools
- The most relevant are:
  - The emulator, that need some configuration before being run
  - The Android Debug Monitor, that provides debugging and profiling support for both emulators and real devices

Deploying Apps on Phones

- To install applications on your phone through USB cable, the “Debug mode” must be enabled
  - You need to activate the Developer Options
  - Different phones have different ways to activate the Developer Options

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PROJECT SETUP

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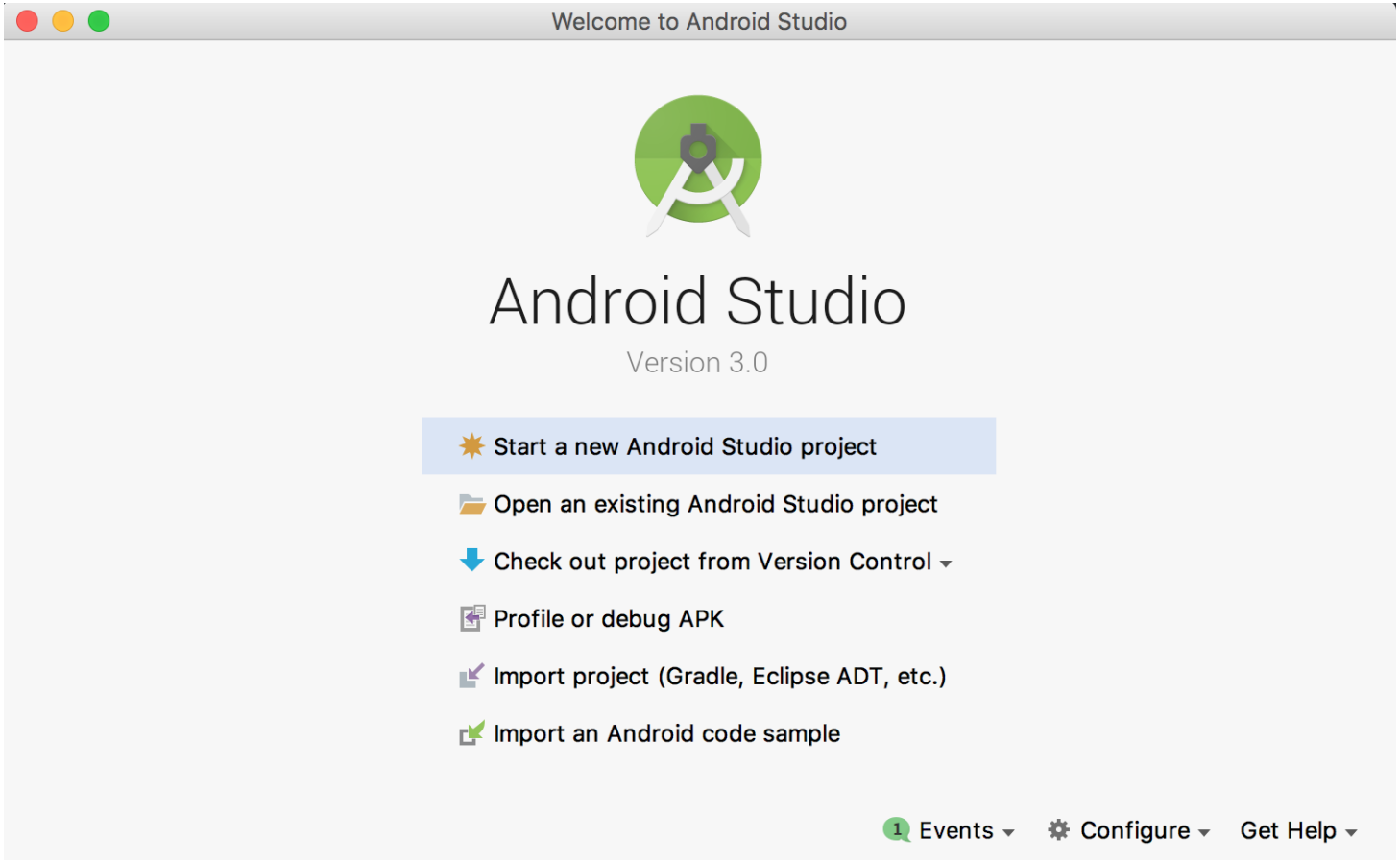
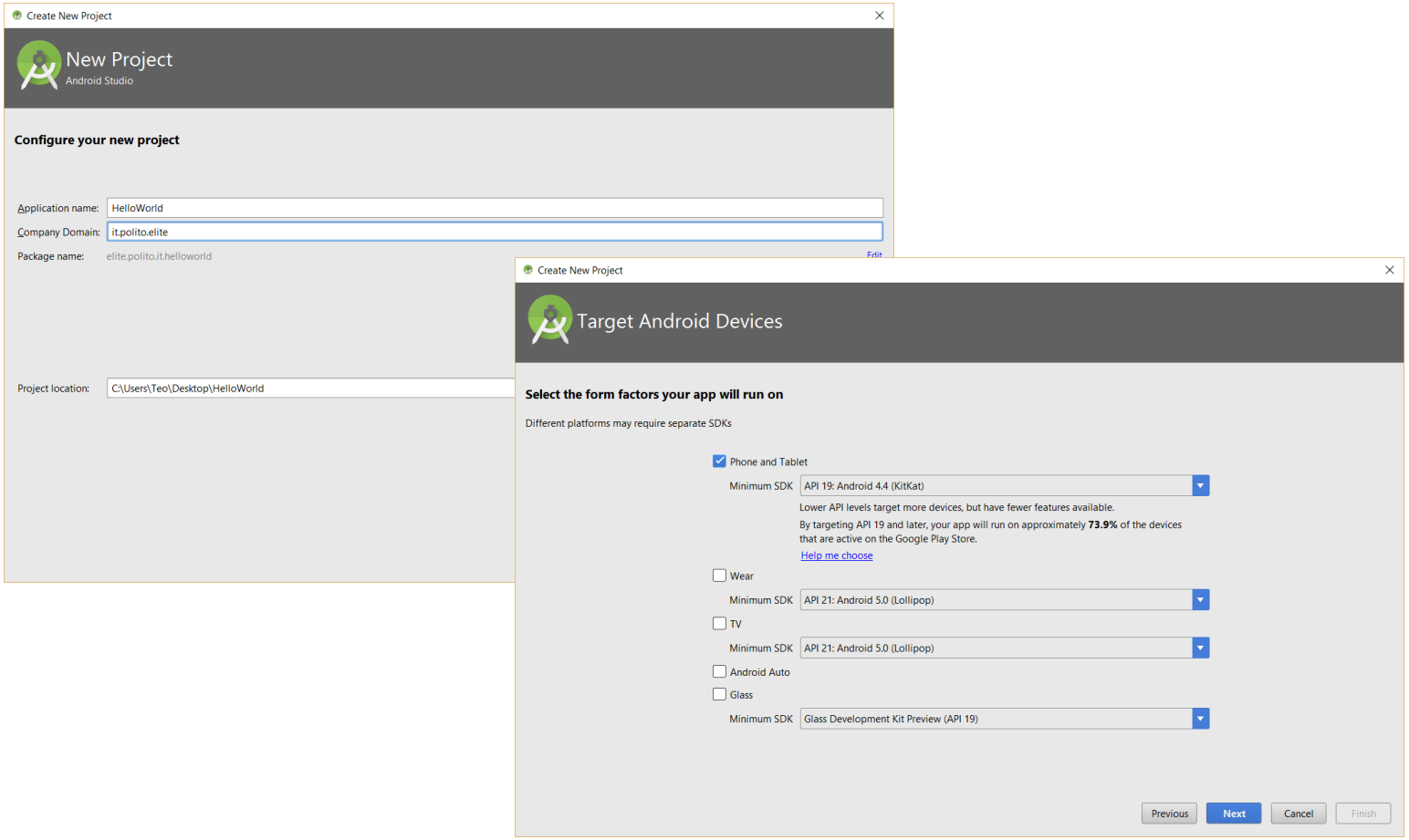
Using Android Studio



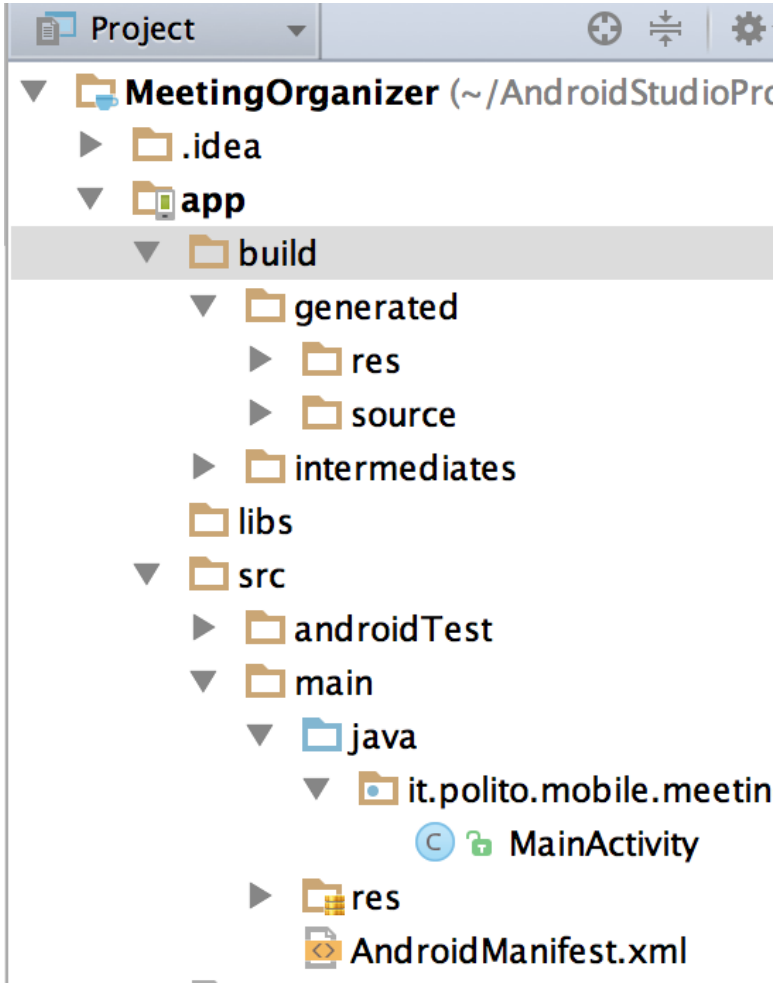
Using Android Studio

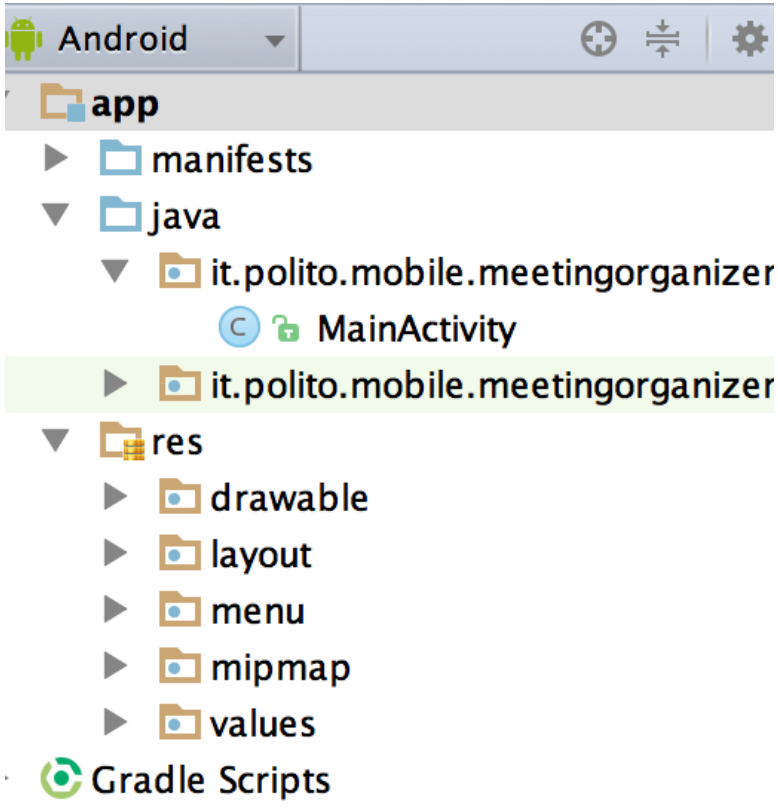


Project Structure

- Android Studio provides several alternative views for the project structure
  - The “Android” view shows a flattened version emphasizing source files
  - The “Project” view provides a more detailed vision of the folder structure, showing generated files

Project Structure





Source Files

- Source files are split into manifest, java, and resource files
  - A Manifest file describes the features, permissions and software components of the application
  - Java files are organized in packages and sub-packages according to the programmer's will
  - Resources are non-executable contents needed at program run-time (images, layout, values, …)

Setting up a virtual device

- To emulate the execution of an app, an Android Virtual Device (AVD) should be configured and run
  - Configuration provides information about the Android OS version, the device hardware capabilities and screen configuration, the size of an external SDCard, …
  - Common practice is to create several AVDs with different configuration to test various execution environments

Questions?

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