Programming with Android: System Architecture

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Outline

- Android Architecture: An **Overview**
- Android **Dalvik** Java **Virtual Machine**
- Android Components: **Activities**
- Android Components: **Intents**
- Android Components: **Services**
- Android Components: **Content Providers**
- Android Application **Distribution** and **Markets**

Android … What?

- **Android** is a *Linux-based* platform for *mobile devices* …
  - *Operating System*
  - *Middleware*
  - *Applications*
  - *Software Development Kit* (**SDK**)

- Which kind of **mobile devices** … (examples)

SMARTPHONES

TABLETS

EREADERS

ANDROID TV

GOOGLE GLASSES

?

Android … What?

SMART FRIDGE

ANDROID MICROWAVE

SMARTPHONES

TABLETS

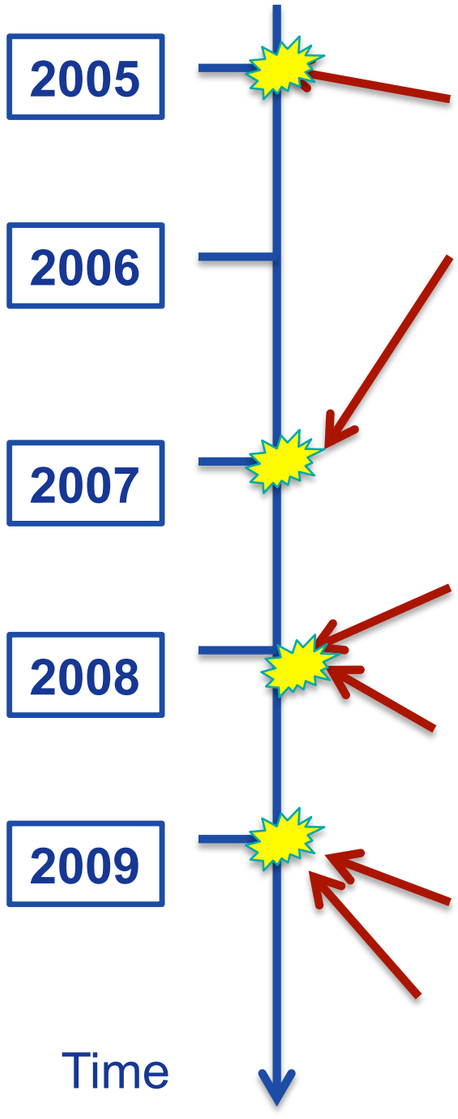
EREADERS

ANDROID TV

GOOGLE GLASSES

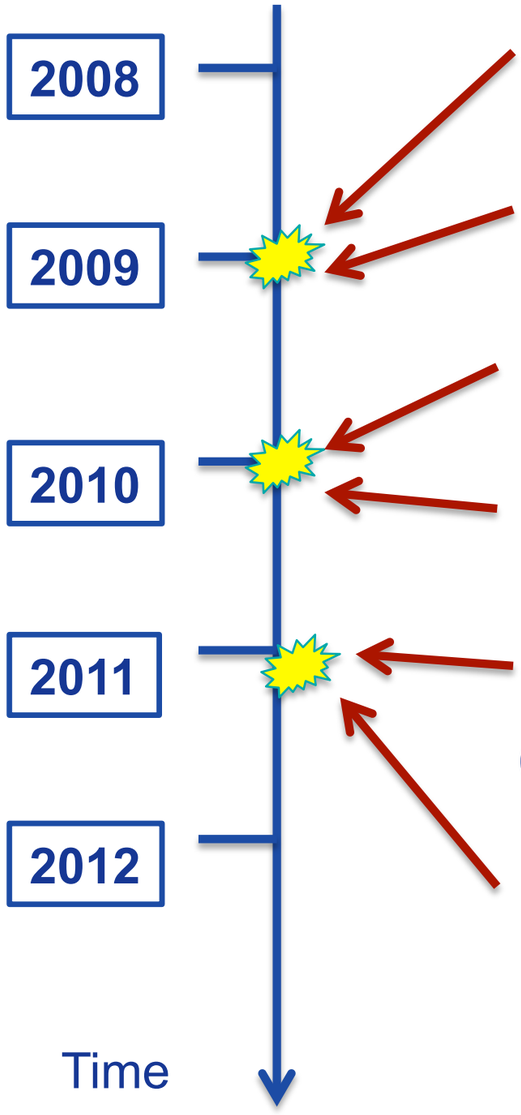
?

Android … When?



- **Google** buys Android from the **Android Inch**
- Open Handset Alliance (**OHA**) created for open standards for mobile devices. Partners of OHA: Google, Motorola, Samsung, Vodafone, T-Mobile, etc
- Android 1.0 Released
- The first Android smartphone: G1 HTC-Dream
- Android **1.1** Released
- Android **1.5 (CupCake)** Released

Android … When?



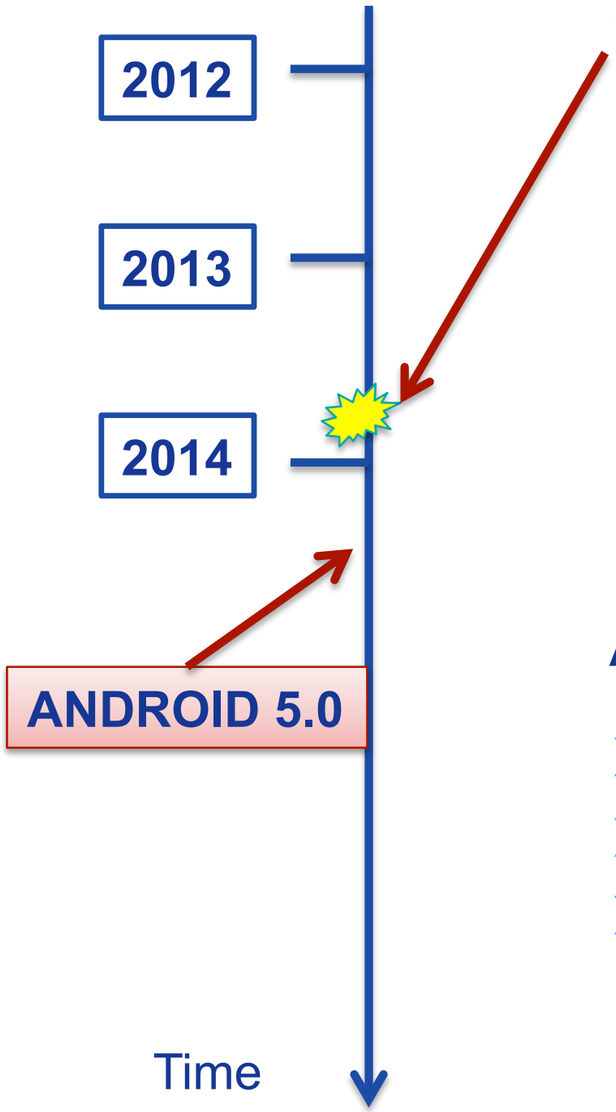
- Android **1.6** (**Donut**) Released
- Android **2.0** (**Eclair**) Released

- Android **2.2** (**Froyo**) Released
- Android **2.3** (**Gingerbread**) Released
- Android **3.0** (**Honeycomb**) Released

(First version for devices with larger screens such as tablets)

- Android **4.0** (**Ice-Cream Sandwich**) Released. (It merges the 3.x tab centric design and the v2.x phone based design into a single version.)

Android … When?

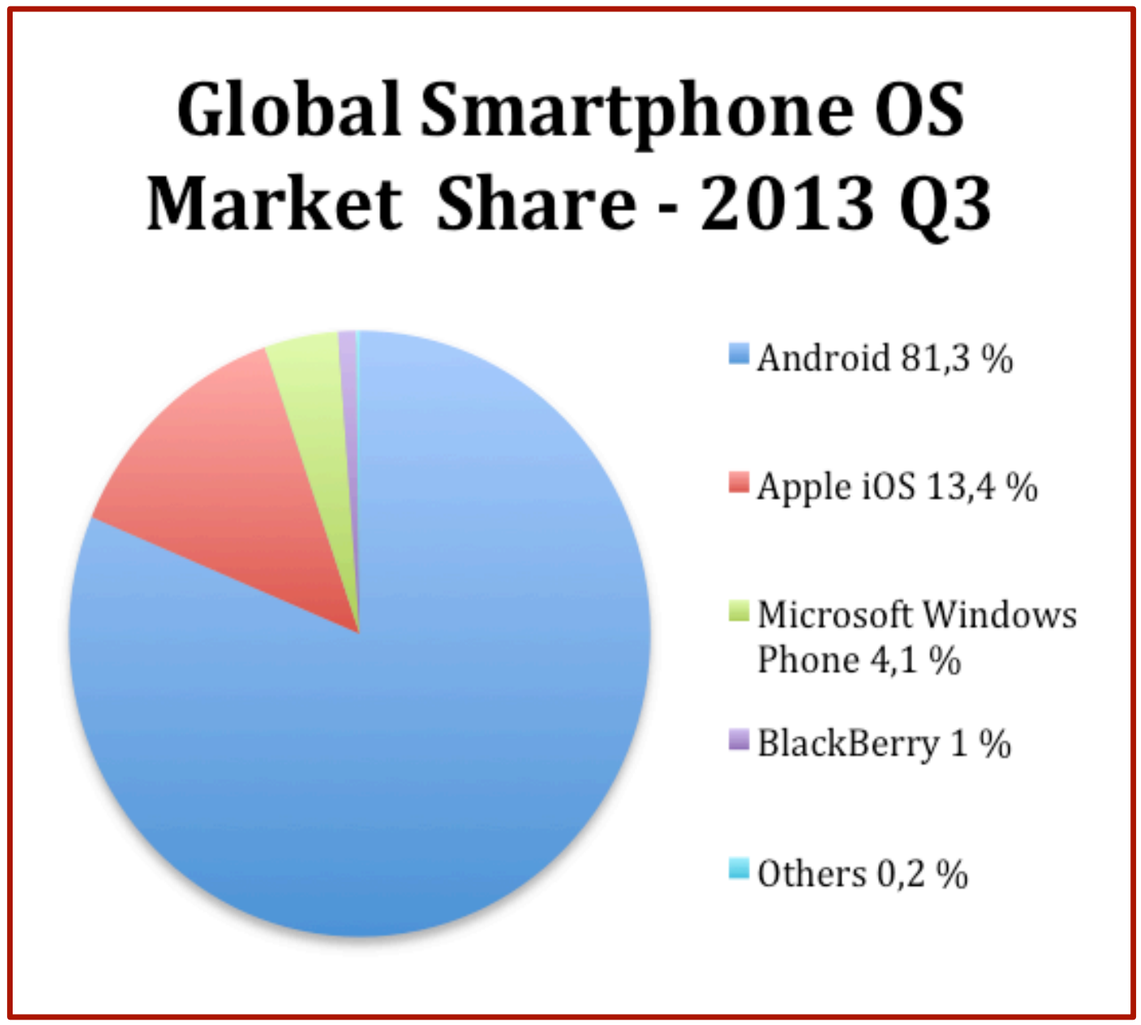


- Android **4.4** (**Kitkat**) Released
  - Wireless printing capability
  - Ability for applications to use "immersive mode"
  - Performance optimization
  - New experimental runtime virtual machine, ART…

API Level 19 (Android 4.4):

- Support to new embedded sensors (e.g. STEP_DETECTOR)
- Adaptive video playback functionalities
- Read and write SMS and MMS messages (managing default text messaging client)

Android … When?

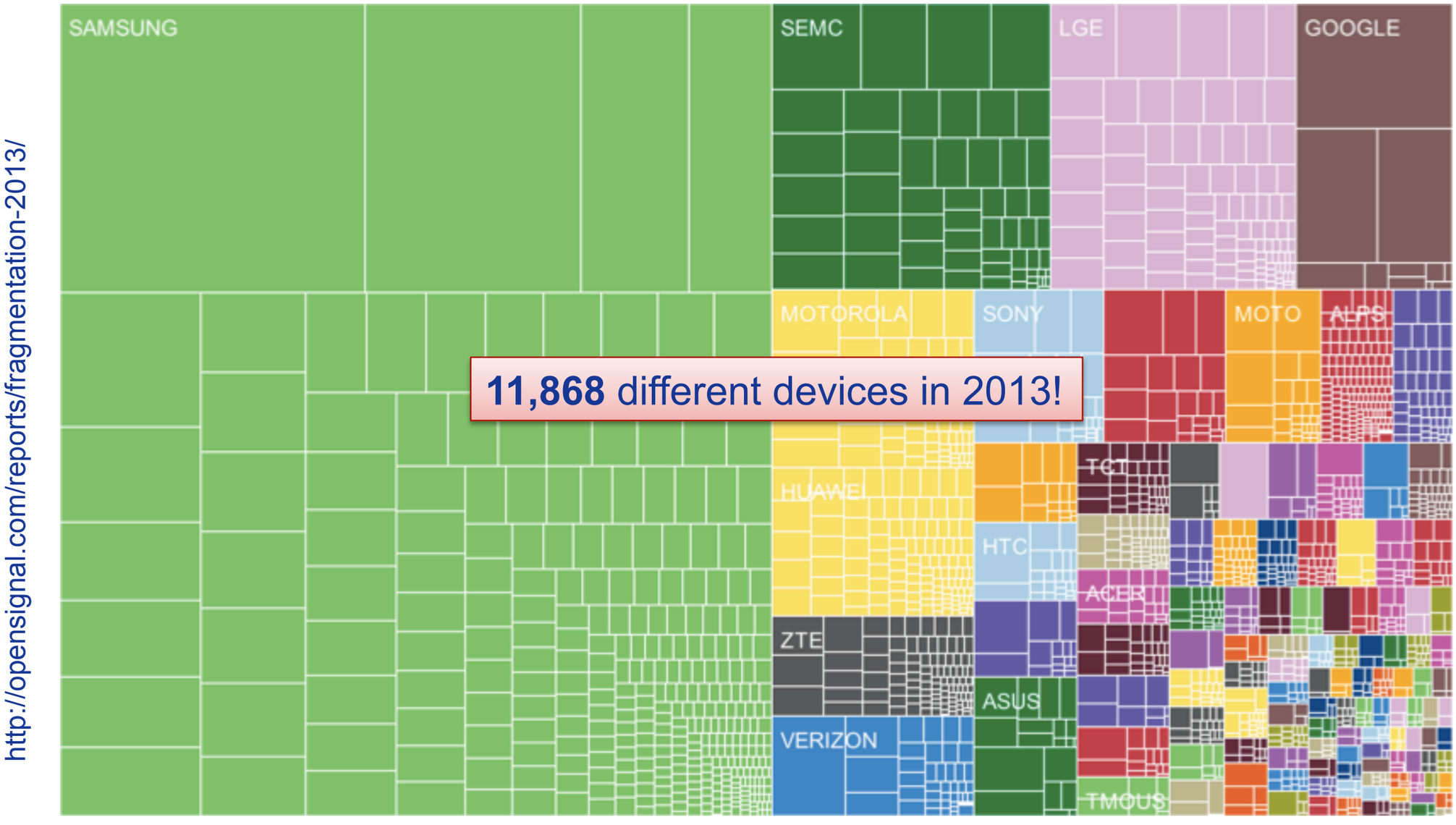


2012 Market Share

www.gartner.com

2013 Market Share

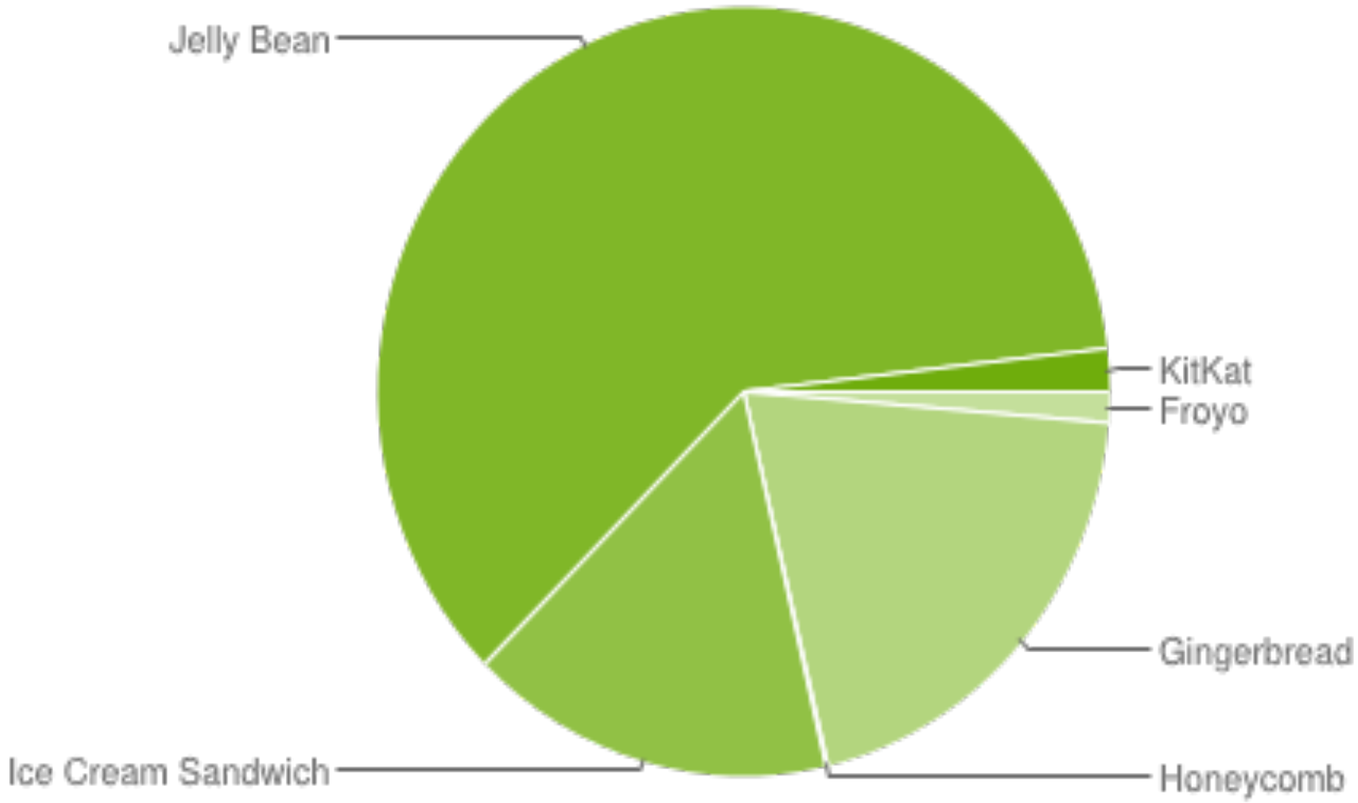
Android … When?



http://opensignal.com/reports/fragmentation-2013/

Android … When?

Version	Codename	API	Distribution
2.2	Froyo	8	1.3%
2.3.3 - 2.3.7	Gingerbread	10	20.0%
3.2	Honeycomb	13	0.1%
4.0.3 - 4.0.4	Ice Cream Sandwich	15	16.1%
4.1.x		16	35.5%
4.2.x	Jelly Bean	17	16.3%
4.3		18	8.9%
4.4	KitKat	19	1.8%

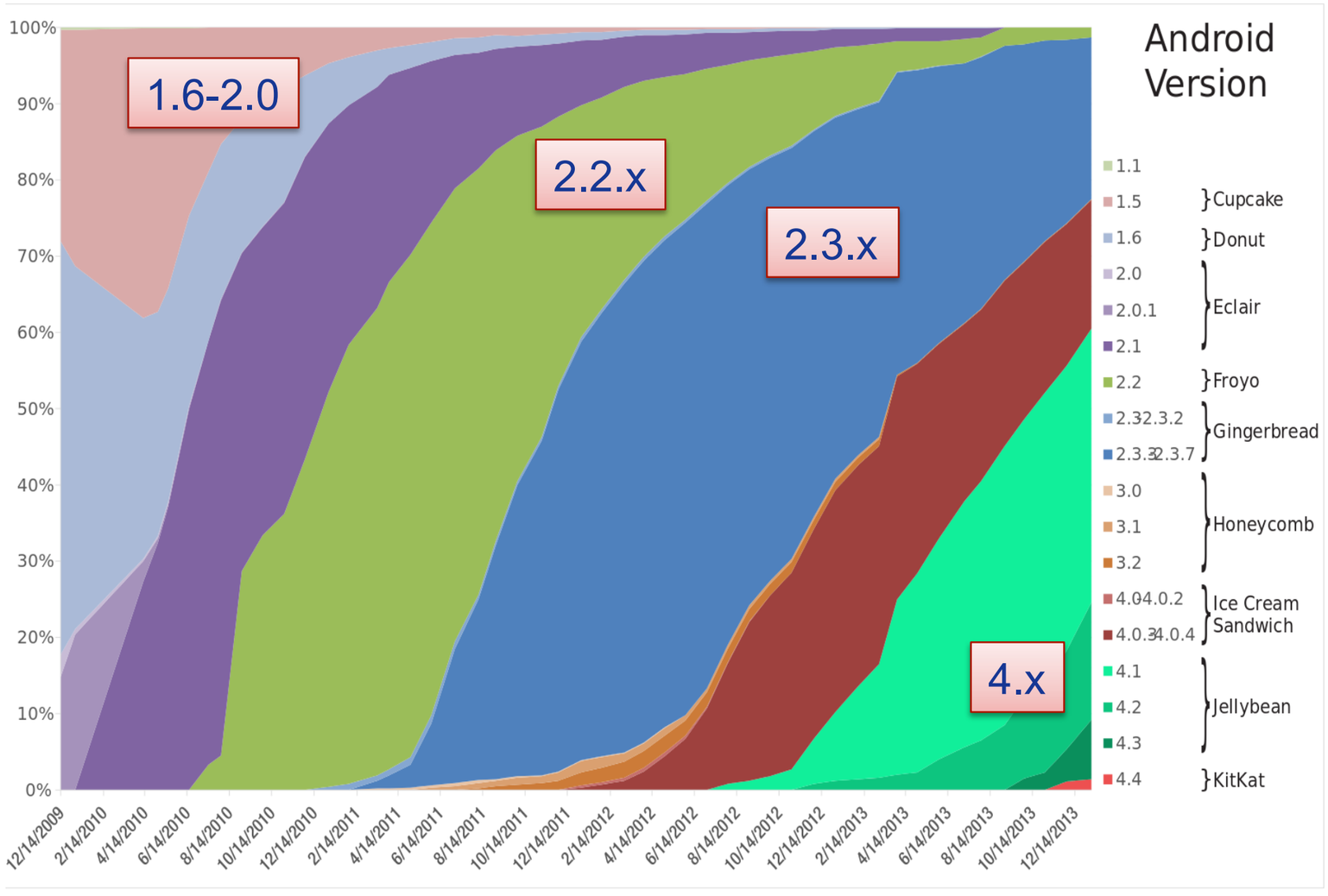


http://developer.android.com/about/dashboards/index.html

Updated at February 2014

Android … When?

http://en.wikipedia.org/wiki/Android_version_history

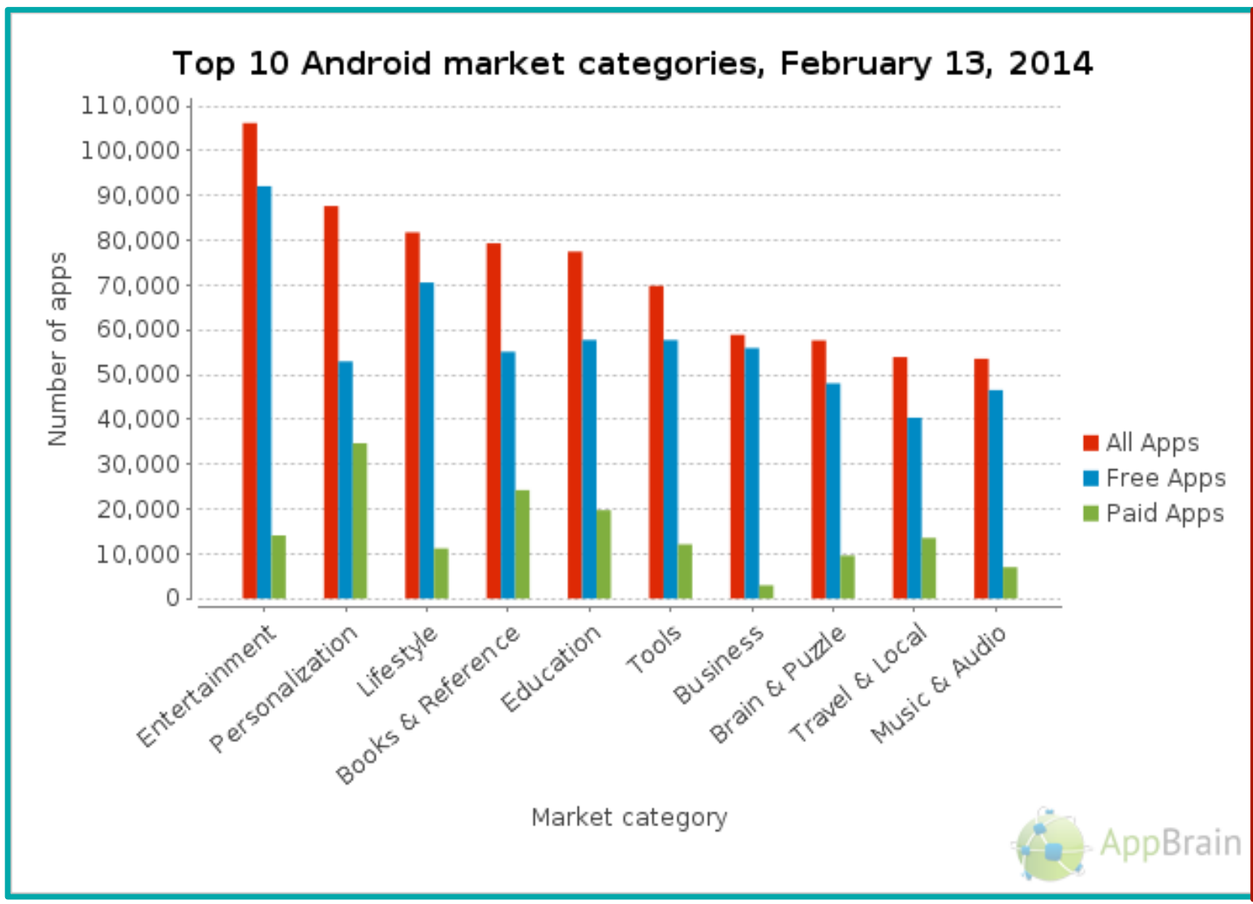


ANDROID VERSION HISTORY AND POPULARITY

(2009-2013)

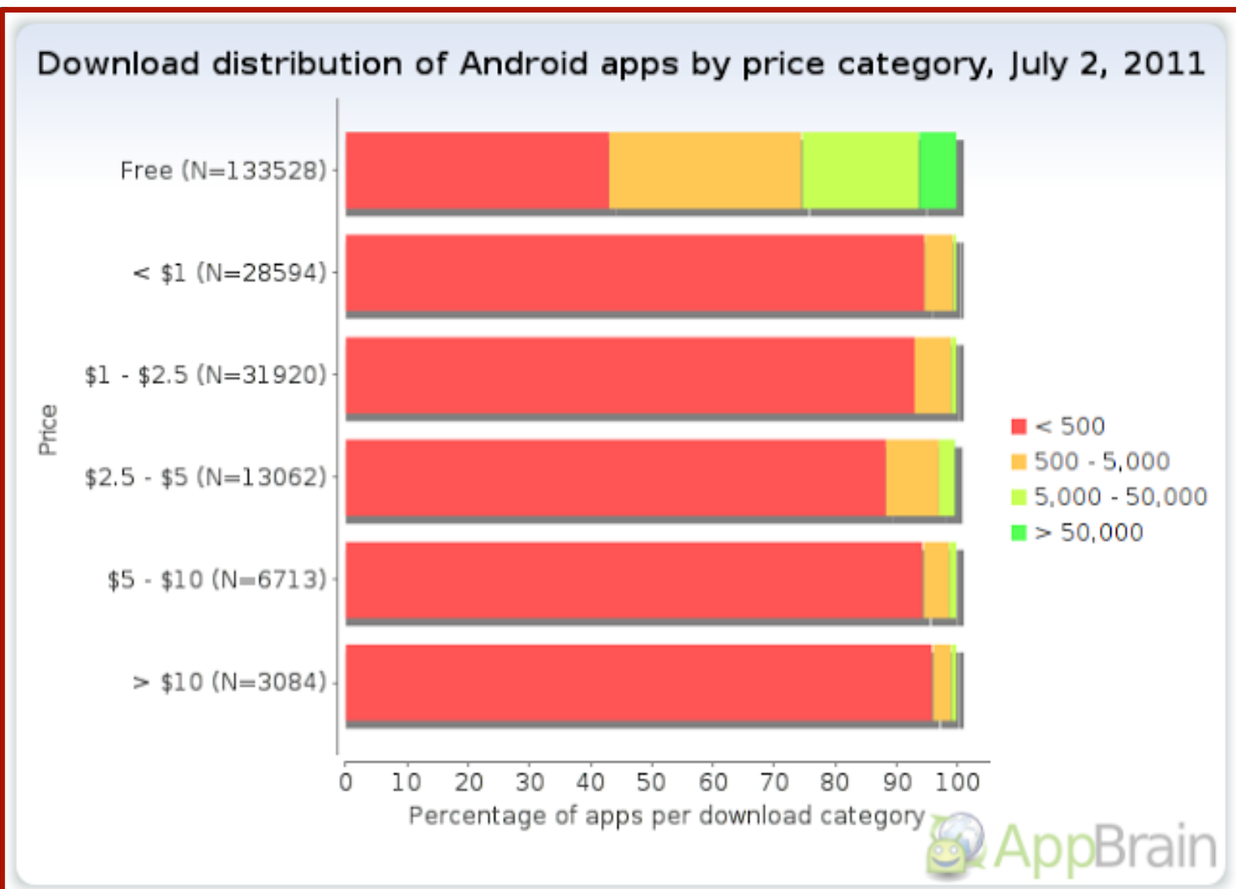
Android … When?

ANDROID APP CATEGORIES



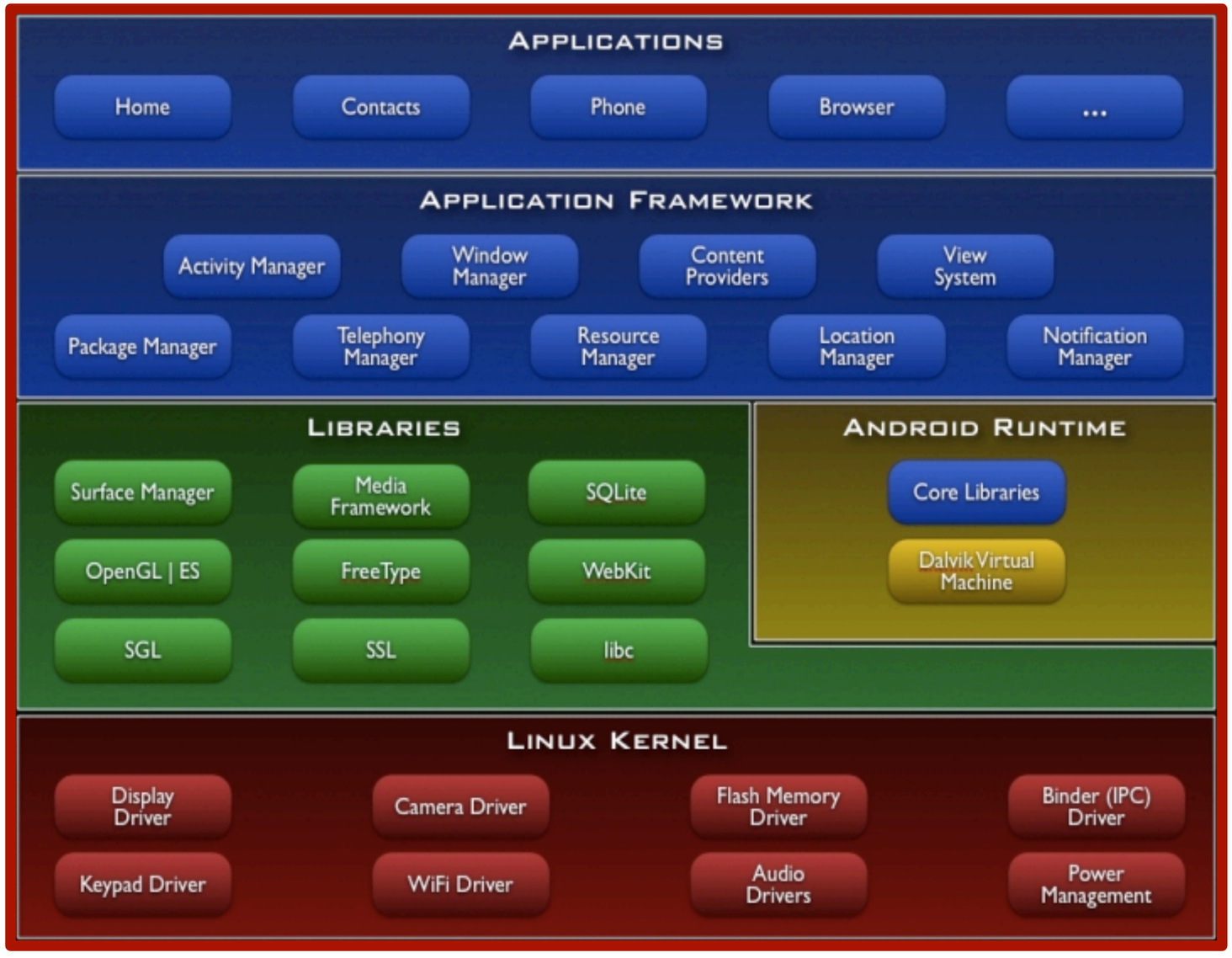
http://www.appbrain.com/stats/android-market-app-categories

ANDROID APP PRICE



http://www.onlinemarketing-trends.com/2011/07/android-marketplace-top-5-statistics.html

The Android Architecture

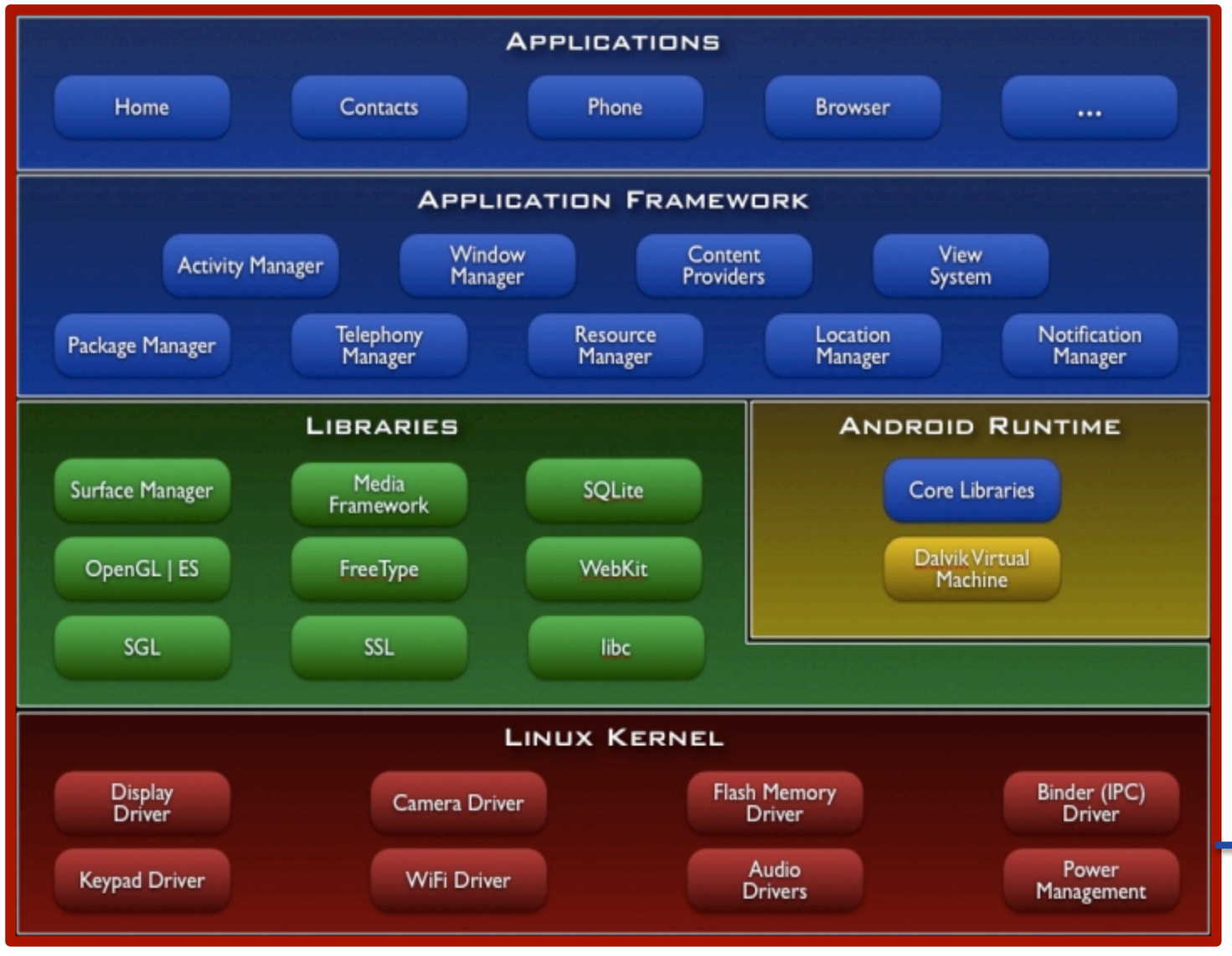


Stack
Architecture

Open Source Architecture
(Apache/MIT License v. 2.0)

Business-friendly License

The Android Architecture

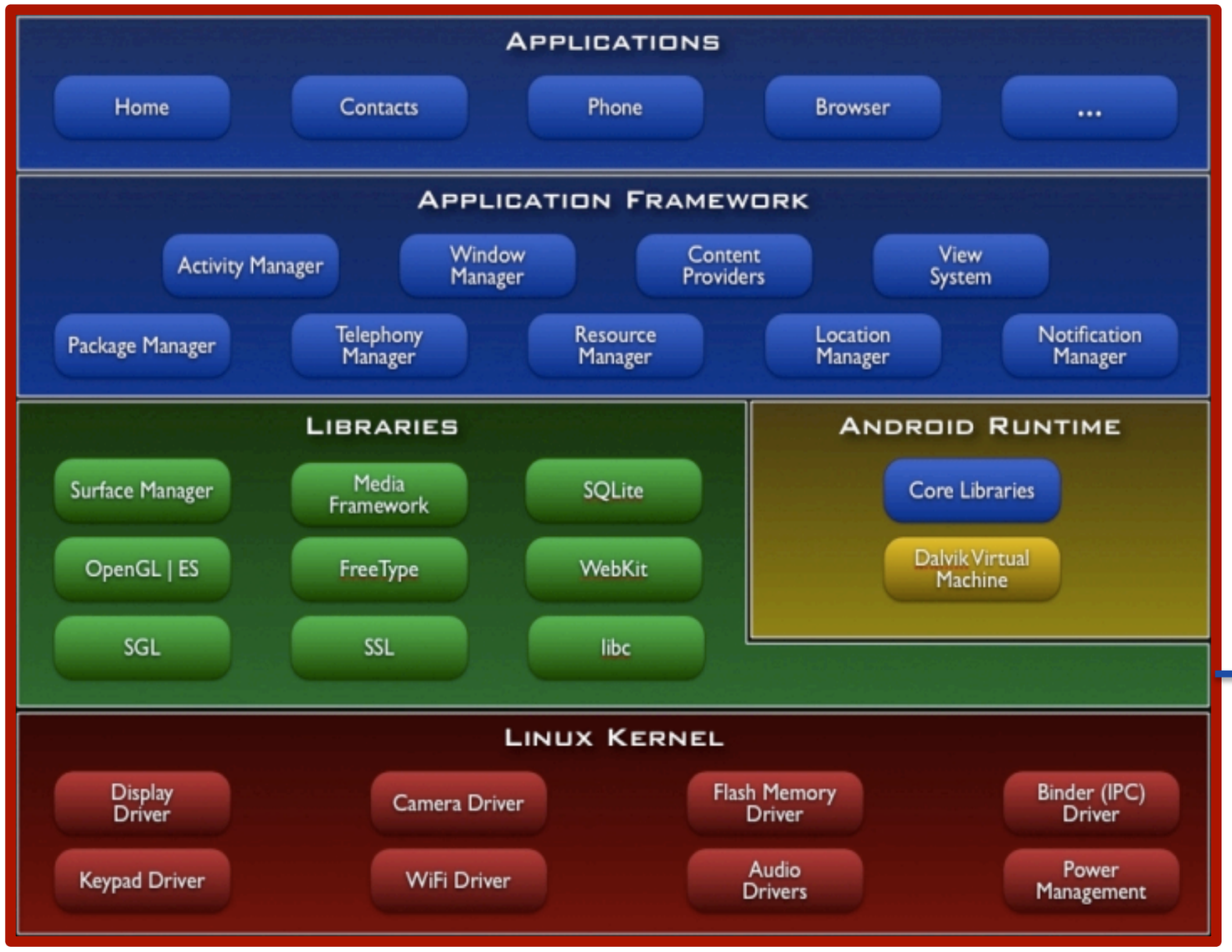


Built on top of **Linux kernel** (v. 2.6-3.4)

Advantages:

- **Portability** (i.e. easy to compile on different hardware architectures)
- **Security** (e.g. secure multi-process environment)
- **Power** Management

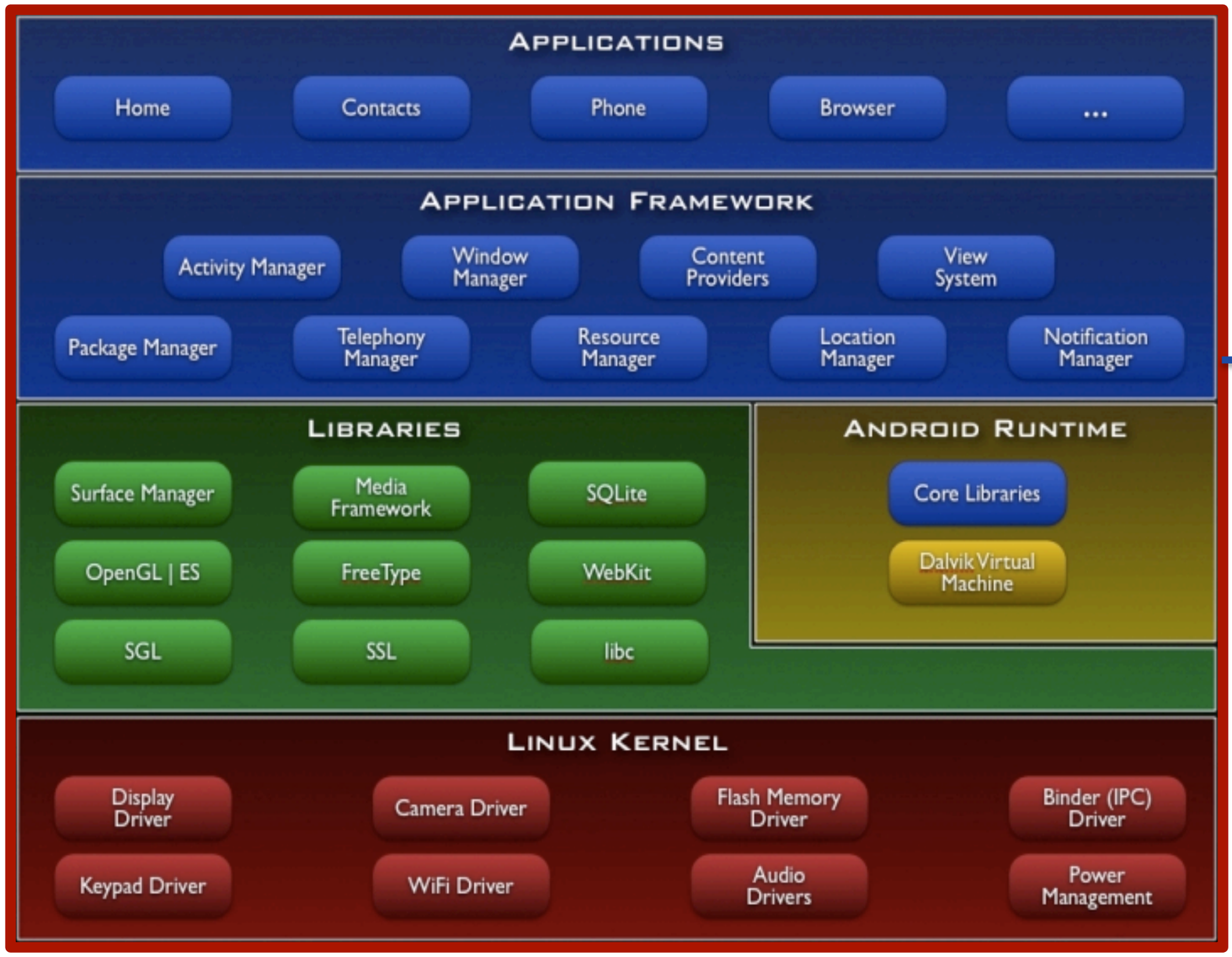
The Android Architecture



Native **Libraries**
(C/C++ code)

- **Graphics** (Surface Manager)
- **Multimedia** (Media Framework)
- **Database DBMS** (SQLite)
- **Font Management** (FreeType)
- **WebKit**
- **C libraries** (Bionic)
- ….

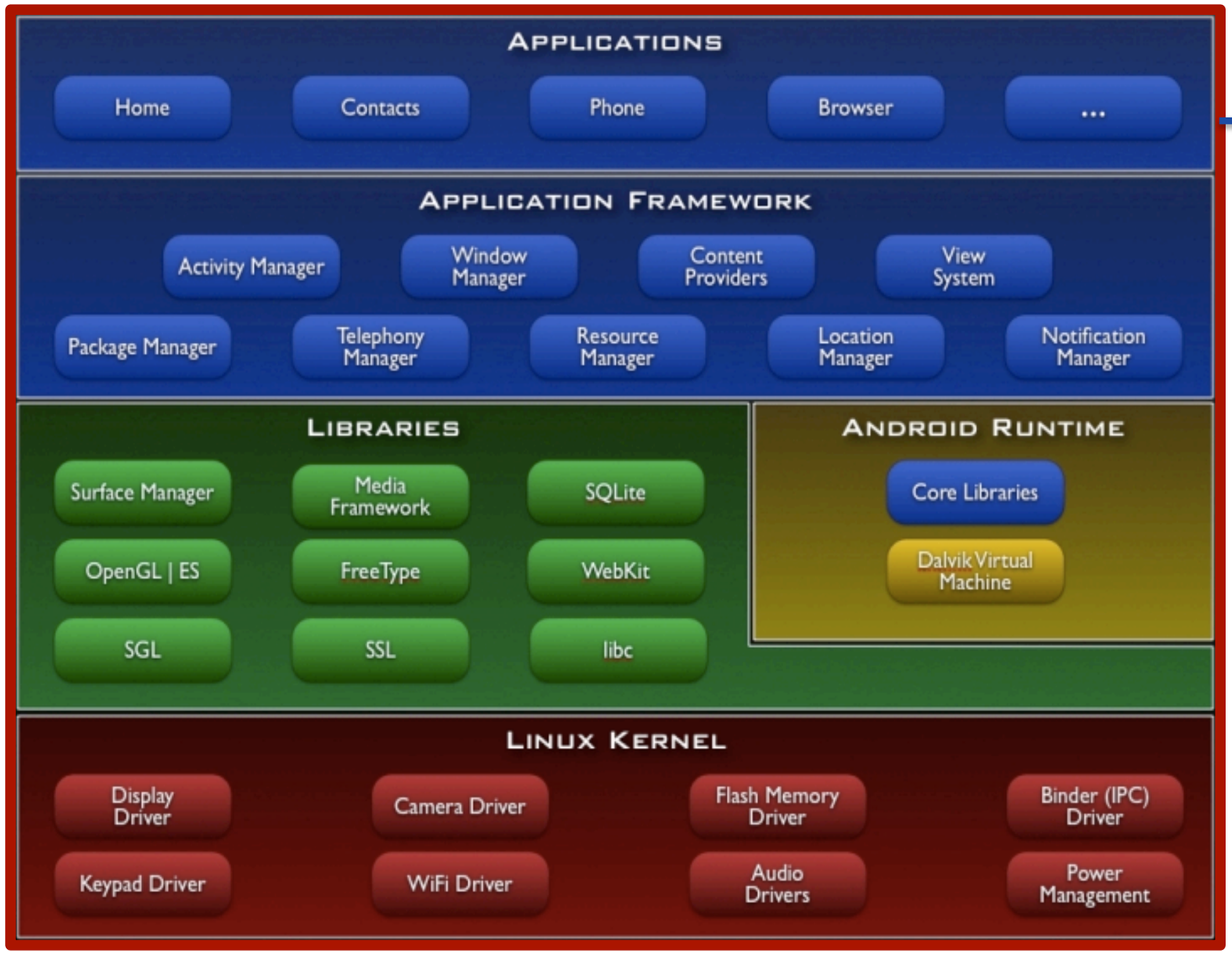
The Android Architecture



Application Libraries
(Core Components of Android)

- **Activity Manager**
- **Packet Manager**
- **Telephony Manager**
- **Location Manager**
- **Contents Provider**
- **Notification Manager**
- **….**

The Android Architecture

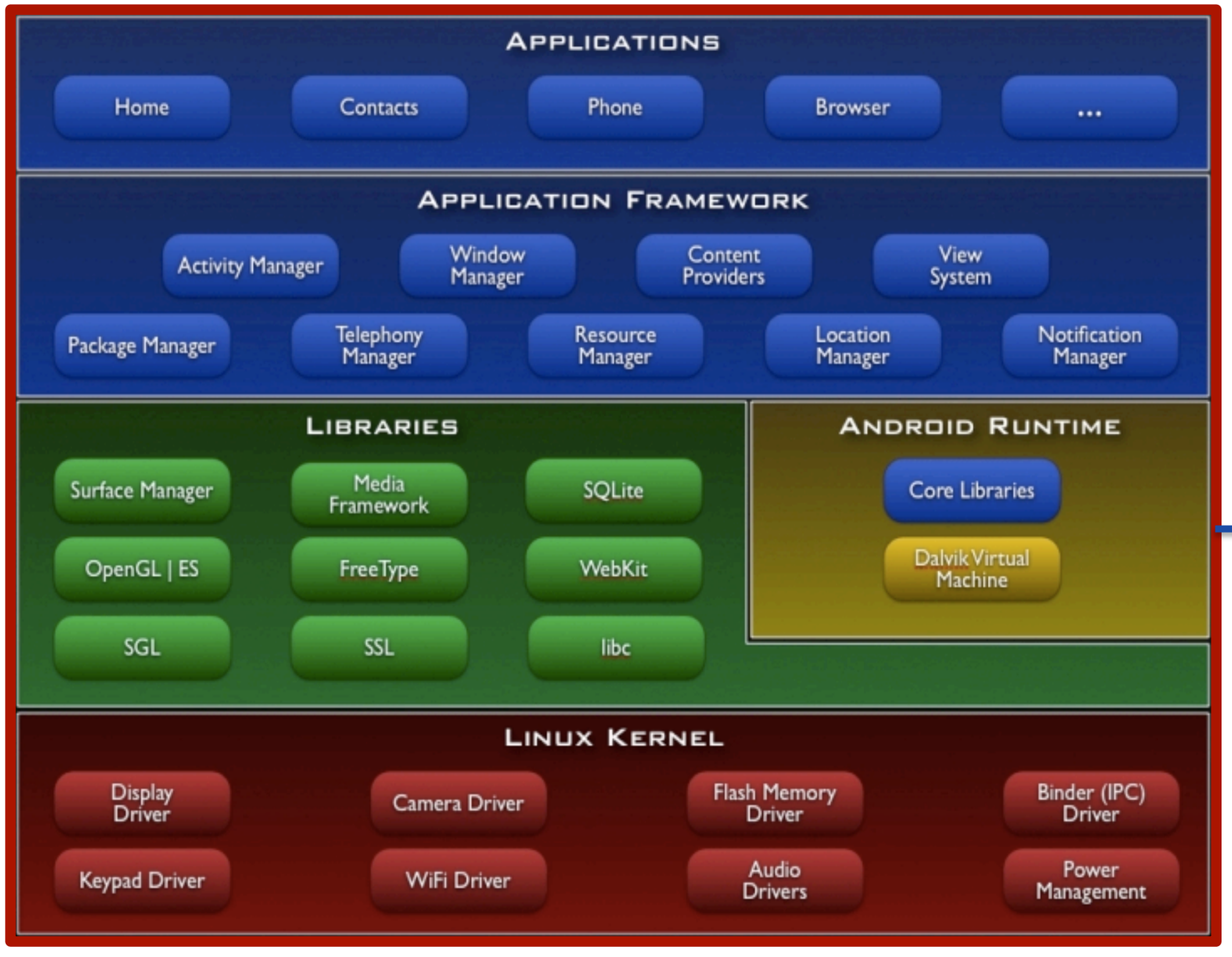


Applications

(Written in **Java** code)

- **Android Play Store**
- **Entertainment**
- **Productivity**
- **Personalization**
- **Education**
- **Geo-communication**
- **….**

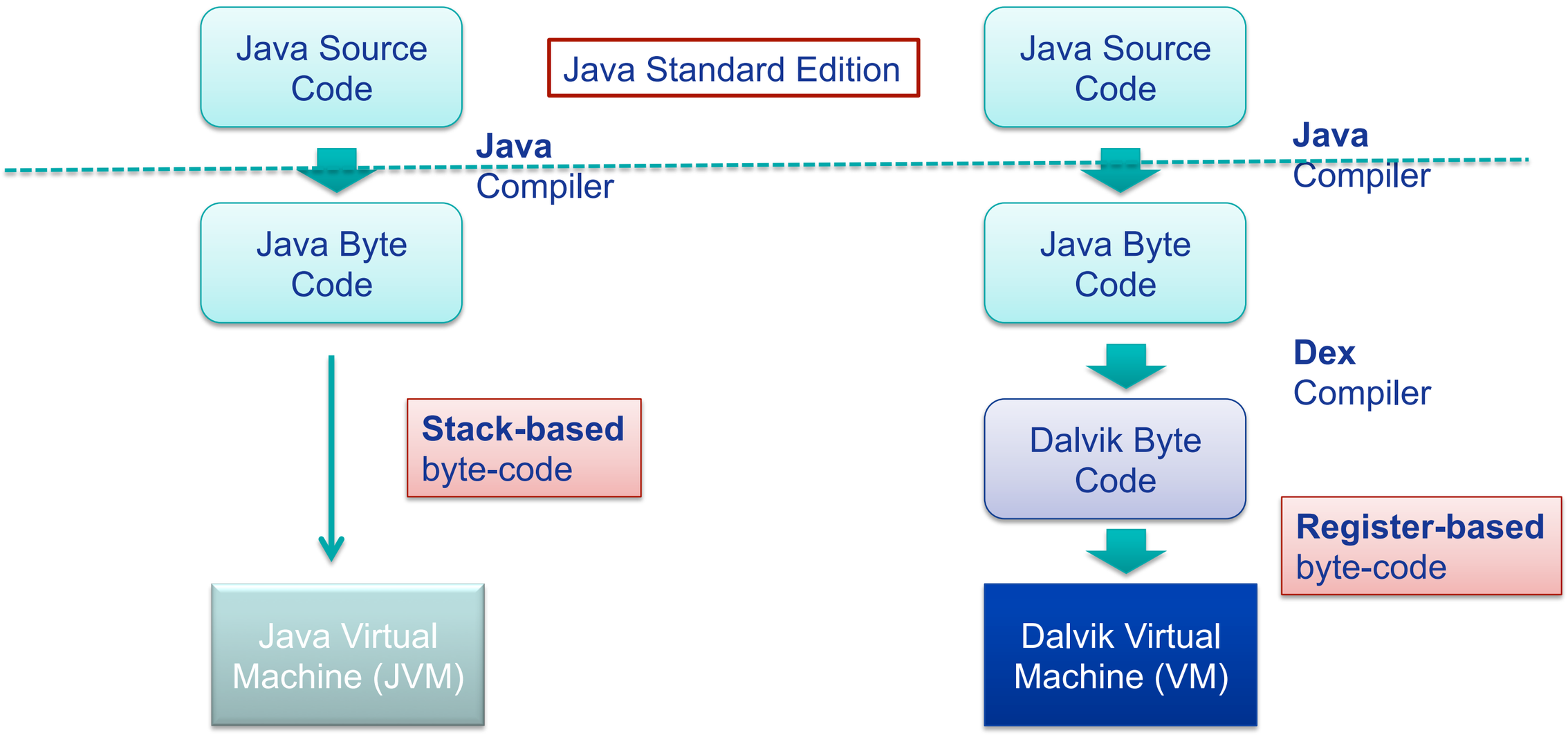
The Android Architecture



Dalvik Virtual Machine (VM)

- **Novel** Java Virtual Machine implementation (not using the Oracle JVM)
- Open **License** (Oracle JVM is not open!)
- **Optimized** for memory-constrained devices
- **Faster** than Oracle JVM
- ….

Dalvik Java Virtual Machine (JVM)



Android Applications Design

APPLICATION **DESIGN**:

- **GUI** Definition
- **Events** Management
- Application **Data** Management
- **Background** Operations
- **User** Notifications

Android Applications Design

APPLICATION COMPONENTS

- Activities & Fragments
- Intents
- Services
- Content Providers
- Broadcast Receivers

Android Components: Activities

- An **Activity** corresponds to a **single screen** of the **Application**.
- An Application can be composed of *multiples screens* (Activities).
- The **Home Activity** is shown when the user launches an application.
- Different activities can exhange information one with each other.

Android Components: Activities

- Each activity is composed by a list of *graphics components*.
- Some of these components (also called **Views**) can interact with the user by handling **events** (e.g. Buttons).
- Two ways to build the graphic interface:

PROGRAMMATIC APPROACH

Example:

```
Button button=new Button (this);
TextView text= new TextView();
text.setText("Hello world");
```

Android Components: Activities

- Each activity is composed by a list of *graphics components*.
- Some of these components (also called **Views**) can interact with the user by handling **events** (e.g. Buttons).
- Two ways to build the graphic interface:

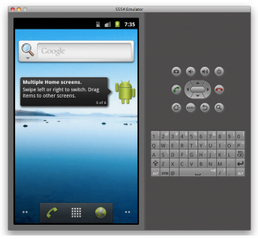
DECLARATIVE APPROACH

Example:

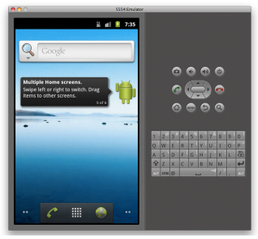
```
< TextView android.text=@string/hello" android:textcolor=@color/blue
android:layout_width="fill_parent" android:layout_height="wrap_content" />
< Button android.id="@+id/Button01" android:textcolor="@color/blue"
android:layout_width="fill_parent" android:layout_height="wrap_content" />
```

Android Components: Activities

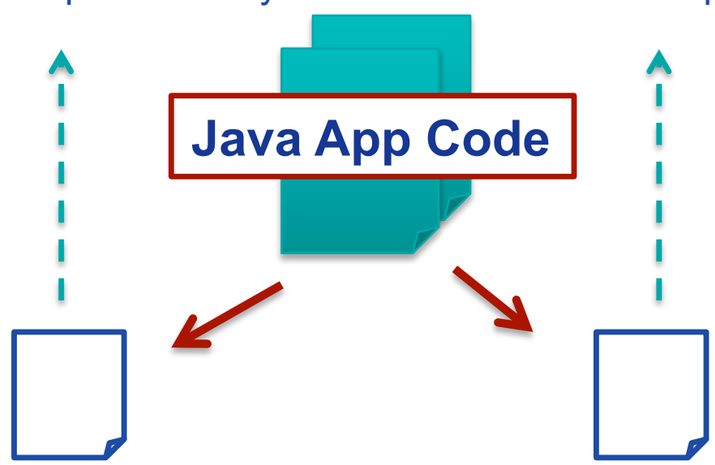
EXAMPLE



Device 1
HIGH screen pixel density



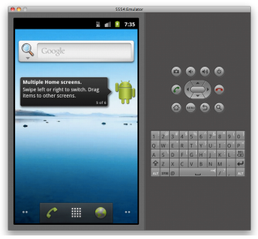
Device 2
LOW screen pixel density

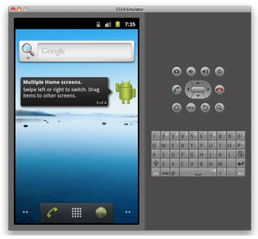


- Build the **application layout** through XML files (like HTML)
- Define **two** different XML **layouts** for two different devices
- At **runtime**, Android detects the current device configuration and loads the appropriate resources for the application
- **No need to recompile**!
- Just add a new XML file if you need to support a new device

Android Components: Activities

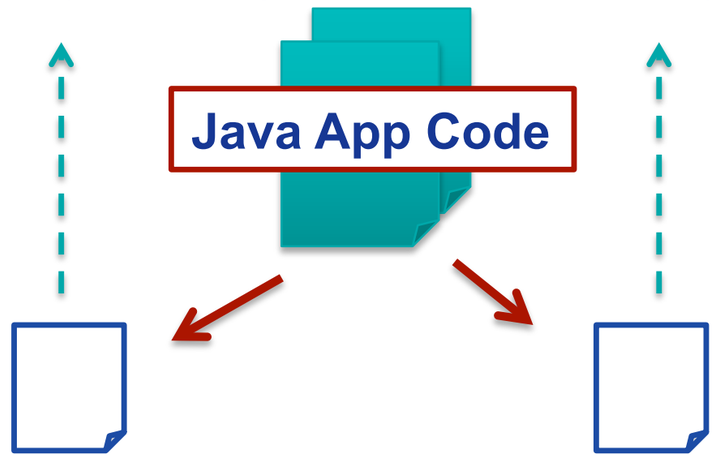
EXAMPLE





Device 1
HIGH screen pixel density

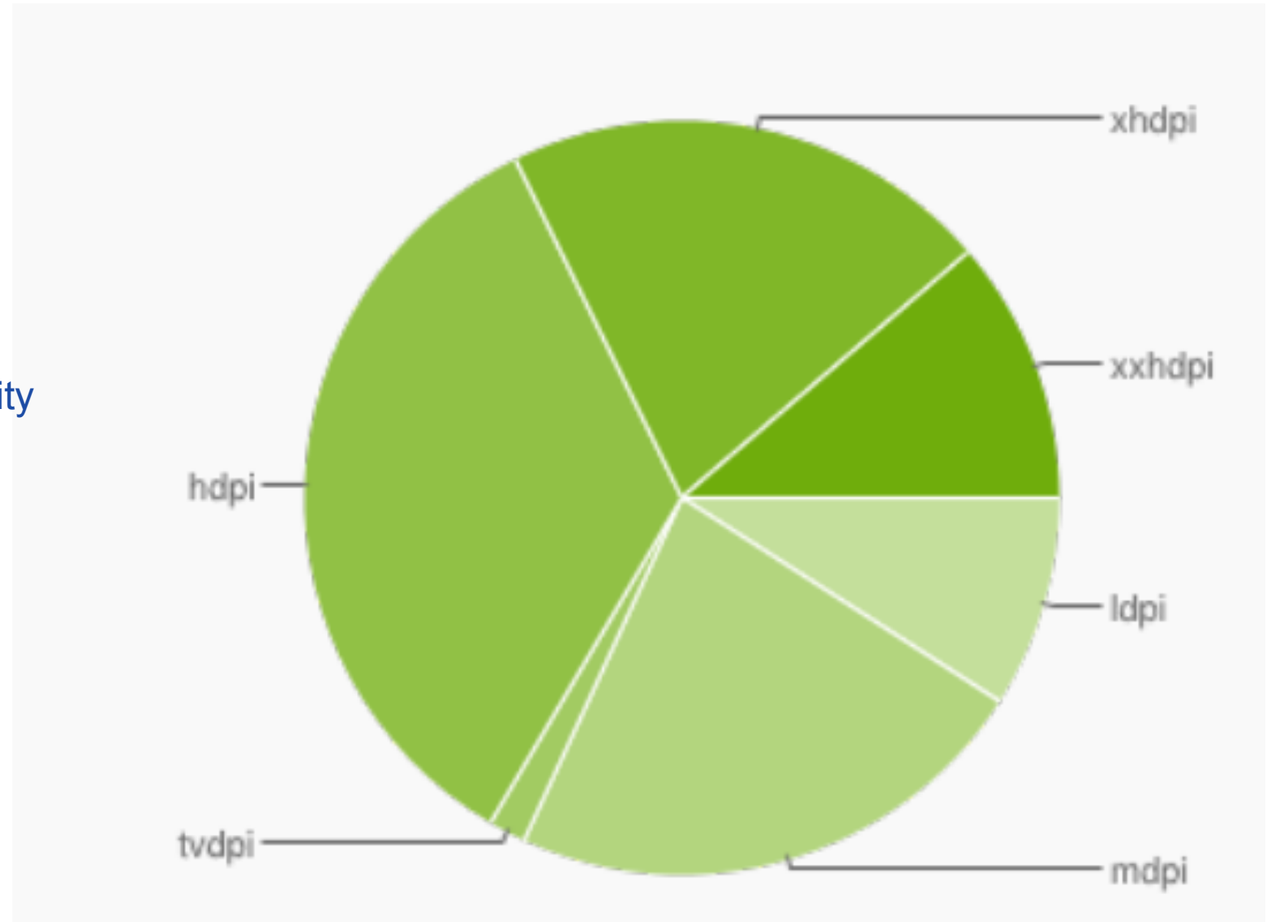
Device 2
LOW screen pixel density



XML Layout File
Device 1

XML Layout File
Device 2

SCREEN CONFIGURATION DISTRIBUTION



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

Android Components: Activities

- *Android applications typically use both the approaches*!

DECLARATIVE APPROACH

⇩

XML Code

⇨ Define the Application **layouts** and **resources** used by the Application (e.g. labels).

PROGRAMMATIC APPROACH

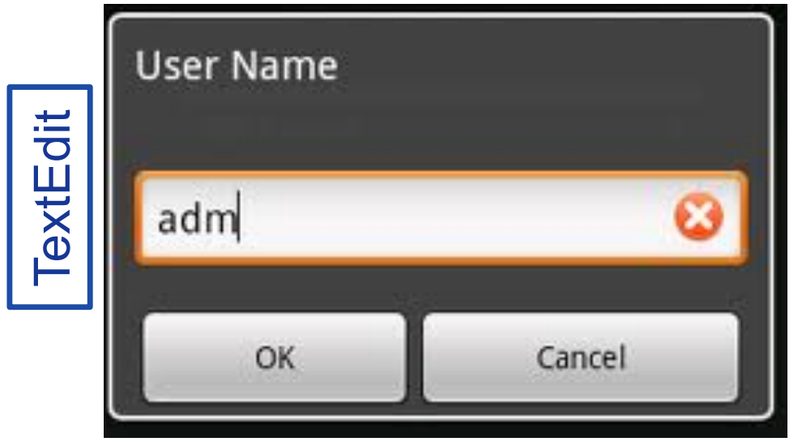
⇩

Java Code

⇨ Manages the **events**, and handles the **interaction** with the user.

Android Components: Activities

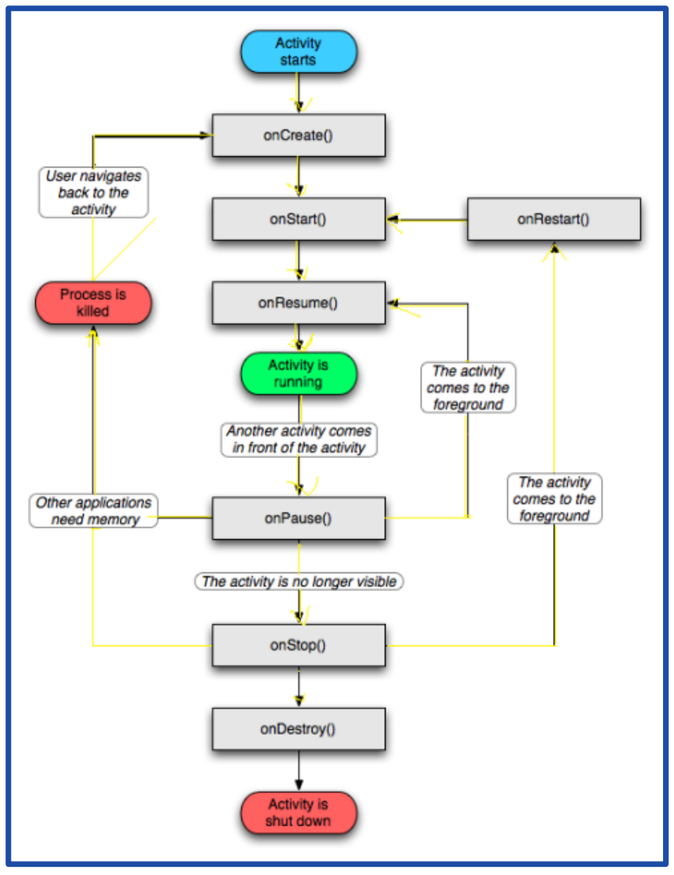
- **Views** can generate **events** (caused by human interactions) that must be managed by the Android-developer.



ESEMPIO

```
public void onClick(View arg0) {
        if (arg0 == Button) {
                // Manage Button events
        }
}
```

Android Components: Activities



- The **Activity Manager** is responsible for creating, destroying, managing activities.
- Activities can be on different **states**: *starting*, *running*, *stopped*, *destroyed*, *paused*.
- Only one activity can be on the **running** state at a time.
- Activities are organized on a **stack**, and have an event-driven life cycle (details later …)

Android Components: Activities

- Main difference between Android-programming and Java (Oracle) -programming:
  - **Mobile devices have constrained resource capabilities!**

- Activity lifetime depends on **users' choice** (i.e. change of visibility) as well as on **system contraints** (i.e. memory shortage).

- Developer must implement **lifecycle methods** to account for state changes of each Activity …

Android Components: Activities

```
public class MyApp extends Activity {

      public void onCreate() { ... }
      public void onPause()  { ... }
      public void onStop()   { ... }
      public void onDestroy(){ ... }
      ….
}
```

Called when the Activity is **created** the first time.

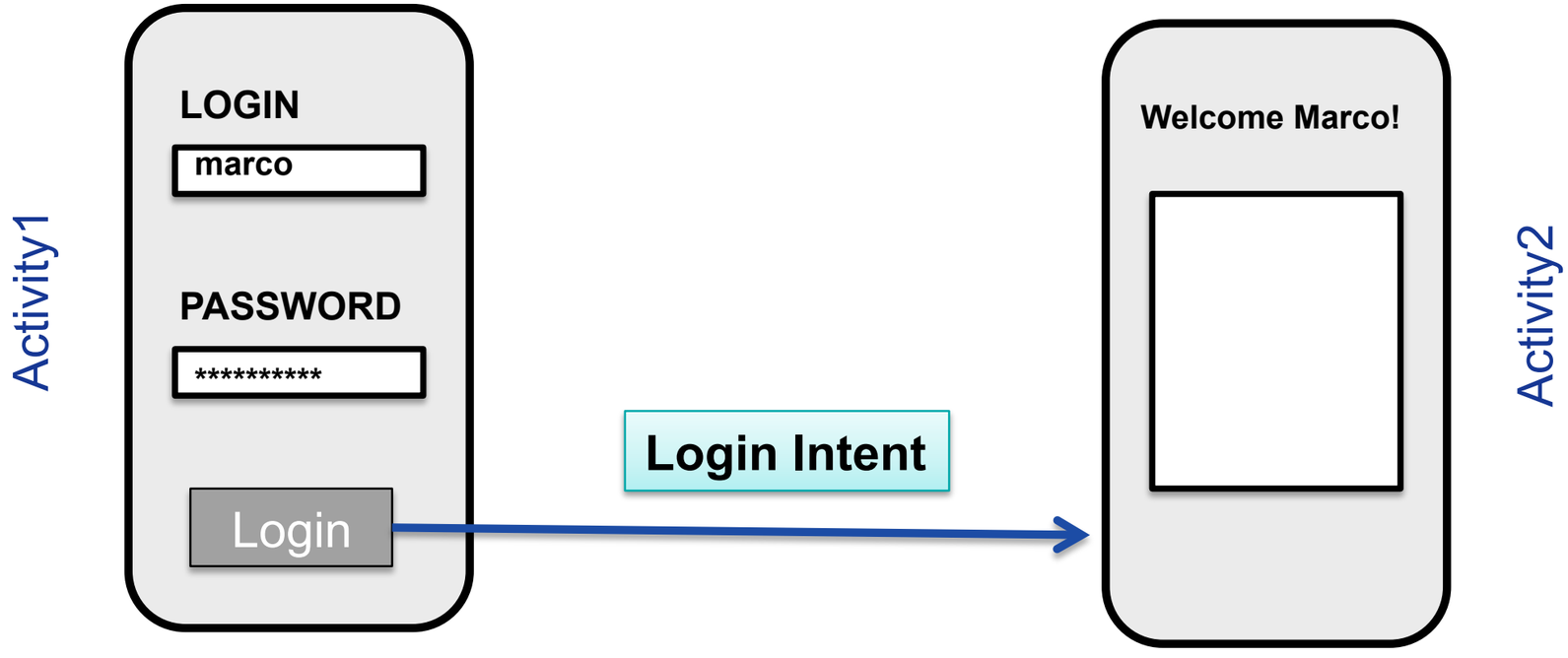
Called when the Activity is **partially visible**.

Called when the Activity is **no longer visible**.

Called when the Activity is **dismissed**.

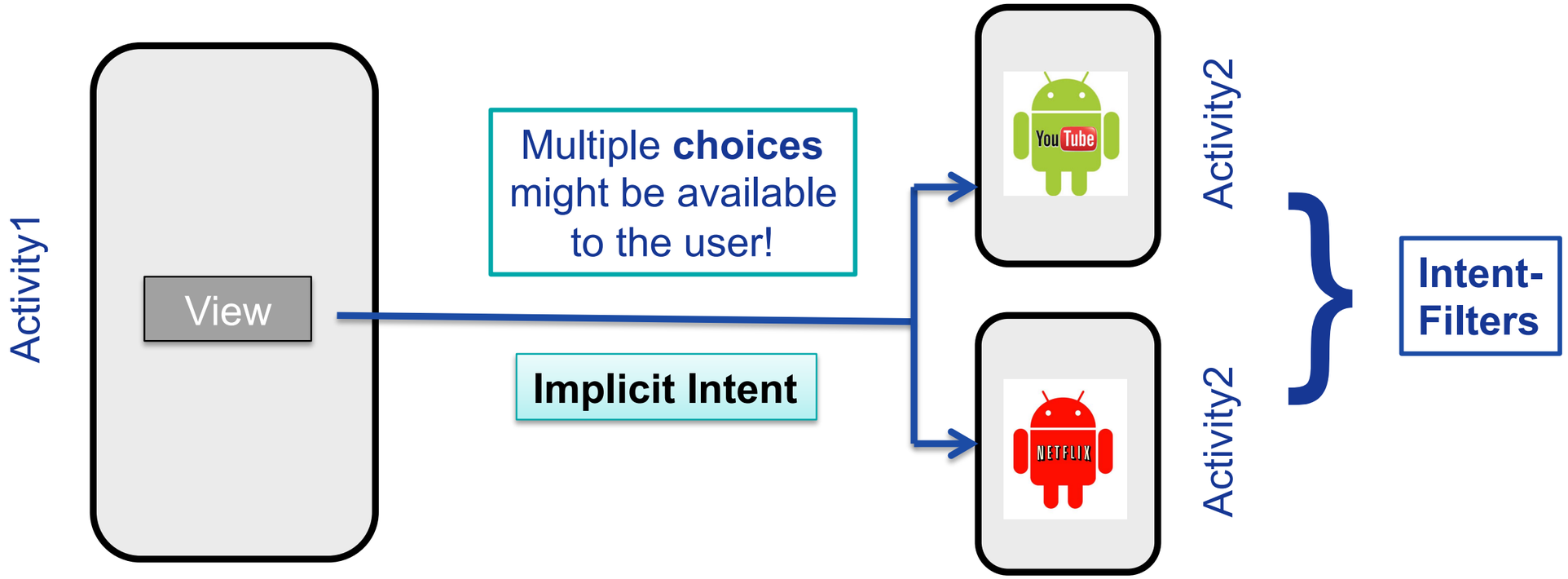
Android Components: Intents

- **Intents**: asynchronous **messages** to activate core Android components (e.g. Activities).
- **Explicit** Intent → The component *(e.g. Activity1)* specifies the destination of the intent *(e.g. Activity 2)*.



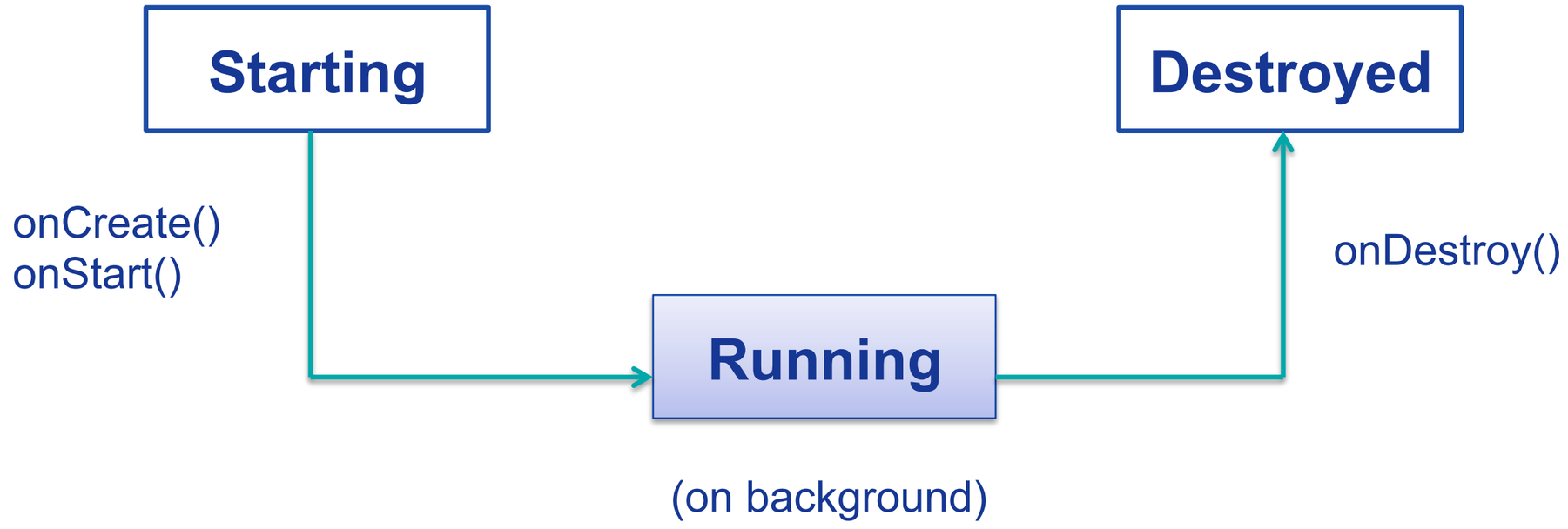
Android Components: Intents

- **Intents**: asynchronous **messages** to activate core Android components (e.g. Activities).
- **Implicit** Intent → The component *(e.g. Activity1)* specifies the type of the intent *(e.g. "View a video")*.



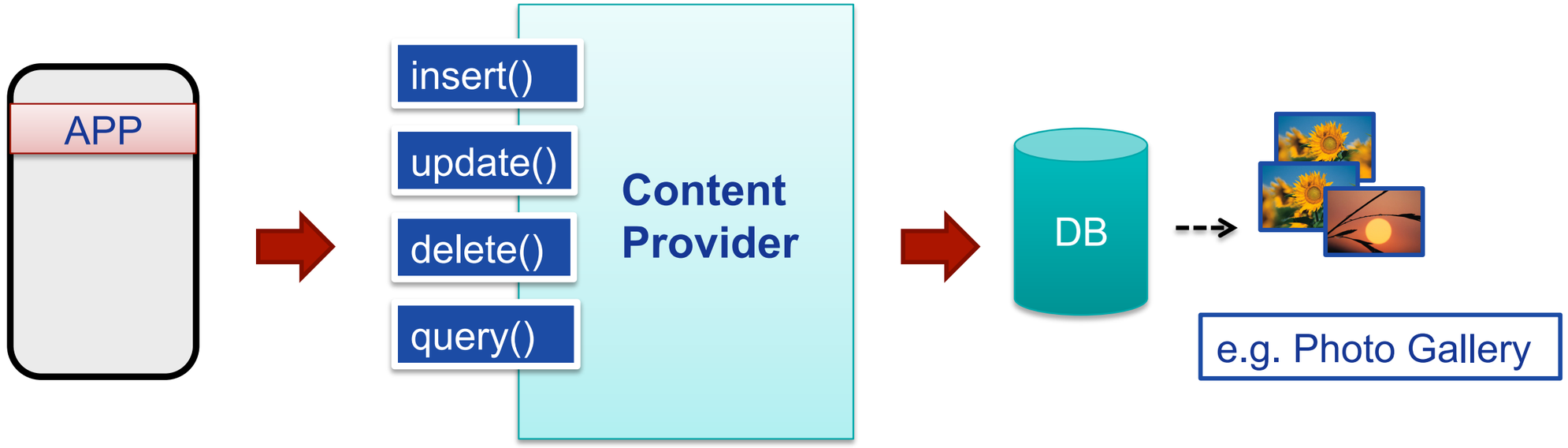
Android Components: Services

- **Services**: like Activities, but run in **background** and do not provide an user interface.
- Used for **non-interactive** tasks (e.g. networking).
- Service life-time composed of 3 states:

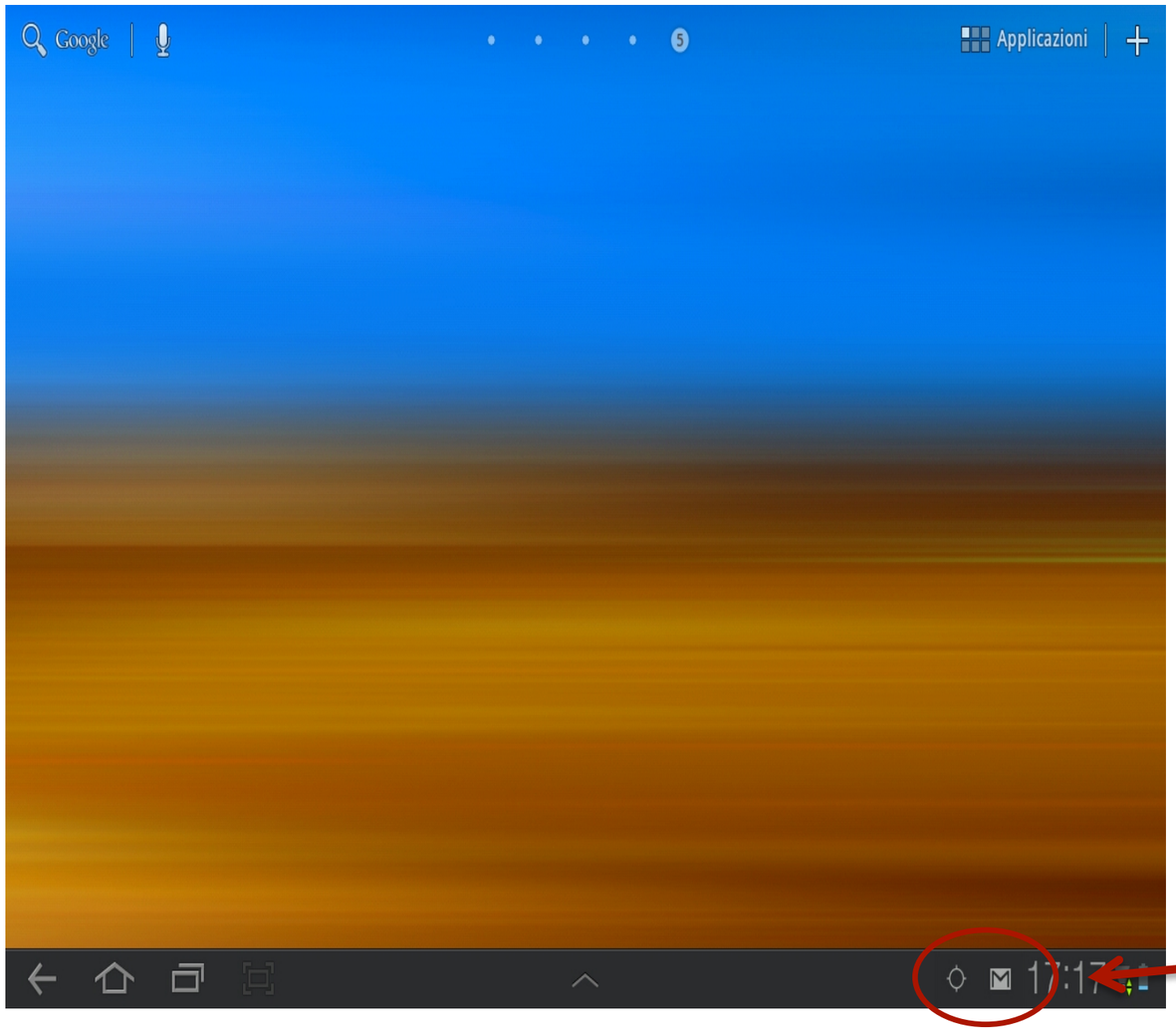


Android Components: Content Providers

- Each Android **application** has its own **private** set of data (managed through *files* or through *SQLite* database).
- **Content Providers**: Standard **interface** to *access and share data among different applications*.



Android Components: Broadcast Receivers



- *Publish/Subscribe* paradigm
- **Broadcast Receivers**: An application can be signaled of **external events**.
- **Notification** types: Call incoming, SMS delivery, Wifi network detected, etc

Android Components: Broadcast Receivers

BROADCAST RECEIVER example

```
class WifiReceiver extends BroadcastReceiver {
        public void onReceive(Context c, Intent intent) {
            String s = new StringBuilder();
            wifiList = mainWifi.getScanResults();
            for(int i = 0; i < wifiList.size(); i++){
                s.append(new Integer(i+1).toString() + ".");
                s.append((wifiList.get(i)).toString());
                s.append("\\n");
            }
            mainText.setText(sb);
        }
    }
```

Android Components: System API

- Using the **components** described so far, Android applications can then leverage the system API …

SOME EXAMPLEs …

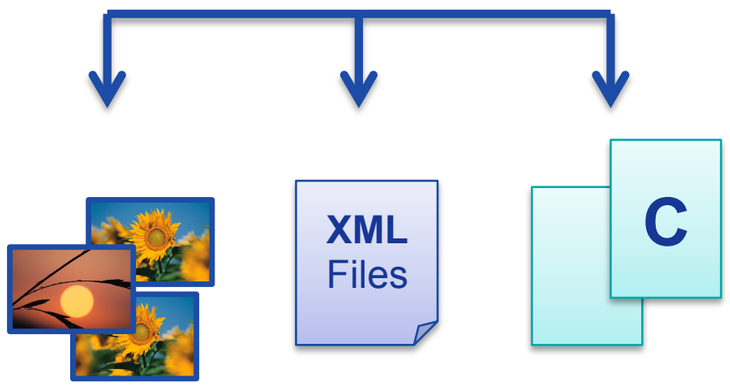
- *Telephony Manager* data access (call, SMS, etc)
- *Sensor* management (GPS, accelerometer, etc)
- Network *connectivity* (Wifi, bluetooth, NFC, etc)
- *Web* surfing (HTTP client, WebView, etc)
- *Storage* management (files, SQLite db, etc)
- ….

Android Components: Google API

- … or easily interface with other **Google services**:

Android Application Distribution

- Each Android **application** is contained on a single **APK** file.
  - Java **Byte-code** (*compiled for Dalvik JVM*)



  - **Resources** (e.g. images. videos, XML layout files)
  - **Libraries** (optimal native C/C++ code)

Android Application Distribution

- Each application must be signed through a **key** before being distributed.
- Applications can be **distributed** via *Web* or via *Stores*.
- **Android Play Store:** application store run by Google … but several other application stores are available (they are just normal applications).

Android Application Security

- Android applications run with a distinct system identity (Linux user ID and group ID), in an **isolated** way.
- Applications must explicitly share resources and data. They do this by declaring the ***permissions*** they need for additional capabilities.
  - Applications statically **declare** the permissions they require.
  - User must **give his/her consensus** during the installation.

ANDROIDMANIFEST.XML

```
<uses-permission android:name="android.permission.IACCESS_FINE_LOCATION" />

<uses-permission android:name="android.permission.INTERNET" />
```