Android

Operating System and Architecture

Android

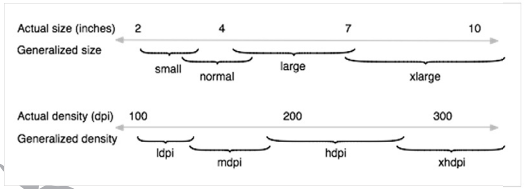
❖ Operating System and development system from Google and Open Handset Alliance since 2008

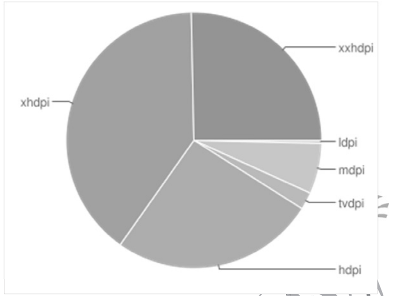
- At the lower level is based on the Linux kernel and in a higher level is based on a Java virtual machine
- Several versions in quick succession
  - 1.0, 1.1, 1.5 (cupcake), 1.6 (donut), 2.0, 2.1 (éclair), 2.2 (froyo), 2.3 (gingerbread), 3.0-2 (honeycomb) (tablets), 4.0 (ice cream sandwich), 4.1-3 (jelly beans), 4.4 (kitkat), 5.0-1 (lollipop), 6.0 (marshmallow), 7.0-1 (nougat), 8.0-1 (oreo), 9.0 (pie), 10.0 (Q)
- Supports a high hardware variability
- Integrates a sensor collection (gps, accelerometer, compass, gyroscope …)
- High graphics and sound quality
  - Screen densities of 120, 160, 240, 320 and 480 dpi and higher
  - Resolutions from 240x320 to 1600x2520 pixels (4K 2160x3840)

Screens

Aug. 2019

	Low	Med	TV	High	Xhigh	XXhigh	
Small	0.4%				0.1%	0.1%	< 3.0”
Normal		0.9%	0.3%	24.0%	37.7%	23.6%	from 3.0” to 5.5”
Large		2.4%	1.9%	0.6%	1.6%	1.7%	from 4.5” to 7.0”
Xlarge		3.1%		1.3%	0.6%		from 7.0” to 10.0”
	120 dpi	160 dpi	213 dpi	240 dpi	320 dpi	480 dpi	



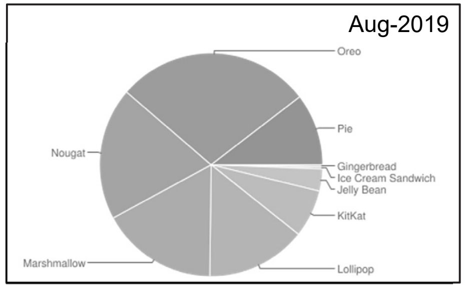


Actual screen resolutions:
from 240x320 pixels
to (4K = 2160x3840)

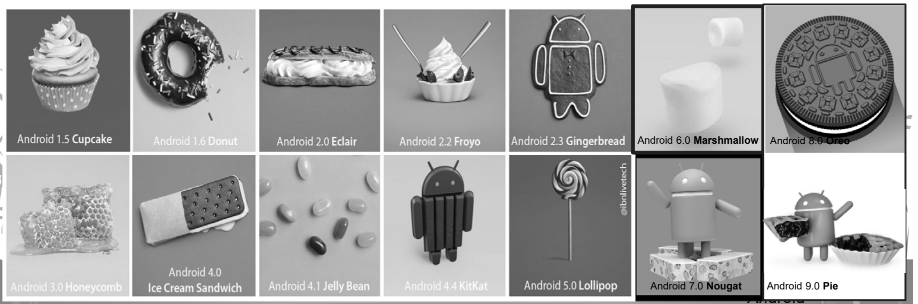
Main features

- ❖ Framework based in reuse and extension patterns
- ❖ Optimized virtual machine (Dalvik VM) → ART
- ❖ Integrates a browser (based on WebKit) → Blink
- ❖ 2D and 3D graphics (OpenGL ES 1.1, 2.0) → 3.2
- ❖ Local relational data base based on SQLite
- ❖ Several standard multimedia formats supported (MPEG4, H.264, MP3, AAC, JPG, PNG, GIF, …)
- ❖ Comms in GSM, 3G/4G, WiFi, Bluetooth and NFC
- ❖ Camera, GPS, compass and accelerometer
- ❖ Application development uses Java or Kotlin

Versions in use

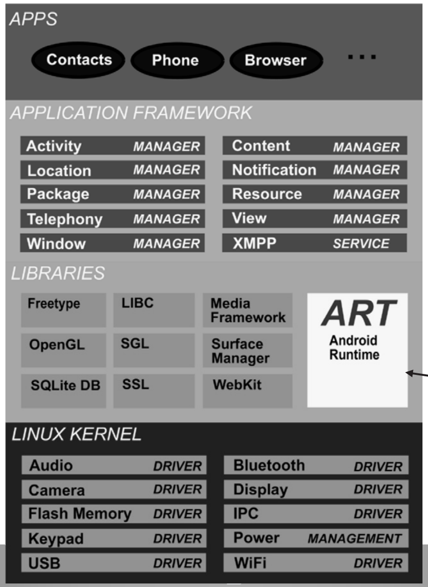


Platform	API Level	Distribution
Android 2.3.3-7	10	0.3%
Android 4.0.3-4	15	0.3%
Android 4.1-3	16-18	3.2%
Android 4.4	19	6.9%
Android 5.0-1	21-22	14.5%
Android 6.0	23	16.9%
Android 7.0-1	24-25	19.2%
Android 8.0-1	26-27	28.3%
Android 9.0	28	10.4%



Software Architecture

Android OS Layers and Components



Java code

C/C++ native compiled code

Java virtual machine
Java libraries
JIT and AOT compilers

OS

Operating system components (1)

- ❖ Linux kernel
  - Low level OS services (memory and process management, communications and network, files) and hardware access (peripheral and sensor drivers)
- ❖ Native libraries
  - Written in C/C++ and compiled to the processor native instructions
    - Surface management, 2D and 3D graphics, multimedia codecs, DBMS SQL, Web engine
    - Wrapped in Java
    - It is possible to develop and install new native libraries using the NDK (Native Development Kit)
- ❖ Android runtime
  - Java virtual machine optimized for small devices and processors (Dalvik VM)
  - Java base library (with some superposition with Java SE and Java ME)

Operating system components (2)

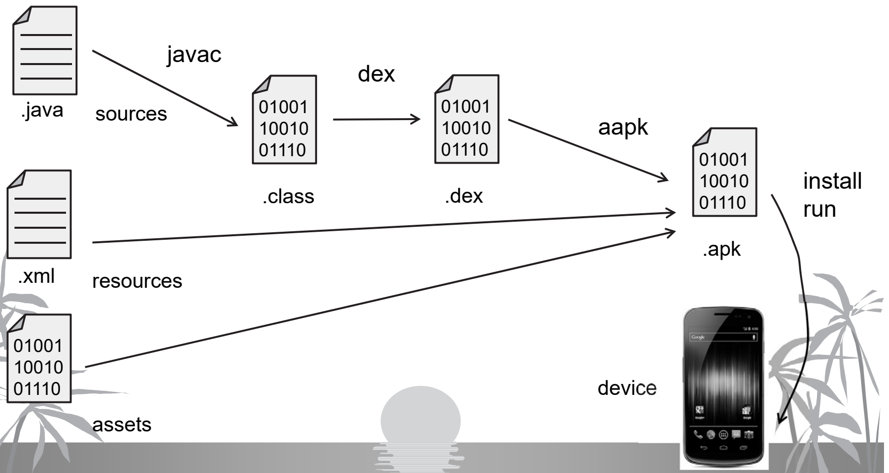
- ❖ Application Framework
  - High level library, in Java, suitable to the creation of user Android applications (Android API); also the higher level Android management services (Java)
    - Activity manager – controls the application lifetime and navigation between 'screens'
    - Content manager – control shared data between applications providing a standard format and access
    - Resource manager – Management of non-code specifications and assets in applications
    - Location manager – Android device position determination (the device knows always its position in the world using GPS Wi-Fi or GSM receptors)
    - Notification manager – External event management like messages, to-do's, alerts, etc

The Android system

- ❖Applications (Apps)
  - Programs that control the full screen to interact with the user
    - An Android device contains some pre-defined applications which are mandatory:
      - Home
      - Launcher
      - Phone dialer
      - Calendar and Email
      - Contacts
      - Web browser
      - Play Store
- ❖Widgets
  - Operate only on a small rectangular portion of the screen, inside the Home application

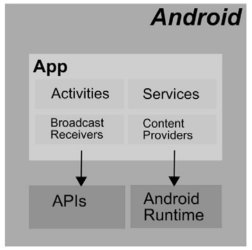
Building Applications

- ❖ Built from Java source code, Resources and Assets



Application components (1)

- ❖ The Android applications can contain several independent components
  - Activities, Services, Broadcast Receivers and Content Providers

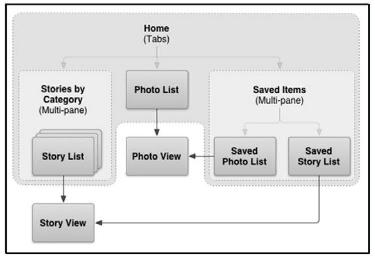


- ❖ Components
  - Activities
    - Contain a portion of the user interface (full screen or window)
    - Execute a well defined task inside the application
    - One application can contain one or more activities
    - Are independent but can be invoked by others
    - Are subclasses of the android.app.Activity class
    - Are usually composed by a hierarchy of Views
    - One activity must be the starting activity of an application

Application components (2)

- ❖Other components
  - Services
    - Don't have user interface
    - Can execute in background for an indeterminate period
    - It's possible to establish a connection with the service and communicate through a well defined programming interface
  - Broadcast receivers
    - Can receive and react to notifications originated in the system or other applications
    - Applications can initiate a notification 'broadcast'
  - Content providers
    - Make available to other applications a data collection maintained by this application
    - Define an interface to access, add and update the supported data types

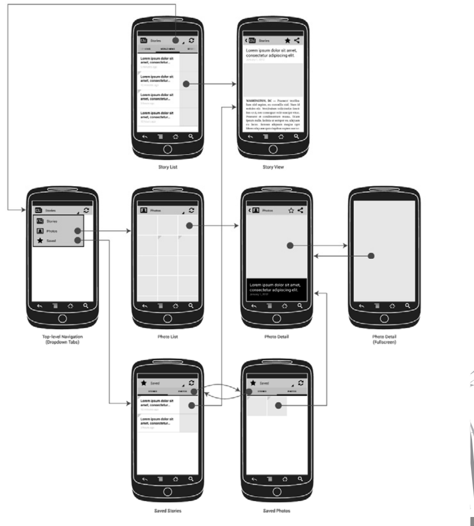
Application planning



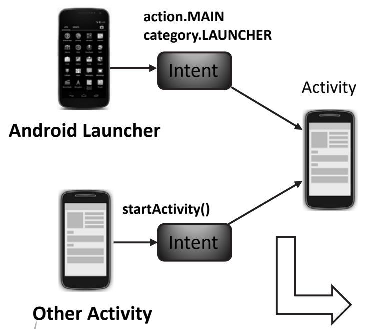
Activity Diagram

Navigation

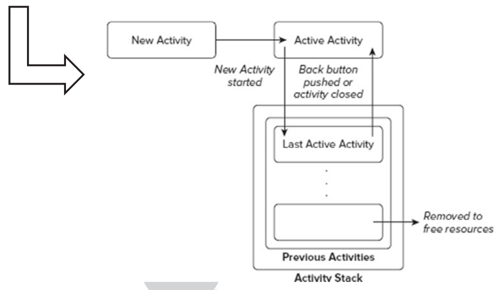
Sketch and Wireframe



Activity Launching



Back button



Component activation (1)

❖ Activities and Services

- Are activated through an *Intent*
- Intents identify the component or specify actions for activities and services
  - Explicit intents contain the class name of the destination
  - Implicit intents can specify an *action*, a *category*, *data* (in the form of an uri) and possibly *extra* information
    - Android will try to find a matching component capable of executing the action in the data (or data type) specified
  - When activities and services are declared in the manifest they can specify '*intent-filters*' describing their accepting intents

Inside an activity, when we need to navigate to other activity of the same application, we normally use an *explicit* intent:

```
Intent otherActivity = new Intent(thisActivity, OtherActivity.class);
thisActivity.startActivity(otherActivity);
```

Component activation (2)

❖ Broadcast receivers

- Intents for activating broadcast receivers identify a 'message' to be delivered to matching receivers
  - The 'message' is specified using an action, category, data and extra info (put together in an intent object)
  - It is sent by a call to sendBroadcast(Intent)
  - A broadcast receiver that has been installed matching the intent (with a compatible intent-filter) will be then activated (runs its onReceive(Context, Intent) method)

Component activation (3)

❖ Content providers

- When declared in the manifest they must have an ‘authority’ (which is a kind of provider name)
- Also they must recognize a name for its data collection
- Usually they support CRUD operations on that collection
- They are activated through a ContentResolver object
  - Obtained by getContentResolver() method from an activity
  - ContentResolvers have operations (methods) like: query, insert, update and delete
  - These methods require a Uri identifying the provider and data collection following the format
    - content://<authority>/<data collection>[/<item>]

Intents

❖ Component invocation mechanism

- For Activities (UI), Services (background), Broadcast Receivers (notifications)
- All the *intents* have a name (action) and can have more data associated (uri, category, extra info)
  - They can be also *explicit* with a class name (inside an app)
- An *intent* is a class in the Android API
- There are many pre-defined *intents* in the Android API

Example 1:

```
Intent intent = new Intent(Intent.ACTION_DIAL);
startActivity(intent);
```

Matches the Android activity (in the Dialer application) that allows the user to make a phone call, declared in an <intent-filter> that can handle this action

Example 2:

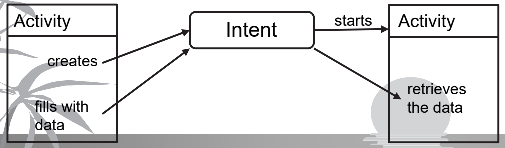
```
Intent intent = new Intent(Intent.ACTION_CALL);
intent.setData(Uri.parse("tel:555-555-5555"));
startActivity(intent);
```

Matches the activity that makes a phone call from a number

Intents data

❖ Intents can transport data between components

- The Data field can be used for any type of an Uri
  - The calling component uses the method setData(Uri data), while the new component can read it with Uri getData()
- The Extra field is used for arbitrary data types
  - It is a Bundle – set of (name, value) pairs organized as an hash table
    - The value can be a String, simple type, or an array
    - Can also be any Serializable or Parcelable (more efficient) object
    - The values are inserted with some PutExtra(String name, ... value) method and retrieved with ... get...Extra(String name)



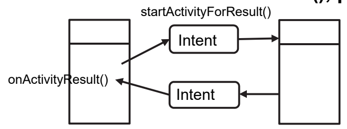
```
protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
     ...
    Intent intent = getIntent();

    String fName = intent.getStringExtra("firstName");
    String lName = intent.getStringExtra("lastName");
}
```

Getting result data

❖ Specially invoked activities can return data

- Invocation using startActivityForResult(...)
  - Besides the intent, it has a requestCode (int) as a parameter
    - The new activity should create a result Intent, fill it with the result data, and call setResult(), passing this intent, before finishing



```
...
Intent resultIntent = new Intent();
resultIntent.putExtra("some_key", "String data");
setResult(Activity.RESULT_OK, resultIntent);
finish();
```

    - The original activity can retrieve this intent and get the data

```
@Override
public void onActivityResult(int requestCode, int resultCode, Intent data) {
  super.onActivityResult(requestCode, resultCode, data);
  switch(requestCode) {
    case (MY_CHILD_ACTIVITY) : {
      if (resultCode == Activity.RESULT_OK)
          String returnValue = data.getStringExtra("some_key");
      break;
    }
  }
}
```