# Deep Inside Android...

OpenExpo 2008 - Zurich
September 25th, 2008

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## Agenda

- What is Android?
- The Android platform
- Anatomy of an Android application
- Creating and deploying an application

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# What is Android?

***A complete software stack for mobile devices.***

## Introducing Android

A first joined project of the Open Handset Alliance (OHA).

- First open, complete and free platform
- Software stack open-sourced under Apache 2.0 license
- Source code will be available and everyone will have the capability to built an image

## The Android platform

It includes an operating system, a middleware and some applications.

- Lightweight and full featured
- Developers can extend and replace existing components

## A generous development environment

A SDK is available to build, compile, test and debug user applications.

- Applications are developed using Java programming language
- No difference between the built-in applications and the user ones

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## Agenda

What is Android?

- **The Android platform**
  - Linux Kernel
  - Native Libraries
  - Android Runtime
  - Application Framework…

Anatomy of an Android application

Creating and deploying an application

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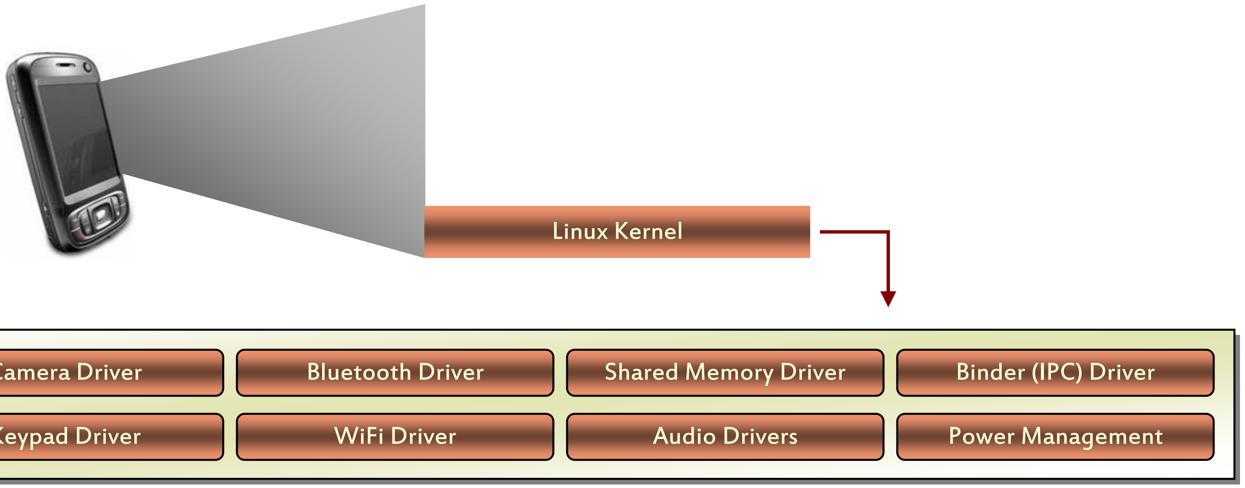
## Linux Kernel



### A Linux 2.6.24 fit for Android

Some common features have been removed

- No GBLIC support
- No native windowing system
- Does not include the full set of Linux utilities

New Android specific components have been added

- Alarm, “Android Shared Memory”
- “Kernel Memory Killer”, Kernel Debugger, Logger

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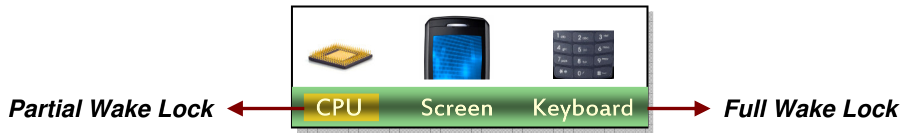
# Linux Kernel (cont.)

## "Power Management"

Based on the standard Linux Power Management, Android has its own component.

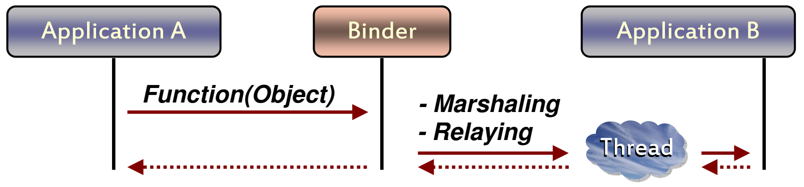
- Application uses user space library to inform the framework about its constrains.
- Constraints are implemented using lock mechanism.



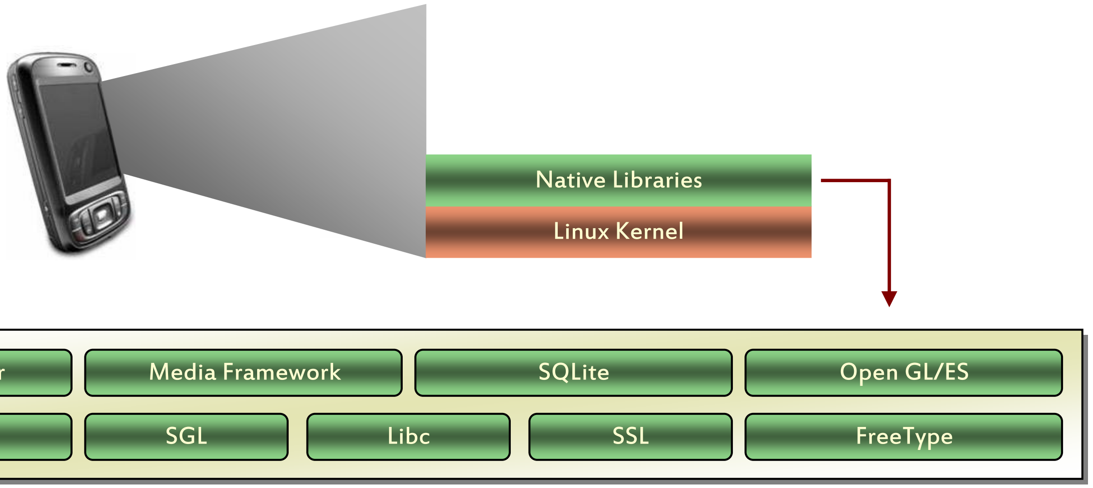
## "Binder"

Driver to facilitate inter-process communication between applications and services.

- A pool of threads is associated to each application to process incoming IPC
- The driver performs mapping of object between two processes
- "Binder" uses an object reference as an address in a process's memory space



# Native Libraries



## Android "Libc" implementation

A custom implementation, optimized for embedded use.

- BSD license
- Small size and fast code paths
- Very fast custom pthread implementation
- Built-in support for android-specific services (system properties, log capabilities)

- Doesn't support some POSIX features

## Native Libraries (cont.)

### Storage, rendering, multimedia,…

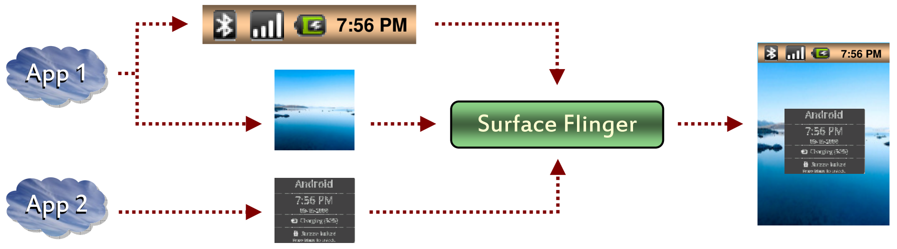
Provides the main features on the Android platform:

- "SQLite", a simple relational database management system (No IPC, single file,…)
- "WebKit", an application framework that provides foundation for building a web browser
- "Media Framework", based on PacketVideo openCORE platform (codec)
- Optimized 2D/3D graphic library based on OpenGL ES
- …

### "Surface Manager"

Provides a system-wide surface "composer" to render all the surfaces in a frame buffer.

- Can combined 2D and 3D surfaces
- Can use OpenGL ES and 2D hardware accelerator for its compositions

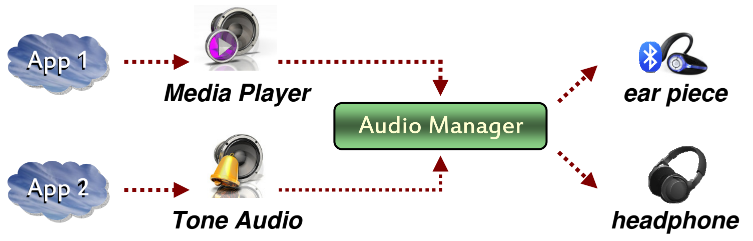


# Native Libraries (cont.)

## "Audio Manager"

Processes multiple audio streams into PCM audio out paths.

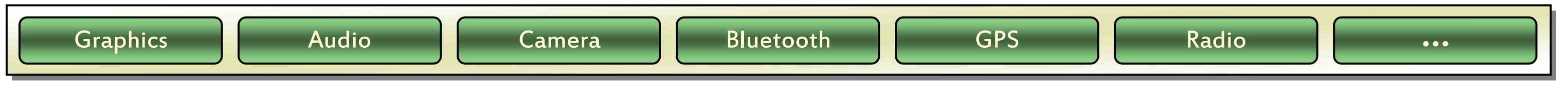
- Handle several types of devices (headphone, ear piece,…)
- Redirects audio stream to the specified output



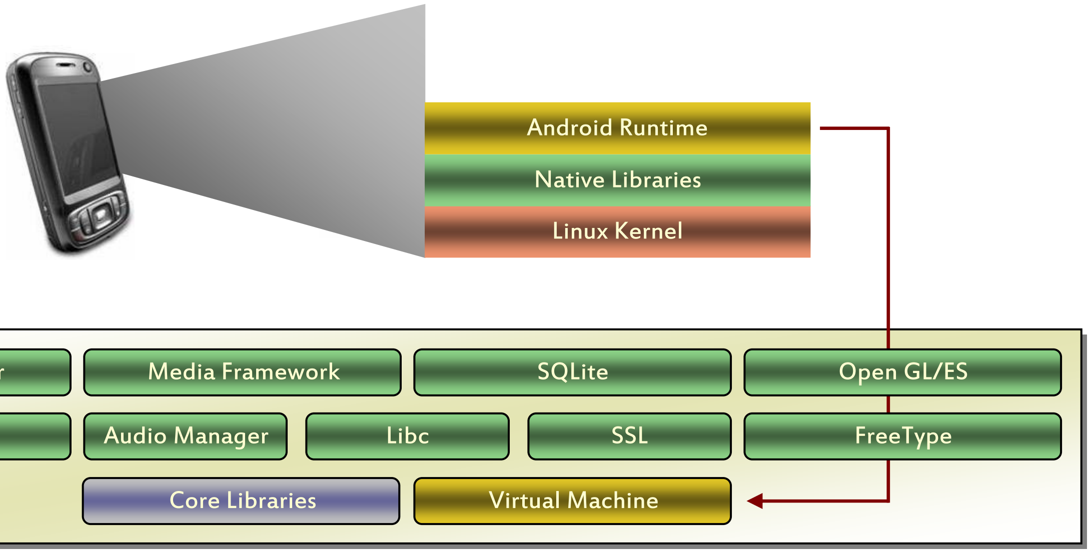
## "Hardware Abstraction Libraries"

Defines the interface that Android requires hardware "drivers" to implement.

- Set of standardized APIs the developer will have to implement
- Available for all the components a manufacturer can integrate on its Android platform



## Android Runtime



### Dalvik Virtual Machine

An interpreter-only virtual machine (no JIT), register based.

- Optimized for low memory requirements
- Designed to allow multiple VM instances to run at one
- Relying on underlying OS for process isolation, memory management and threading support
- Executes Dalvik Executables (DEX) files which are zipped into an Android Package (APK)

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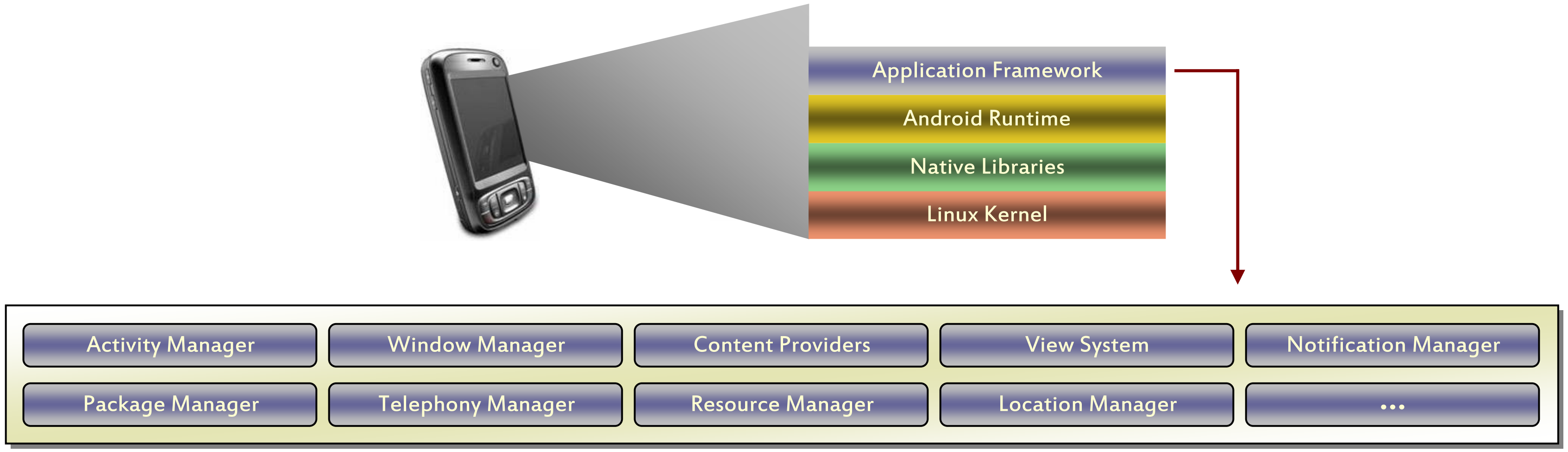
## Application Framework



### Some essential services…

However, home made applications don't interact directly with them.

- "Activity Manager" handles application lifecycle
- "Package Manager" holds information about applications loaded in the system
- "Windows Manager" handles all the application related windows
- "View system" provides all the standard widgets to build an application

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- Hardware services provide access to lower-level hardware APIs:
  Bluetooth, telephony, location,…

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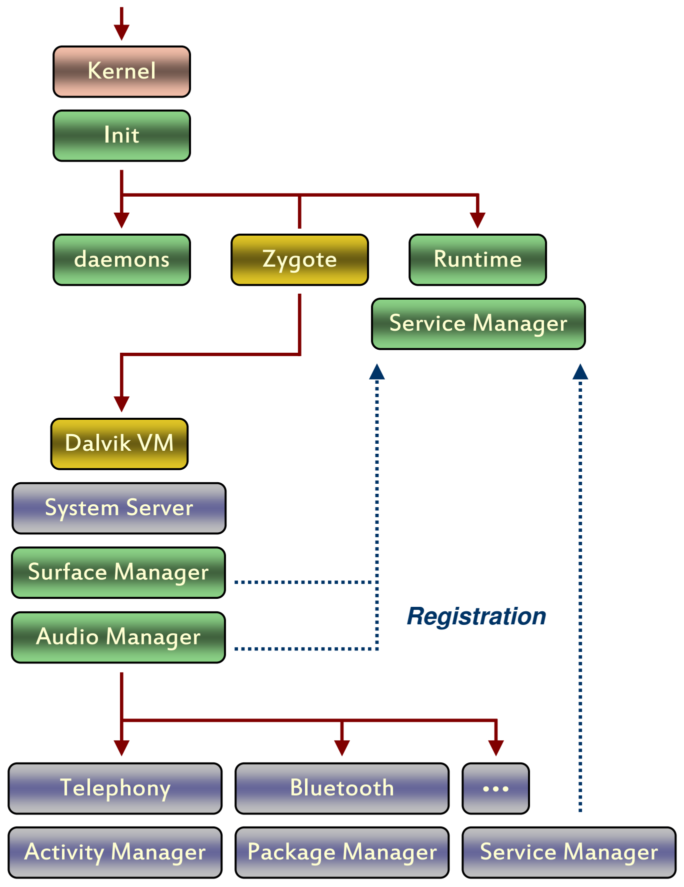
## Platform initialization



*The bootloader loads the kernel and starts the init process*

*Daemons for handling low level hardware interfaces are started up (usb, adb, debugger, radio)*

*"Zygote", the initial Dalvik VM process is created*

*"Runtime" process initiates the "Service Manager", a key element for "Binders" and IPC communication*

*"Runtime" process requests "Zygote" to start a new instance of Dalvik for running the "System Server"*

*The two first processes are able to handle graphic and audio outputs*

*All the others android components are then started*

## Agenda

What is Android?

The Android platform

- **Anatomy of an Android application**
  - Activity
  - Service
  - Content Provider
  - Processes and Tasks…

Creating and deploying an application

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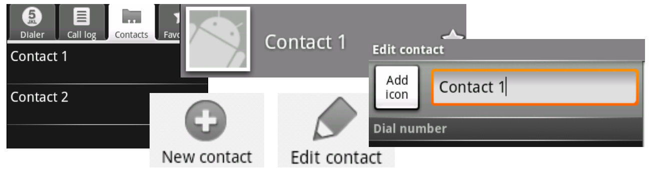
## "Activity"

***One single screen in an Android application***

### What is really an "Activity"?

Displays a user interface component and responds to system/user initiated.

- When an application has a user interface, it contains one or more "Activities"
  One activity is then considered as the main entry point by the system
- An existing "Activity" can be replaced with a new one that fulfill the same contract
- Each "Activity" can be invoked from others applications



Adding a new "Activity" in an Android project

- The new Java class must extend the framework "Activity" class
- Created "Activity" must be defined into the application's Manifest

```
<activity android:name=".sampleActivity"
          android:label="@string/app_name">
     ...
</activity>
```

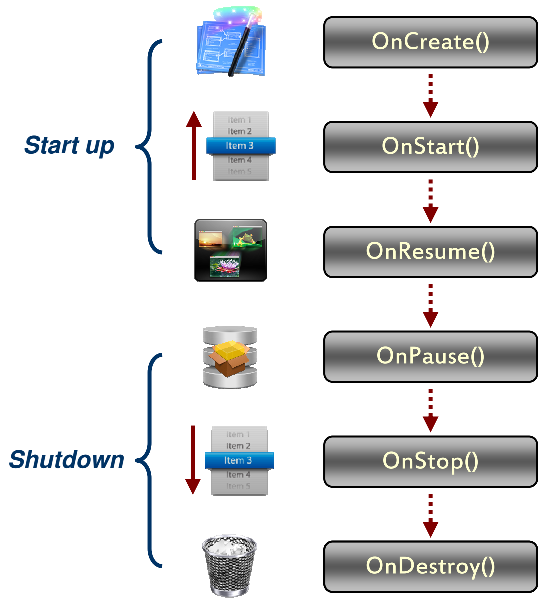
Class name

# "Activity" Lifecycle

***Android maintains an history stack***
***of all the activities which are spawned in an application***

## A "Classic" scenario

An "Activity" is started and explicitly finalized (i.e. *finish()* is called).



*First method called during lifetime; the "Activity" is created*
→ ***Initialize all the resources (i.e. create a thread, connection to a database)***

*Execution of the "Activity" can start at anytime; system put it on top of the stack*
→ ***Activity is on-screen (may be not in foreground); user cannot interact with.***

*Activity is visible to the user and has the focus.*

*Focus is lost and potentially the "Activity" will shutdown*
→ ***Save data (persistence)***

*"Activity" is no more on the top of the stack*

*"Activity does not exist anymore in the system*
→ ***Resources can be freed***

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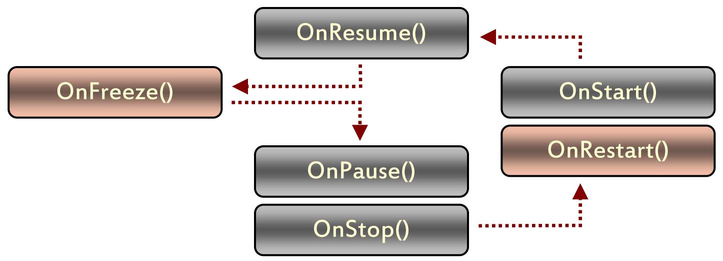
# “Activity” Lifecycle (cont.)

## Switching between “Activities”

Android will notify the running “Activity” through two new callbacks.



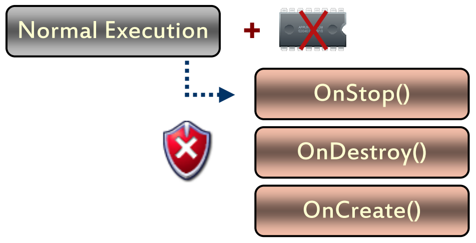
*On Freeze(): All the “Activity” to save UI state*
***Save the value belonging to the UI (i.e. field in a form)***

*On Restart(): Signal the “Activity” will be restarted*

## Dropping an “Activity”

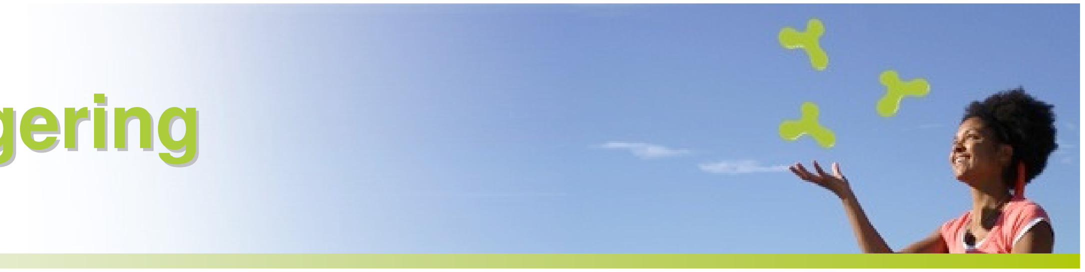
An “Activity” can be dropped from memory only in the following specific states:

- When it is paused, even if it is completely alive
- When it is completely obscured by another “Activity” (stopped)



*The system can:*
*- Ask the user to finish it*
*- Directly kill the process it belongs to*

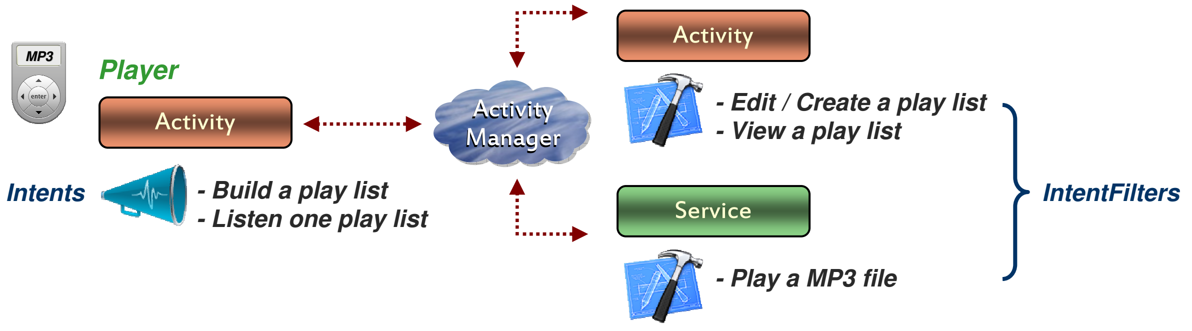
# Navigation and Triggering



## "Intents / Intent Filters"

Simple message objects that represent:

- An intention to do something
- A declaration of capacity and interest in offering assistance to those in need



An "intent" is made up a number of pieces of information describing the action or the service:

- "action" attribute is typically a verb (*VIEW*, *EDIT*, *DIAL*,…)
- The data to operate on is expressed in the form of an Universal Resource Identifier (URI)
- "category" attribute gives additional information about the action to execute

```
<intent-filter>
  <action android:value="android.intent.action.VIEW" />
  <data android:mimeType="com.esmertec.player/media/12" />
</intent-filter>
```

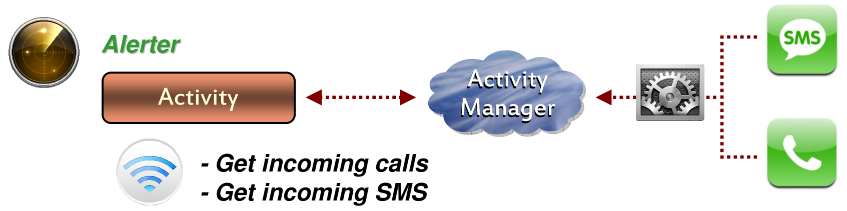
# "Broadcast Intent Receiver"

***Broadcasted notifications from the system***

## When using these "Receivers"?

When an application desires to receive and respond to a global event.

- In order to be triggered when an event occurs, application does not have to be running
- By default, Android includes some built-in "Intents Receiver"



How to receive these specific "Intents"?

- The user class must extend the framework "IntentReceiver" class
- To process incoming "Intents", "onReceiveIntent()" method is implemented
- "receiver" element must be described into the application's Manifest

```
<receiver android:name=".Alerter">  ←— Class name
  <intent-filter>
    <action android:name="android.provider.Telephony.SMS_RECEIVED" />
  </intent-filter>
</receiver>
```

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# “Service”

## *A long-running background task*

### Defining and invoking a “Service”

Adding a “Service” with Android is quite similar than for an “Activity”.

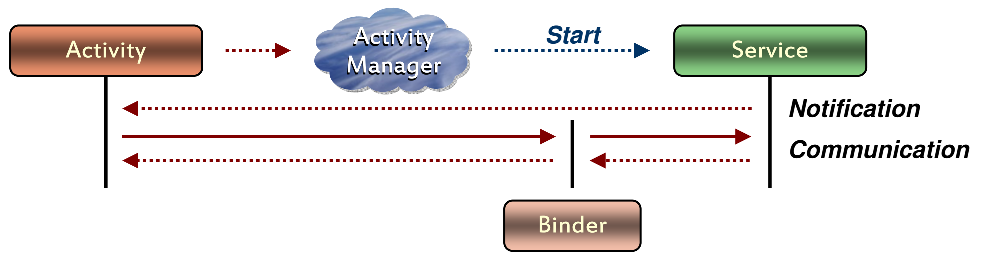
- Framework “Service” class must be extended
- The new “Service” must be defined into the application’s Manifest

```
<service class=".AdderServiceImpl"/>
```

***Class name***

When a “Service” is using IPC, an AIDL description of its features is also needed.

- Android Interface Definition Language (AIDL) is used to generated code to allow communication between two processes through IPC
- This mechanism is interface-based, similar to Corba (Unix) or COM (windows) but lighter weight
- With this specific mode, the “Service” is started through the binder and not with “*startService()*”



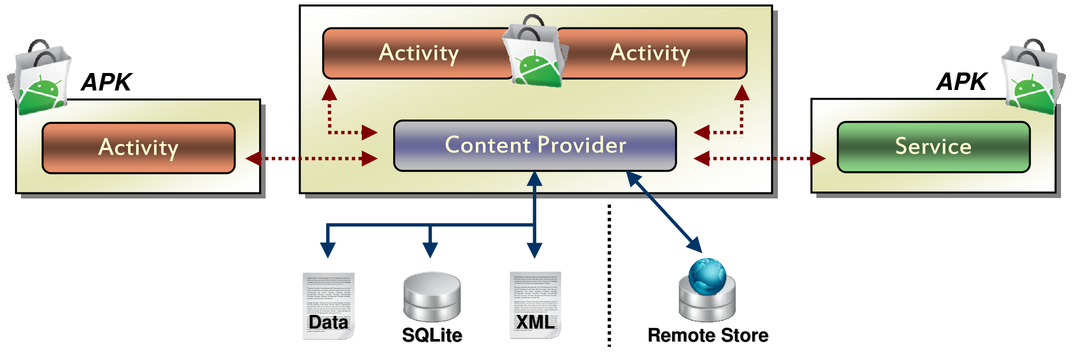
## "Content Provider"

***Handle data and expose them to other applications***

### Why using a "Content Provider"?

The only way to share data between Android applications.

- It implements a standard set of methods to allow access to a data store
- Any form of data storage can be used like SQLite database, files, or memory hash map



A "Content Providers" exposes a unique URI used to query, add, update and delete data:

- A standard prefix ("content://")
- The authority part (fully-qualified to ensure uniqueness)
- The path to determine what kind of data is being requested
- A specific record being requested, if any

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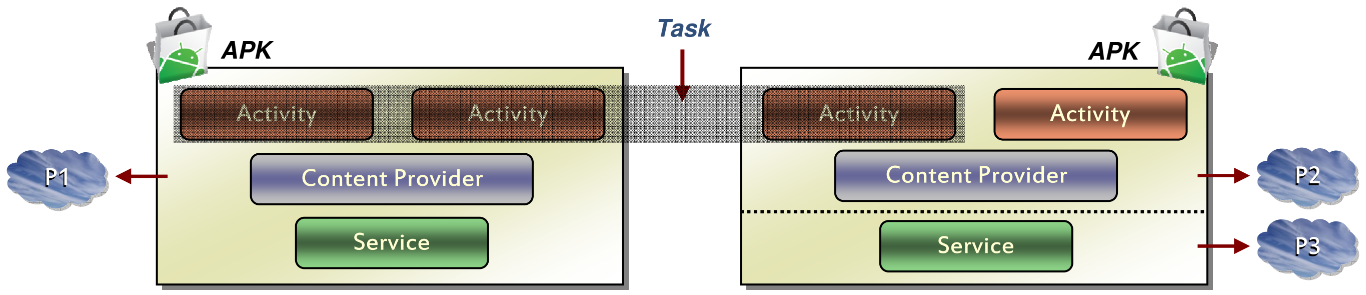
# Processes and Tasks

## *A relation between the kernel and Android*



## Processes

A low-level kernel process in which an application's code is running.

- By default, Android binds the content of an APK to a Linux process
- "Process" tag can be used to tune this relation with a lower granularity (activity, service,…)

## Tasks

A notion that users know on other platform as "application".

- A collection of related "Activities"
- Capable of spanning multiple processes
- Interaction with "Activities" can be controlled through "Activity's launchMode" attribute

## Agenda

What is Android?

The Android platform

Anatomy of an Android application

- **Creating and deploying an application**
  - Eclipse plug-in
  - Building the package
  - Running the application
  - Debugging environment…

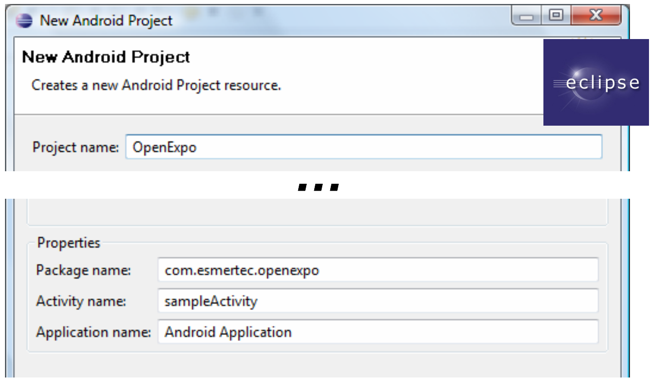
# Creating an Application

## Using the "Eclipse" plug-in

After some clicks, a "basic" application can be created, compiled and executed.

- Only some properties are required to create an Android skeleton
- The plug-in creates all the file/directories useful to generate the final APK
- It can be freely downloaded by following the instructions at

http://code.google.com/android/intro/installing.html



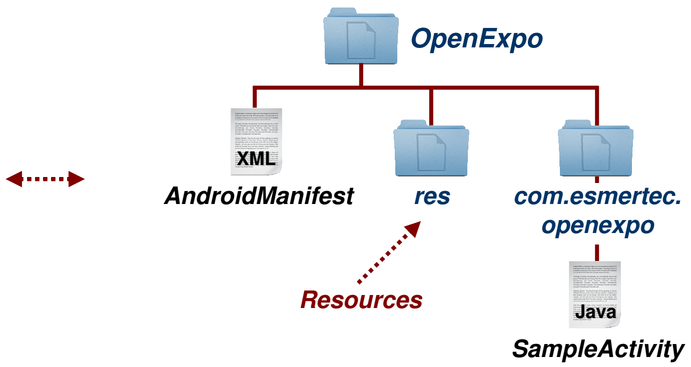
New Android Project

New Android Project
Creates a new Android Project resource.

Project name: OpenExpo

...

Properties
Package name: com.esmertec.openexpo
Activity name: sampleActivity
Application name: Android Application



An element of a complete development environment containing:

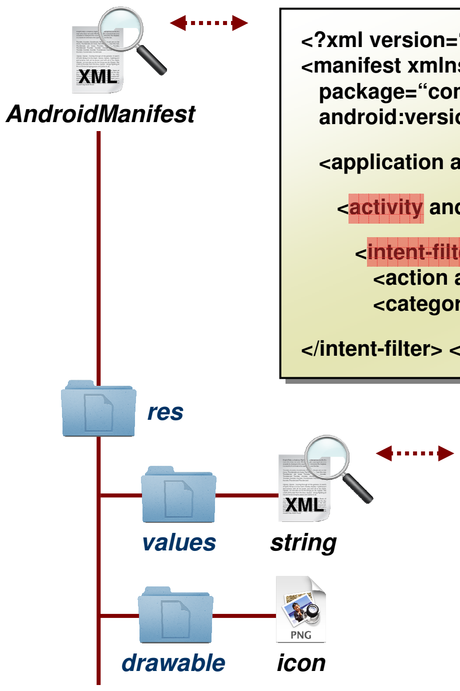
- An Android emulator which mimics the hardware and the software of a mobile phone
- Some tools for debugging, tracing, logging…

## Creating an Application (cont.)

### "AndroidManifest.xml" file

Describes the application components that the package exposes.

- This file is mandatory and is located at the root of the application directory
- A top-level application presented to the user must include at least one "Activity" that supports the "MAIN" action and "LAUNCHER" category



```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
  package="com.esmertec.openexpo"
  android:versionCode="1" android:versionName="1.0.0">

  <application android:icon="@drawable/icon" android:label="@string/app_name">

    <activity android:name=".SampleApp" android:label="@string/act_name">

      <intent-filter>
        <action android:name="android.intent.action.MAIN" />
        <category android:name="android.intent.category.LAUNCHER" />

</intent-filter> </activity> </application> </manifest>
```

```
<?xml version="1.0" encoding="utf-8"?>
<resources>
  <string name="act_name"> SampleActivity </string>
  <string name="app_name"> Android Application
</string>
</resources>
```

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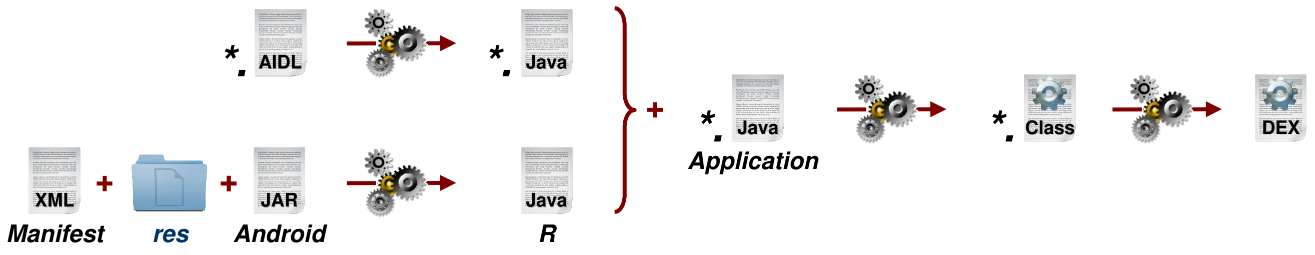
# Building an APK…

## Dalvik Executable (DEX files)

A optimized format for efficient storage and memory mappable definition.

- All classes are compiled with a standard Java language compiler
- Migration between a standard class file and the Android bytecode is done with the “dx” tool
  (For debugging purpose, it can also present a people-friendly readable format)



Generating the Android specific java files:

- When an application contains IPC services, AIDL files must be preprocessed to get Java classes
- Interface based AIDL tool saves developer the time used to write marshalling code

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- All Android projects have a resource ID file called “R.java”
- It’s basically a series of integers that can be used to reference the actual resources
- This file is generated automatically by “aapt” and should not be edited

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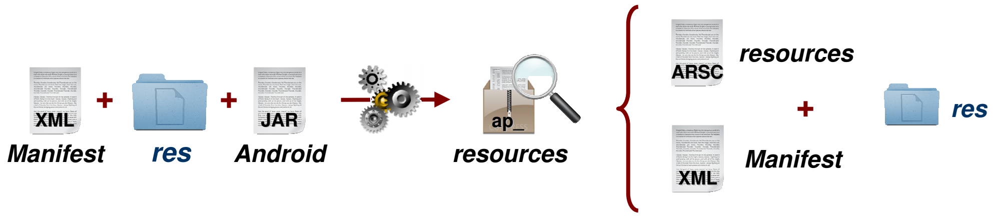
# Building an APK… (cont.)

## Packaging the resources

During the build process, an archive containing application resources is also created.

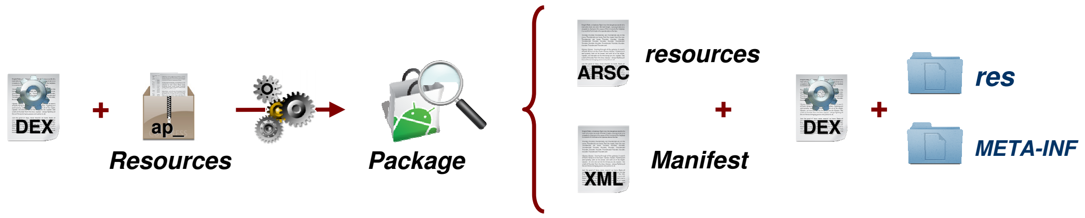
- This file is automatically generated by the “aapt” utility
- Among other things, it’s made up of an index resource file called “resources.arsc”



## Generating the Android PacKage (APK)

Typically, an APK includes all the files related to a single Android application:

- A compressed collection of “AndroidManifest.xml”, application code, resources…
- Additionally, “META_INF” directory can integrate certificates used to sign application



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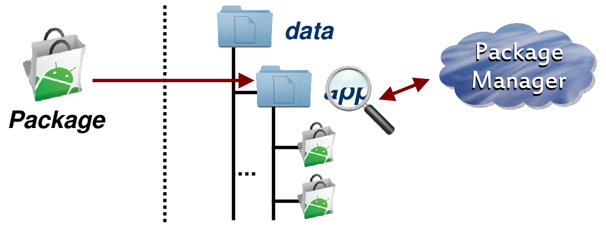
# Running the application

## Installing / Removing a package

All Android applications are handled by the “Package Manager”.

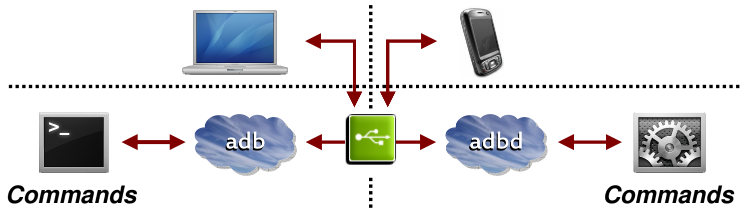
- An APK must just be uploaded to a specific directory
- Two locations are monitored: “/data/app” (user) and “/system/app” (system)



## Android Debug Bridge (ADB)

A client/server application used as a gateway to communicate with the device. It allows:

- Copying files to/from the device or the emulator (“push”, “pull”, “install”)
- Running shell binary commands



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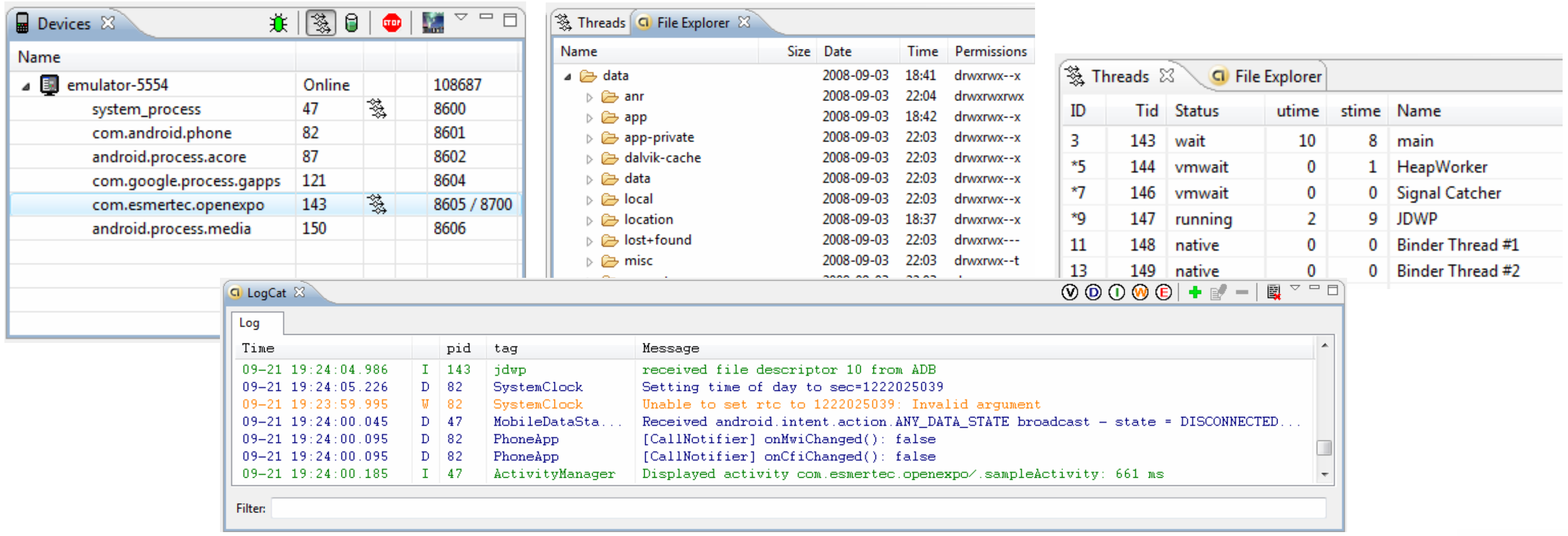
# Debugging environment

## Dalvik Debug Monitor Service (DDMS)

A GUI application providing debugging information to Android developers:

- Processes and threads examination
- Memory heap statistics and allocation tracker
- Emulator controls to simulate specific device events
- File explorer to perform basic management on the file system
- Dump of the printed out messages,…



| Name | | | | |
|---|---|---|---|---|
| emulator-5554 | Online | | | 108687 |
| system_process | 47 | | | 8600 |
| com.android.phone | 82 | | | 8601 |
| android.process.acore | 87 | | | 8602 |
| com.google.process.gapps | 121 | | | 8604 |
| com.esmertec.openexpo | 143 | | | 8605 / 8700 |
| android.process.media | 150 | | | 8606 |

| Name | Size | Date | Time | Permissions |
|---|---|---|---|---|
| data | | 2008-09-03 | 18:41 | drwxrwx--x |
| anr | | 2008-09-03 | 22:04 | drwxrwxrwx |
| app | | 2008-09-03 | 18:42 | drwxrwx--x |
| app-private | | 2008-09-03 | 22:03 | drwxrwx--x |
| dalvik-cache | | 2008-09-03 | 22:03 | drwxrwx--x |
| data | | 2008-09-03 | 22:03 | drwxrwx--x |
| local | | 2008-09-03 | 22:03 | drwxrwx--x |
| location | | 2008-09-03 | 18:37 | drwxrwx--x |
| lost+found | | 2008-09-03 | 22:03 | drwxrwx--- |
| misc | | 2008-09-03 | 22:03 | drwxrwx--t |

| ID | Tid | Status | utime | stime | Name |
|---|---|---|---|---|---|
| 3 | 143 | wait | 10 | 8 | main |
| *5 | 144 | vmwait | 0 | 1 | HeapWorker |
| *7 | 146 | vmwait | 0 | 0 | Signal Catcher |
| *9 | 147 | running | 2 | 9 | JDWP |
| 11 | 148 | native | 0 | 0 | Binder Thread #1 |
| 13 | 149 | native | 0 | 0 | Binder Thread #2 |

```
Time                  pid  tag               Message
09-21 19:24:04.986  I  143  jdwp              received file descriptor 10 from ADB
09-21 19:24:05.226  D  82   SystemClock       Setting time of day to sec=1222025039
09-21 19:23:59.995  W  82   SystemClock       Unable to set rtc to 1222025039: Invalid argument
09-21 19:24:00.045  D  47   MobileDataSta...  Received android.intent.action.ANY_DATA_STATE broadcast - state = DISCONNECTED...
09-21 19:24:00.095  D  82   PhoneApp          [CallNotifier] onMwiChanged(): false
09-21 19:24:00.095  D  82   PhoneApp          [CallNotifier] onCfiChanged(): false
09-21 19:24:00.185  I  47   ActivityManager   Displayed activity com.esmertec.openexpo/.sampleActivity: 661 ms
```

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