LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Praktikum Mobile und Verteilte Systeme

Android-Basics

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http://www.mobile.ifi.lmu.de
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Programming with Android

Today:

- Android basics
- Components of an Android application
- Communication between components
- Google Services
- Android Studio as Android IDE
- …

What is Android?

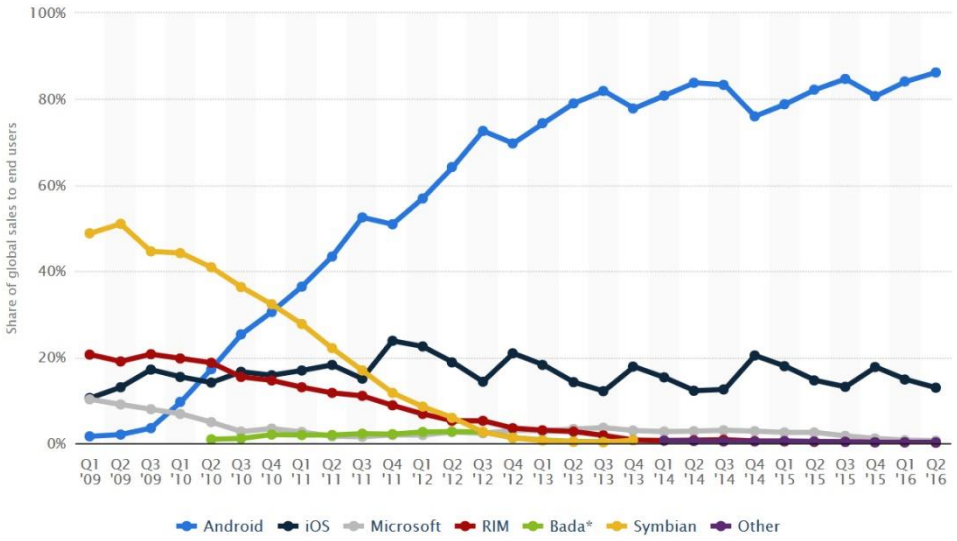
- Android is a multi-user, **Linux-based OS** developed by Google and the Open Handset Alliance
- primarily designed for touchscreen mobile devices based on **direct manipulation** by the user
- the Android code is **open source,** released under the Apache License (freely modifiable)
- comes with some standard smartphone applications
- the **Android SDK** offers free developer tools, API libraries, and an IDE (IntelliJ based)
- it allows **simple application** (app) **development** using customized Java

http://developer.android.com/sdk/index.html

Android statistics I

- In September 3, 2013: 1 billion Android devices became activated
- Q2 2016: Android has become **the world's most popular smartphone platform** with a market share of 86,2% (excluding, US, Australia, and Japan)
- is deployed on tv-sets, games consoles, digital cameras, watches, ...

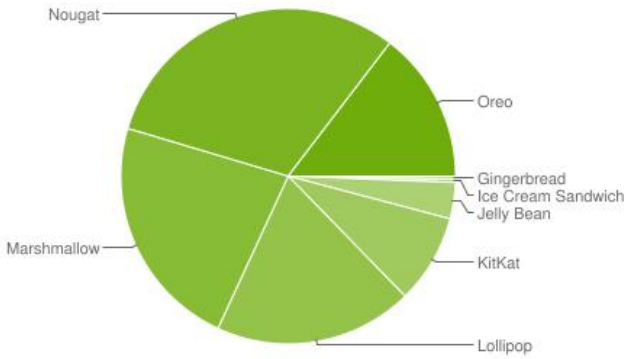
OS	Q2 2016 Market Share
Android	86.2%
iOS	12.9%
Microsoft Windows Phone	0.6%
BlackBerry (RIM)	0.1%
Others	0.2%
Total	100.0%



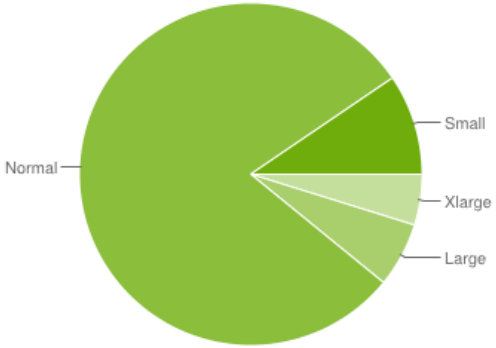
https://www.statista.com/statistics/266136/global-market-share-held-by-smartphone-operating-systems/

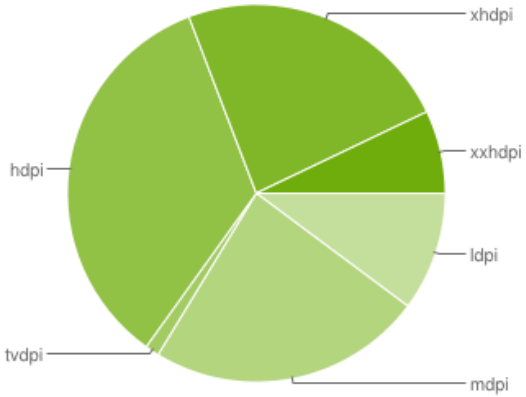
Android statistics II

"In **July 2015** there were more than 24,000 different models of Android devices, scores of screen sizes and eight OS versions simultaneously in use."



Android Display Size / Resolution Share **2016**





http://developer.android.com/

Android Version Share (**October 2018**)

- 19.2% Oreo
- 29.3% Nougat
- 21.6% Marshmellow
- 18.3% Lollipop
- 7.8% KitKat
- 3.8% others

Source: https://developer.android.com/about/dashboards/

Evolution of Android I

- Beta version **released in 2007**
- commercially released in 2008 (Android 1.0)
- from April 2009 onwards: dessert codenames, i.e., Cupcake, Donut, Eclaire, Froyo, Gingerbread, Honeycomb, Ice Cream Sandwich, Jelly Bean, KitKat, …

- OS **updates refer to API updates** (version codes vs. API levels)
  - offering both new functionality and restrictions for app developers
  - Important security fixes

- Current version: **Android 9.0 „Pie“**
  API Level 28 (since August 6th, 2018)
- Upcoming: -- not announced yet --

Evolution of Android II

- API level — New features
  - 5 — Bluetooth 2.1, support for more screen sizes, …
  - 8 — C2DM service for push notifications, …
  - 9 — UI update, NFC support, new sensors, rich multimedia, …
  - 11 — tablet-only version, new UI and animation frameworks, StrictMode for network access, …
  - 14 — unified UI framework, social API, calendar API, Android Beam, VPN API…
  - 16 — improved memory management, improved app stack navigation, new permissions, …
  - 17 — support for secondary displays, rtl-UIs, multiple users, …
  - 18 — restricted profiles, Wi-Fi scan-only mode, **BLE / 4.0** …
  - 19 — printing framework, new NFC reader mode, adaptive video playback, …
  - 20 — customized for smartwatches and wearables, …
  - 21 — **material design**, Android runtime, **native 64 Bit**
  - 22 — dual Sim, HD speech transmission, …
  - 23 — **new permission system**, USB type-c, native fingerprint scan, Android-Pay…
  - 24 — **JIT compiler** for improved performance, „Dozier“-mode, Trusted Face, **File-based encryption…**

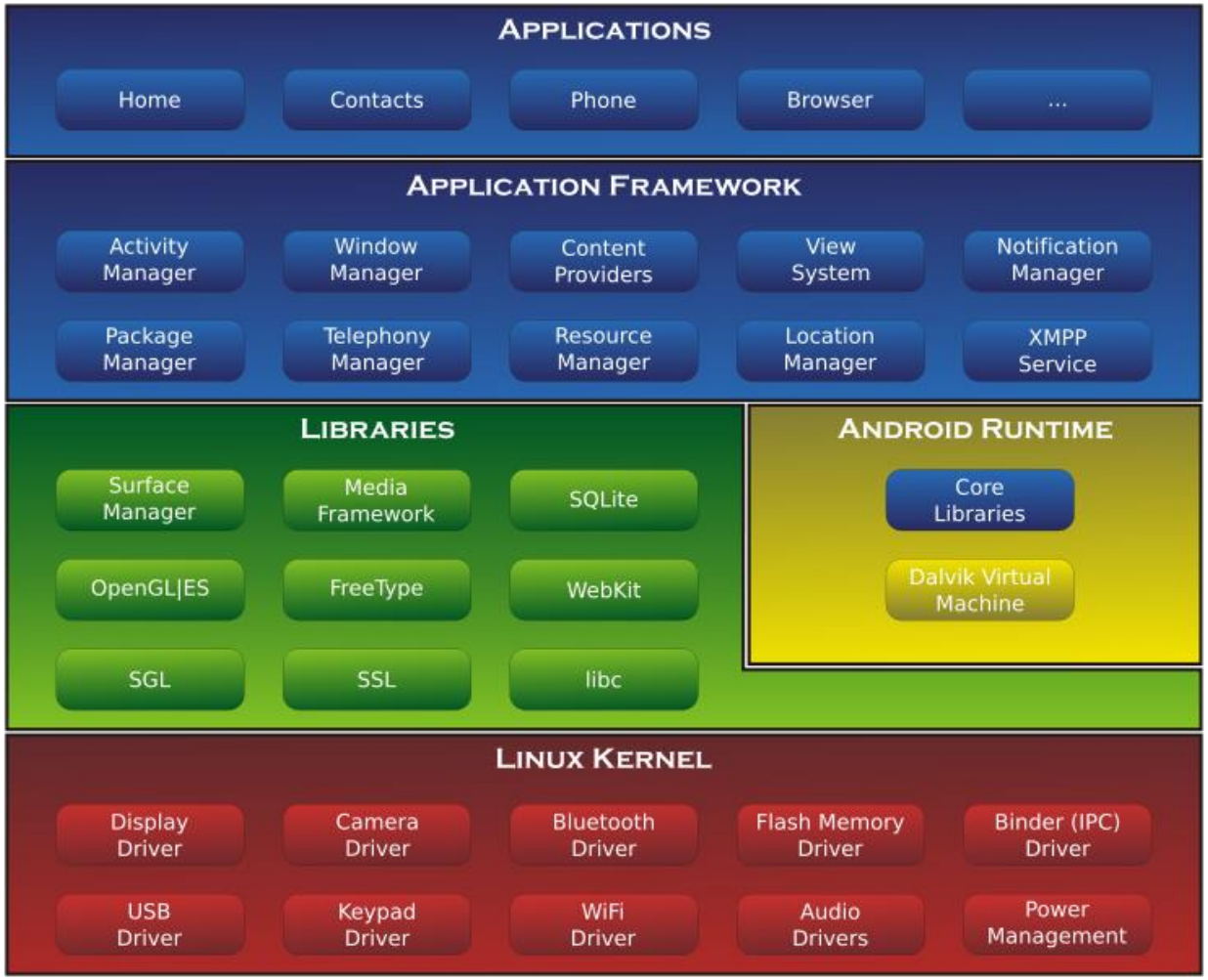
Evolution of Android III

- **Android 8.0 / 8.1 Oreo** (API Level 26/27)
  - Improved notification system (visualization, timeouts, channeling of notifications, dozy notifications) (8.0)
  - Auto-fill for in-app forms (8.0)
  - Security Patches (8.0/8.1)
  - Extended 16 Bit PNG image color space (8.0)
  - Play-Protect malware scanner (8.0)
  - Improved memory handling (8.1)
  - **Neural Network API (8.1)**
  - Others…

Evolution of Android IV

- **Android 9.0 Pie** (API Level 28)
  - Gesture-based navigation
  - Improved quick settings and audio settings handling
  - Improved Neural Network API
  - Security Patches
  - Improved Energy Efficiency
  - others…

Android basics: System architecture (until 5.0)



http://en.wikipedia.org/wiki/Android_(operating_system)

Android basics: System architecture (since 5.0)

https://developer.android.com/guide/platform/index.html

- Android System is Open Source: own interfaces and enhancements may be provided
- Introduction of a **Hardware Abstraction Layer (HAL)**: HAL-modules can be defined in hardware.h via software hooks

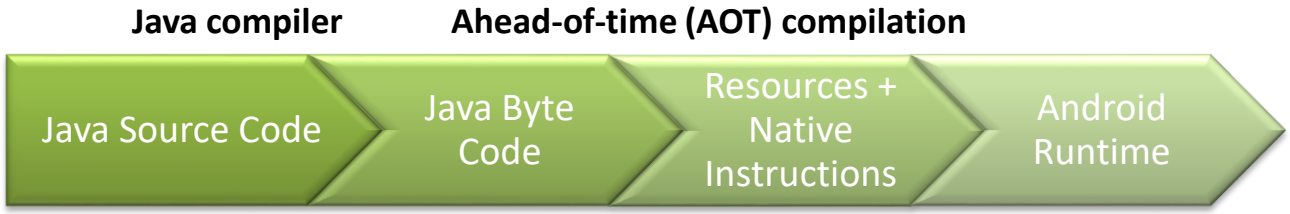
```
typedef struct camera_module {
    hw_module_t common;
    int (*get_number_of_cameras)(void);
    int (*get_camera_info)(int camera_id, struct camera_info *info);
} camera_module_t;
```

- Abstraction of high-level application development and lower-level hardware programming (drivers, etc.)

Android basics: Dalvik Virtual Machine vs. ART

- Java code is typically compiled into **Bytecode**
- At runtime, a **Virtual Machine** translates this code into machine code
  - e.g., **Java Virtual Machine** (JVM) on Desktop PCs (stack-based), Dalvik for Andoid < 5.0

- Now, Android uses the **Android Runtime (ART)**
  - Replaces Dalvik VM **since version 5.0** (backward compatible)
  - All Apps running within own processes and an own ART-instance (→ multiple virtual machines)
  - Transformes Bytecode directly to binary code upon installation
  - Faster execution, improved garbage collection and memory allocation
  - 64-Bit support
  - Apps are stored compiled



http://android-developers.blogspot.de/2013/06/google-play-developer-8-step-checkup.html

Android basics – Security

- Android implements the **principle of least privilege** for its apps

- Each Android app resides in its own kernel-level **security sandbox**:
  - each application is a different user
  - access permissions for all of an application's files are based on the **Linux user ID**
  - every application runs in its own Linux process
  - each process has its own ART-instance (adds to stability)

- Apps can request **permission to access device data and services**, such as user's contacts, SMS messages, SD card, camera, internet, …
- All application permissions must be **requested by the developer** in the app's Manifest file and **granted by the user**

Android process and memory management

- Android employs **real application multi-tasking**, optimized for a mobile usage pattern

- Requirements:
  - apps should appear "**always running**"
  - no swap space → **hard limits on memory usage**
  - **app switching** in less than 1 second

- Implementation:
  - **LRU list** of running apps with preferences
  - when memory gets low, Android **kills the least important process**
  - `Bundle` class can be used for **saving application state**
    - developers have to take **care of** correctly **saving an instance's state**

Android application threads

- Every application is initiated with a single main thread (**UIThread**)

- If **time-consuming tasks** are performed on the main thread, **the UI blocks**
  - leads to ANR dialog after 5 seconds
  - instead, extra worker threads should be used

- the Android UI toolkit is **not thread-safe** and hence **must not be manipulated from a worker thread**

Rules:

1) Do not block the UI thread!

2) Do not access the Android UI toolkit from outside the UI thread!

- Recommendation: use the `Handler-`, Java `Thread-`, `Loader-` and `AsyncTask`-classes

Android application components

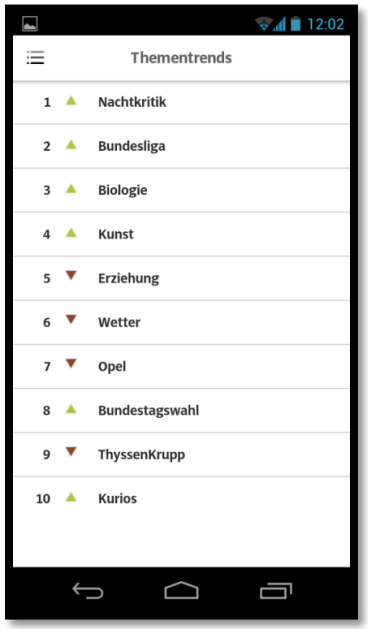
- Android apps might consist of several different building blocks
  - **Activities**
  - **Fragments**
  - **Loaders**
  - **Services**
  - **Broadcast Receivers**
  - **Content Providers**

http://developer.android.com/guide/components/index.html

- Each component **performs different tasks**
- Each component has its own distinct **lifecycle** that you have to take care of as a developer in order to keep your app stable

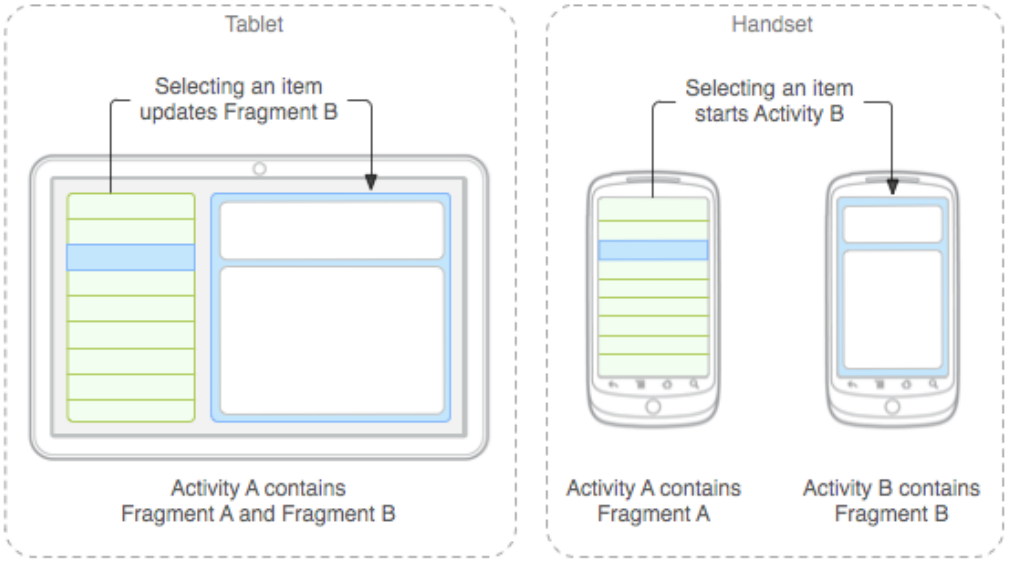
Activities

- Implemented as a subclass of `android.app.Activity`
- An activity represents **a single screen with a user interface**
- Started on App start or by firing **Intents**
  - typically defined in XML, not in code
  - Model-View-Controller (MVC) pattern



Fragments

- represent **a UI portion of an Activity** (i.e., a “subactivity”)
- can be combined in a single activity to **build multi-pane UIs**, but cannot stand alone
- enable the **reuse of code** in multiple activities



- have their **own lifecycle**, too, but **based** on the host **Activity’s** current **state**
- can be managed in the **Activity back stack**
- **different fragment combinations for different screen sizes**
  - e.g., in order to support both tablets and phones, different layout configs can be used to make optimal use of the available screen space

Loaders

- Introduced in Android 3.0 (API Level 11)
- Used to load data from a **Content Provider**
- **Avoid a lack of responsiveness** due to performing slow queries on the UI thread
- Loaders are using **separate threads**
- Thread management is simplified by providing **callbacks** in case of occurring events
- Results may be **cached**, even across configuration changes
- Loaders may **monitor data sources** and underlying data in order to react to changes

Services

- Java class implemented as a subclass of `android.app.Service`
- **running in the background** (without direct user interaction)
- intended for **long-running operations**, e.g. playing music, fetching network data
- can be started (and stopped) from an Activity
  - in order to interact with a Service, an **Activity can "bind"** to it

- Services can request being considered **foreground** („please dont kill me“)
  - indicated by an icon in the status bar to create user awareness

- a process running a service is ranked higher than a process with background activities (and is hence less likely to be killed)

BroadcastReceivers

- implemented as a subclass of `BroadcastReceiver`
- each broadcast is delivered as an `Intent` object

- respond to **system-wide broadcast announcements**…
  - screen turned off
  - battery status
  - picture captured
- … or respond to **custom broadcasts**

- do not display a user interface

- usually, a broadcast receiver is just a **gateway to other app component**s, e.g., by starting an Activity or Service upon a certain event

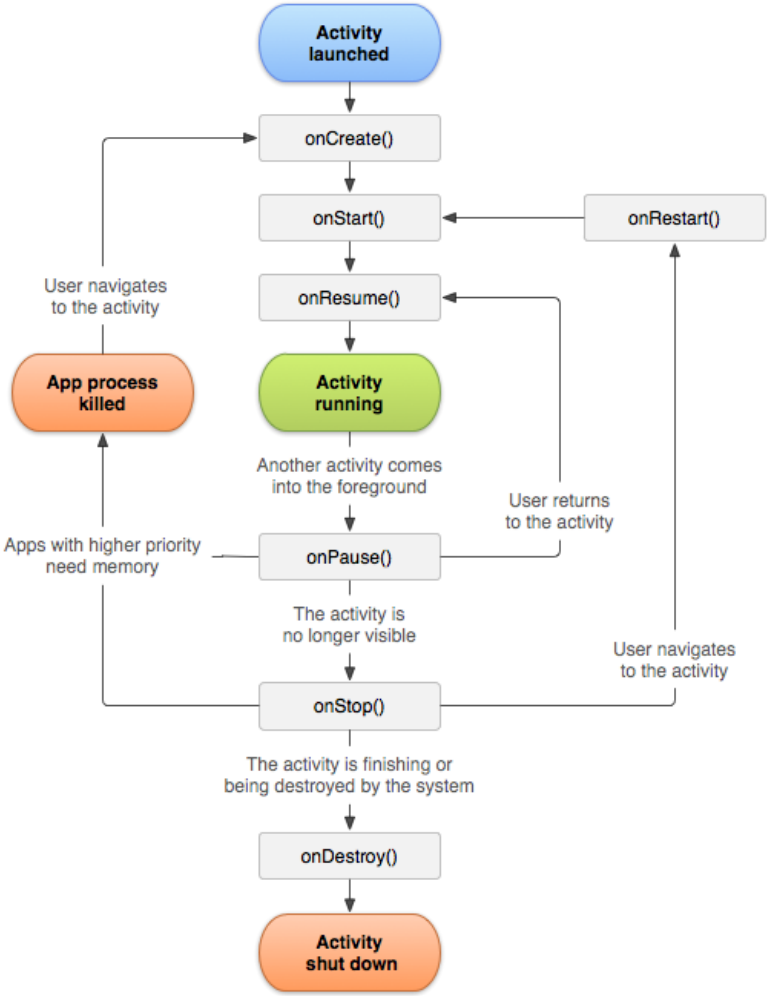
ContentProviders

- implemented as a subclass of `ContentProvider`
- must implement a standard set of APIs enabling other applications to perform transactions (CRUD operations) on the app's information

- manages **shared application data**, stored in files, SQLite databases, on the web, …
- can also be used internally by an App for storing/retrieving private information

- Examples: **Android contact information / Android MediaStore / etc.**
  - any application (given it has the right permissions) is able to query this content provider to read or modify contact information

Activity lifecycle management



- crucial for developing strong and flexible applications
- An activity can exist in essentially three states:
  - ***Resumed***
    The activity is in the foreground of the screen and has user focus
  - ***Paused***
    Another activity is in the foreground and has focus, but this one is still visible
  - ***Stopped***
    The activity is completely obscured by another activity (i.e., in the background)

Communication between components

- Activities, Services and BroadcastReceivers can be activated using an `Intent` object
  - passive **bundle object** describing an action to be performed
  - … or announcing an event

- Intents can be **sent to a certain component**
  - `startActivity()`/`startActivityForResult()`/ `setResult()`/`startService()`/`bindService()`
- or be **broadcasted to all** interested BroadcastReceivers
  - `sendBroadcast()`/`sendStickyBroadcast()`

→ Intents can hence be handled **explicit** or **implicit**

- **if bound** to a (local) service, an activity can make **direct method calls**
  - BroadcastReceiver, etc.

Android Manifest

```
<manifest …>
    <application …>
        <service android:name="de.lmu.ifi.…" …>
            …
        </service>
        …
    </application>
</manifest>
```

- Each application must have an **AndroidManifest.xml** file

- The manifest file **must declare**
  - an app's Java package name
  - **all of an app's components** (activities, services, …)
  - all of the app's requirements (min. Android version, hardware, …)

- and **might** also declare
  - intent filters (for implicit intents)
  - custom permissions
  - used libraries (apart from the standard Android lib)
  - **required permissions**
  - …

Android permissions

- by default, no app is allowed to perform any protected operations
- the **permission mechanism** can be used for a (moderately) fine-grained control of what features an app can access
  - internet, camera, SMS, contacts, reboot, …

- Initially, **a user had to accept the requested permissions** (do-or-die) when installing an application
- since Android 4.3, there was a (hidden) functionality to withdraw individual permissions
- Since Android 6.0, it is possible to install Apps without granting all permissions. They have to be granted on first use

- **custom permissions** can be defined, controlling…
  - from which apps broadcasts might be received
  - who is allowed to start an activity or a service

Android resources

https://developer.android.com/guide/topics/resources/index.html

- all types of non-code resources (images, strings, layout files, etc.) should be managed externally
  - **allowing customized alternatives** for each special use-case (different strings for different languages, customized layouts for different screen sizes)
  - requires each resource to have a **unique resource id,** which is generated automatically

- resource types:
  - Bitmap / Drawable files (`res/drawable, res/mimap-hdpi…`)
  - XML layout files (`res/layout`)
  - string literals and value arrays (`res/values`)
  - …
- alternatives are provided in separate folders: `<resource_name>-<qualifier1[-qualifier2]>`

R.java???

- when compiling your project, a class called `R.java` is generated
  - contains subclasses for each type of resources and IDs
- resources provided externally can be accessed in code using the projects `R` class and the corresponding resource‘s type and its integer ID

- **a resource ID** is composed of
  - the **resource type** (e.g., string)
  - the **resource name** (filename or XML attribute “name“)

- Resources can be accessed in code:
  `getString(R.string.<resource-name>)`
  and in XML: `@string/<resource-name>`
- `(<Classcast>)findViewById(R.layout.<layout-name>)`

Rules:

Never touch R.java!

Never import android.R!

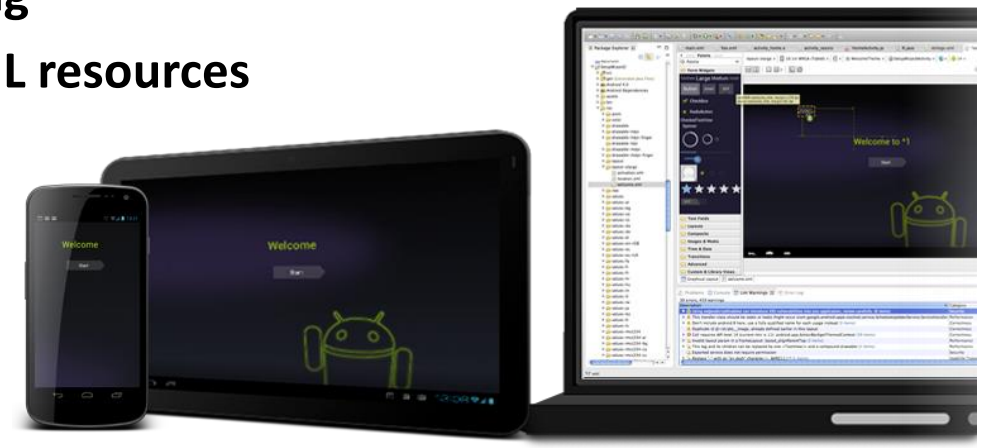
Google Services

https://developer.android.com/google/index.html

- Google offers app developers a number of handy services and APIS that may be integrated
- these services, however, are not part of the Android platform
  - **Google Cloud Messaging Service (GCM)**
    allows developers to send push notification to their users, now superseded by Firebase Cloud Messaging (FCM)
  - **Google Location Services**
    offer utilities for painlessly building location based services (LBS)
  - **Google+**
    allows authentication, social graph interactions, etc.
  - **Google Maps**, **Google Play Services**, …

Android IDE

- **Android Studio**
  - based on IntelliJ IDEA
  - Android-specific **refactoring**
  - **integration of Android XML resources**
  - **graphical UI editor**
  - virtual device **emulator**
  - Integrated Debugging
  - App Signing

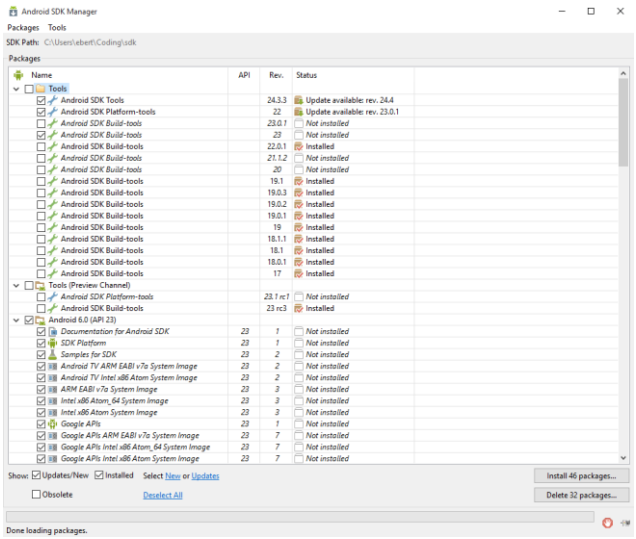


https://developer.android.com/tools/index.html

- **Android Developer Tools** (ADT) **Eclipse plugin**
  - same Features as above
  - BUT: **Deprecated**

Android platform tools

- The Android Developer Tools (ADT) contain a variety of useful tools for application programming, debugging and publishing
  - **SDK Manager**
  - **ADB** (Android Debug Bridge)
    - `devices`
    - `shell`
    - `push/pull`
    - `install/uninstall`
    - `logcat`
  - **DX**
    - converts .class files into .dex format
  - **DEXDUMP**
  - **Android Device Emulator / AVD Manager**
  - **GUI Builder**
  - **DDMS (**standalone, e.g., for **resource usage monitoring)**



Where to start…

https://developer.android.com/

Programming with Android – Practical

- IDE installation and setup (Android Studio)
- „HelloAndroid“
- using the emulator, using adb, enabling hardware acceleration
- …