Programming with Android:
Geo-localization and Google Map Services

Luca Bedogni

Dipartimento di Scienze dell'Informazione

Università di Bologna

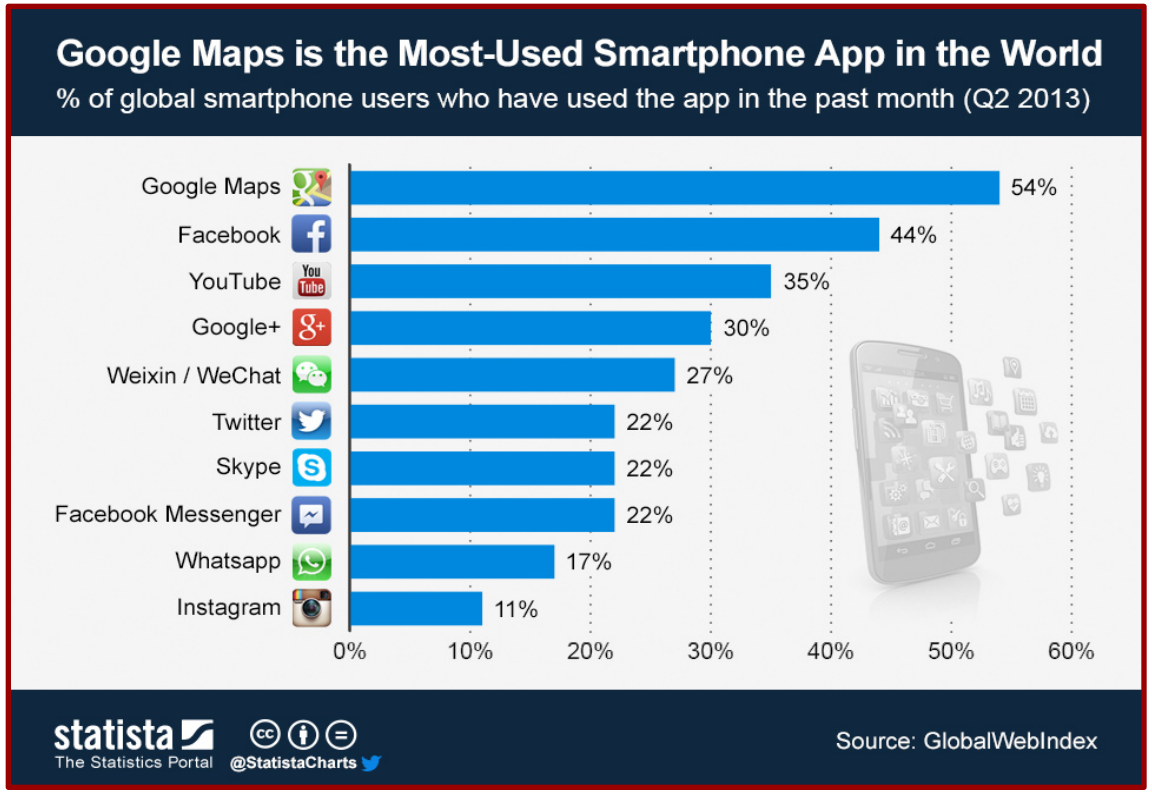
Outline

- **Geo-localization** techniques
- Location **Listener** and Location **Manager**
- **Google Maps Library**: *Getting an activation key*
- **Google Maps Library**: *Display a Map*
- **Google Maps Library**: *Adjust the Camera*
- **Google Maps Library**: *Manage events*
- **Google Maps Library**: *Manage overlays*

Android: Localization basics …

➢ **Geolocalization** → Identification of the real-world geographic location of an the end-user.

- ✧ Feature supported by several Android applications.
- ✧ One of the reason of the popularity of today's smartphone devices.
- ✧ Made possible by the combination of **hardware radio transceivers** and **software localization algorithms**.



Android: Localization basics …

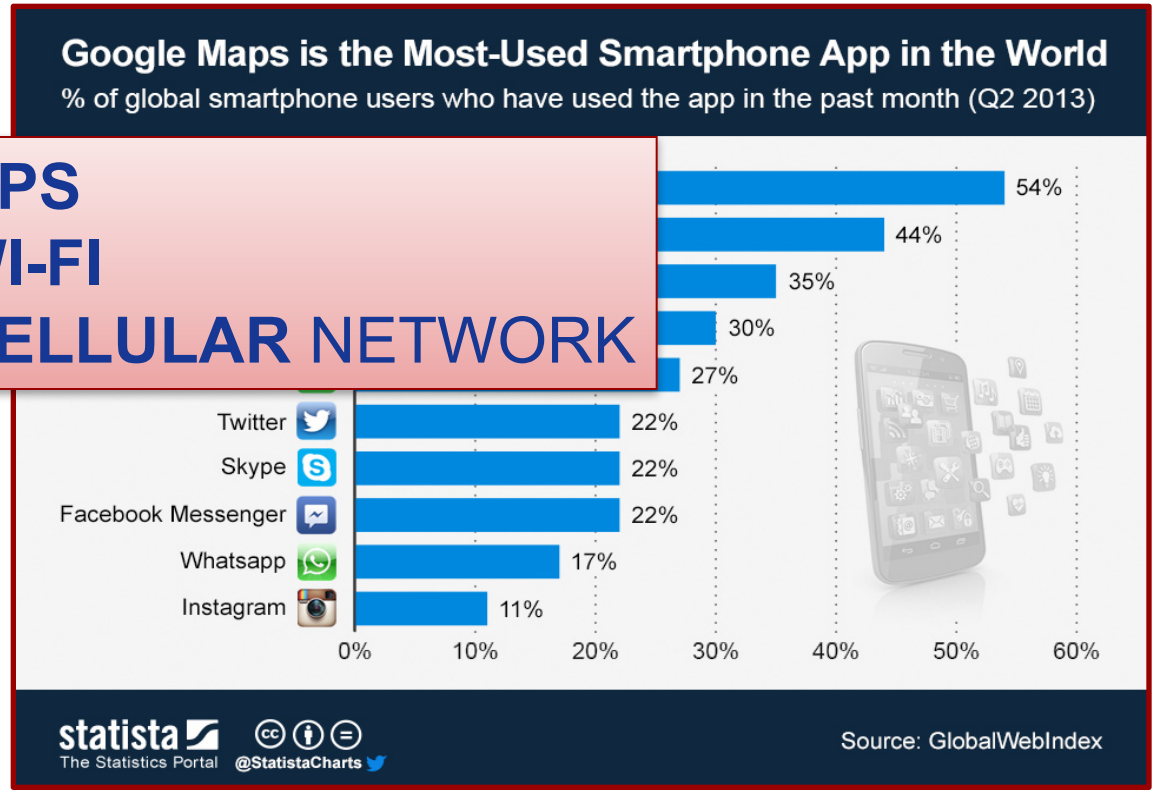
➢ **Geolocalization** → Identification of the real-world geographic location of an the end-user.

✧ Feature supported by several Android applications

✧ LOCALIZATION THROUGH **GPS**
✧ LOCALIZATION THROUGH **WI-FI**
✧ LOCALIZATION THROUGH **CELLULAR** NETWORK

smartphone devices.

✧ Made possible by the combination of **hardware radio transceivers** and **software localization algorithms**.



Android: Localization basics …

GPS stands for **Global Positioning System**

- Fleet of satellites orbiting at a height of 20000km.
- Fleet composed of 24/32 operative satellites.
- Orbit period of 12 hours, speed of 3.9 Km/s.

Navigation systems available:

- **Navstar** → operated by the US Department of Defence (DoD) for civil/military applications
- **Glonass** → operated by the Russian Defence Forces.
- **Galileo** → operated by the EU (still under deployment)

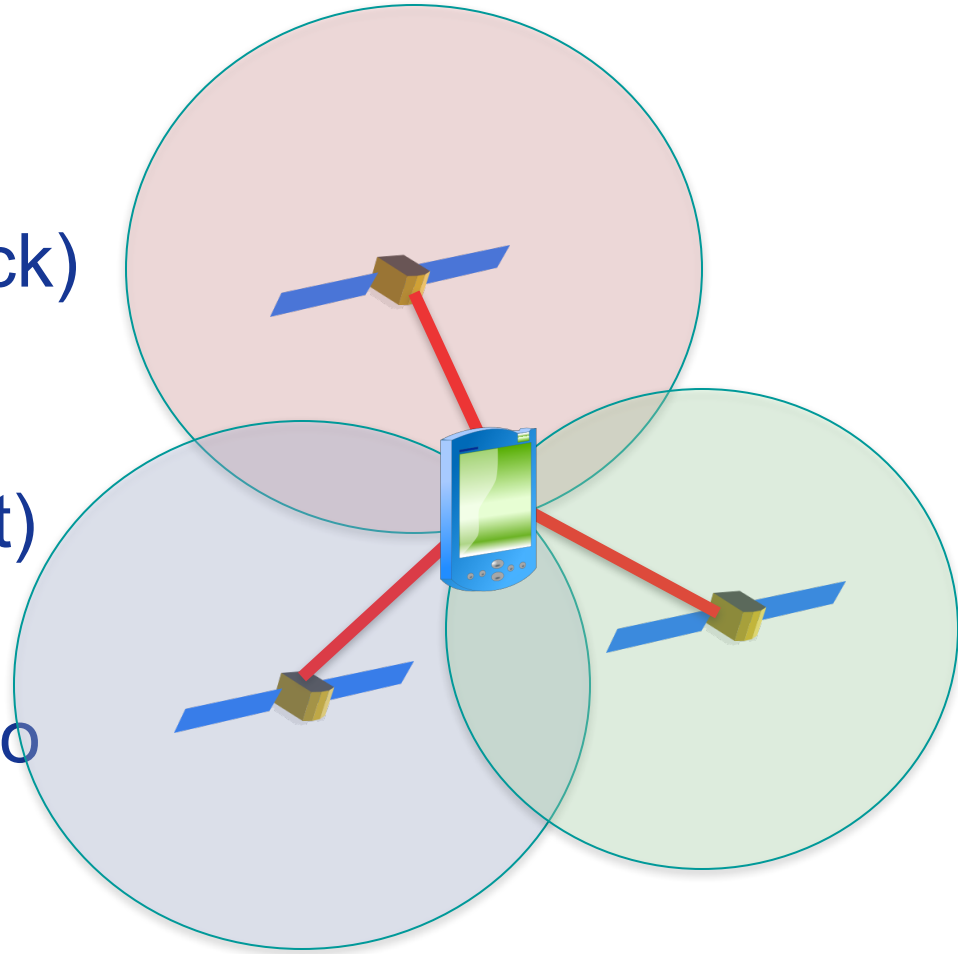
Android: Localization basics …

Each satellite sends periodically:

- Its current **location**
- Current **time** of the day (atomic clock)

GPS receiver operations:

1. Passively receive data (no transmit)
2. Compute delay of received signal
3. From delay compute the distance to the satellite (distance= delay * c)
4. From multiple distance (at least 3), determine current locations.



Android: Localization basics …

PROBLEM: In order to calculate delay of received signal, the end-user clock must be synchronized with the satellite clock…

SOLUTION

- ✧ Utilize four satellite instead of three (minimum)
- ✧ GPS receiver solves a system with four unknown variables

$$(x - x_i)^2 + (y - y_i)^2 + (z - z_i)^2 = \left([\tilde{t}_r + b - t_i]c\right)^2,\ i = 1, 2, \ldots, n$$

x_i, y_i, z_i → user's location

b→ user clock skew

Android: Localization basics …

Each satellite transmits on two **frequencies** in the UHF band:

- L1 channel → **civilian** data
- Signals encoded using code division multiple access (**CDMA**)
- Together with data/location, each satellite transmits the **almanac** data, i.e. orbital courses of the satellites.
- Through the almanac, GPS receiver knows about satellites visible at its location.

Android: Localization basics …

Wi-Fi Localization is performed through triangulation or through **radio fingerprinting** approach (this latter used by Android):

1. Smartphone turns on the WiFi interface, and detects MAC and SSID of WiFi routers in its range.
2. Smartphone makes a query to the Google location service.
3. Based on stored information about known WiFi networks, Google provides hints about current location.

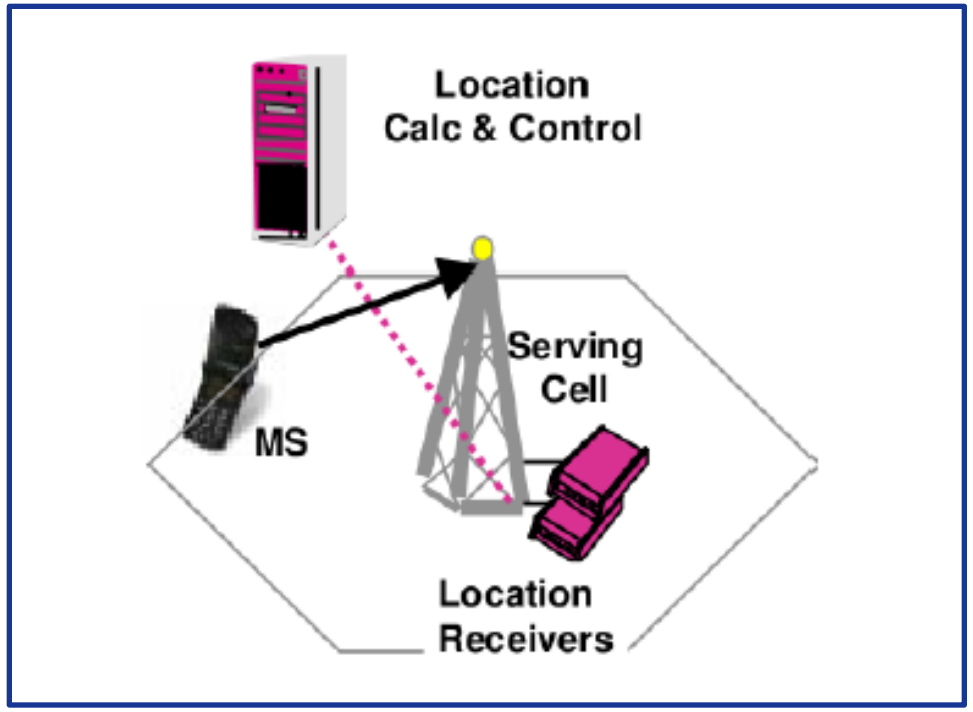
Q. HOW is the Google database populated?

A. By users, enabling the Google's location service.

Android: Localization basics …

- Cellular Localization is performed by recognizing the **mobile cell tower** which the smartphone is attached to. HOW?

- Similar to previous case, current location is determined on the basis of the ID of the cellular BTS which the smartphone is currently attached to.

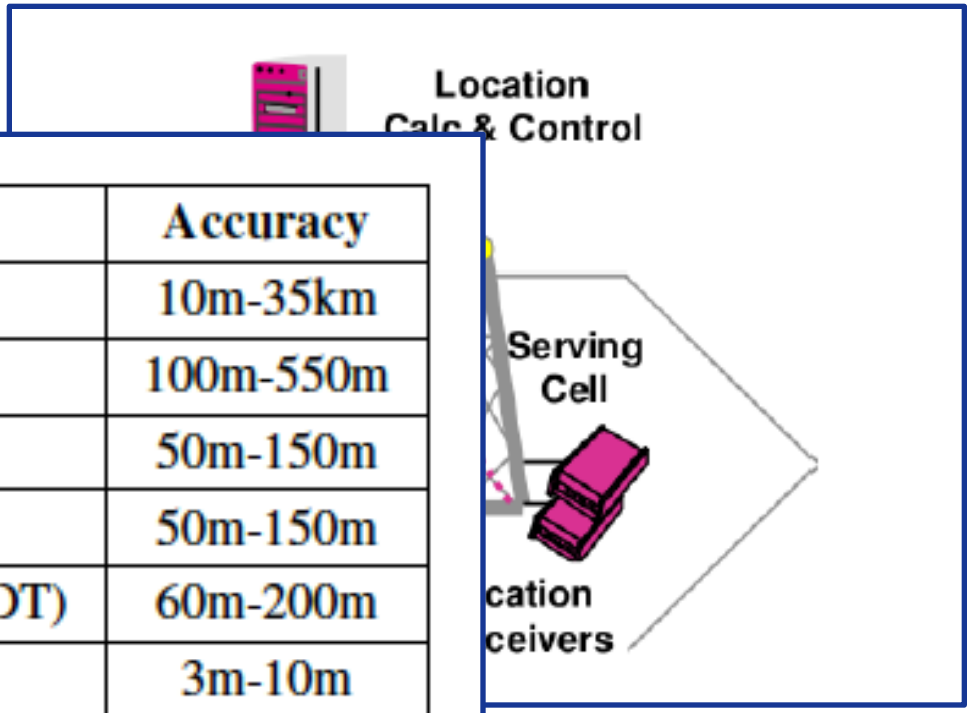


Android: Localization essentials …

- Cellular Localization is performed by recognizing the **mobile cell** where is located. HOW?

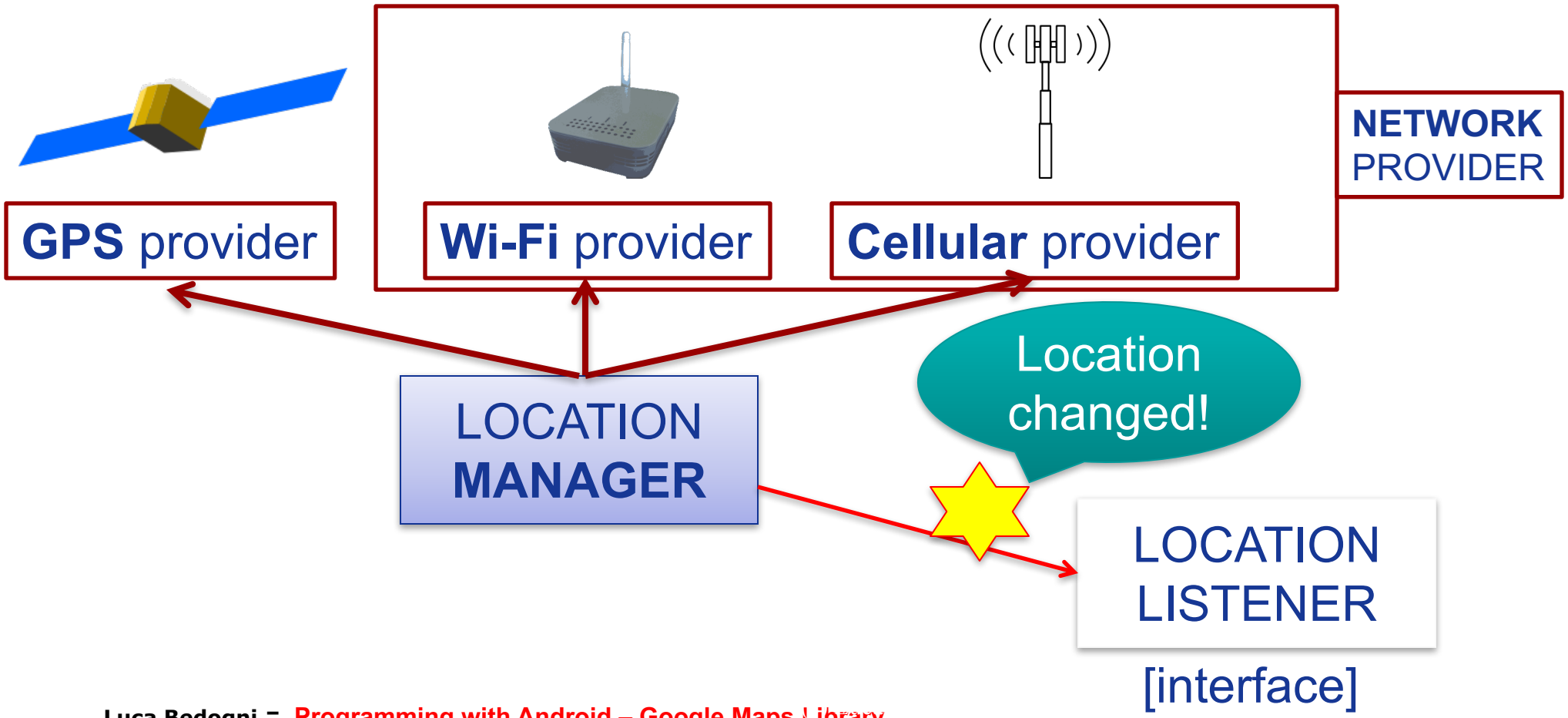
- Similar to previous case,
  cu
  on
  ce
  sm
  att

Method	Accuracy
Cell-ID	10m-35km
Timing Advance (TA)	100m-550m
Angle of Arrival (AOA)	50m-150m
Uplink Time Of Arrival (U-TDOA)	50m-150m
Enhanced Observed Time Difference (E-ODT)	60m-200m
(Assisted-) GPS ((A)-GPS)	3m-10m



Android: Localization in Android

Q . HOW to retrieve the current position in Android?



Android: Localization in Android

1. **Create a Location Listener object,** and implement the callback methods.

```
LocationListener locListener=new LocationListener() {

    public void onLocationChanged(Location location) {
    }
    public void onStatusChanged(String provider, int status,
Bundle extras) {
    }
    public void onProviderEnabled(String provider) {
    }
    public void onProviderDisabled(String provider) {
}
```

Android: Localization in Android

2. **Get a reference** to the Location Manager (system service).

```
LocationManager
lm=(LocationManager)getSystemService(Context.LOCATION_SERVICE)
```

3. **Register the LocationListener** in order to receive location updates from the Location Manager.

```
lm.requestLocationUpdates(provider,
                          minTime,
                          minDistance,
                          locListener)
```

- GPS_PROVIDER
- NETWORK_PROVIDER
- PASSIVE_PROVIDER

Android: Localization in Android

4. **Add** user permissions in the **XML Manifest**

```
<manifest>
   <uses-permissions
android:name="android.permission.ACCESS_FINE_LOCATION" />
   <uses-permissions
android:name="android.permission.ACCESS_COARSE_LOCATION" />
   <uses-permissions android:name="android.permission.INTERNET"
/>
</manifest>
```

Android: Localization in Android

5. Get the **last known location** to reduce the latency caused by first location fix.

```
Location lastKnownlocation=locationManager.
                           getLastKnownLocation(locationProvider)
```

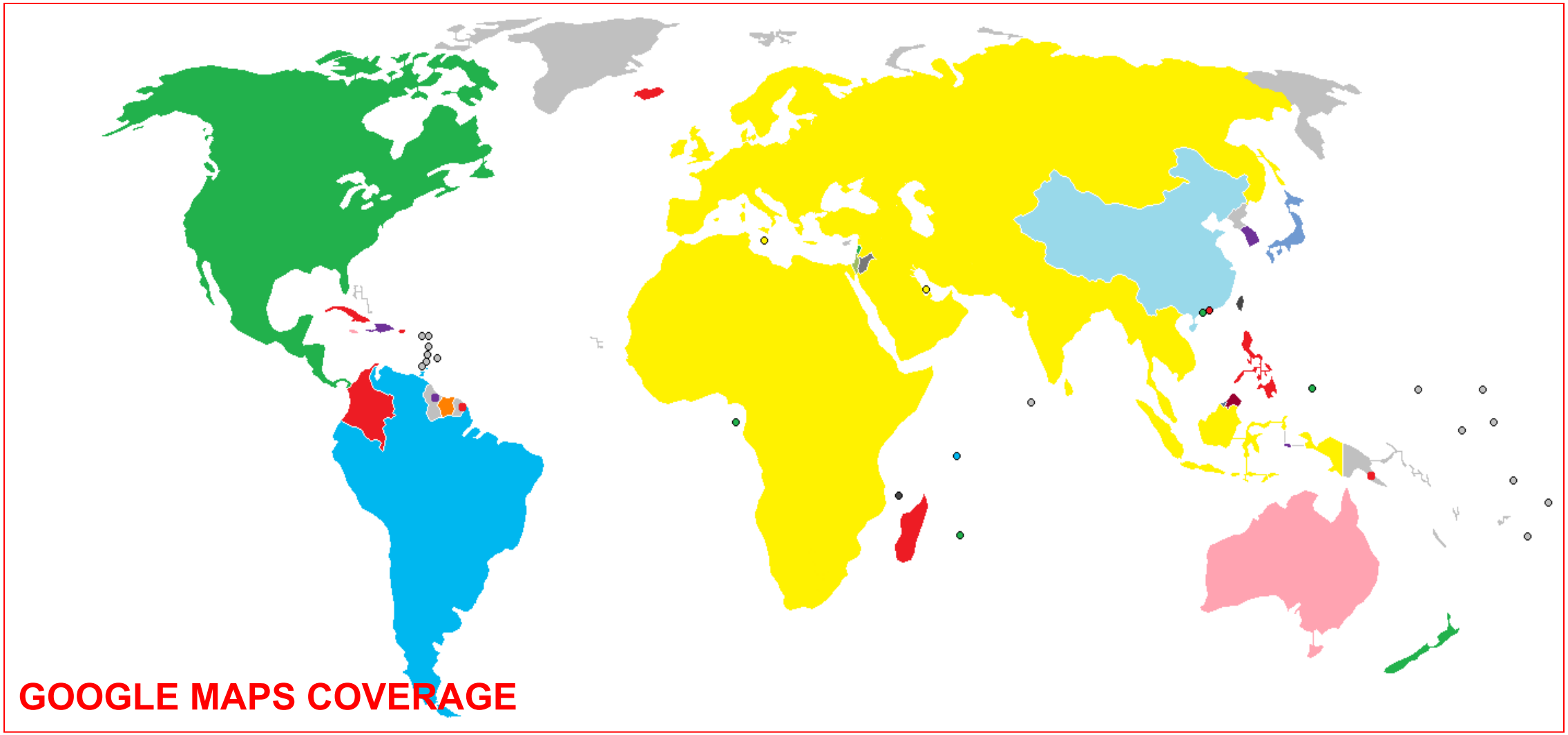
6. To save energy, **stop listening** to location updates when they are not needed anymore by the application.

```
locationManager.removeUpdates(locationListener)
```

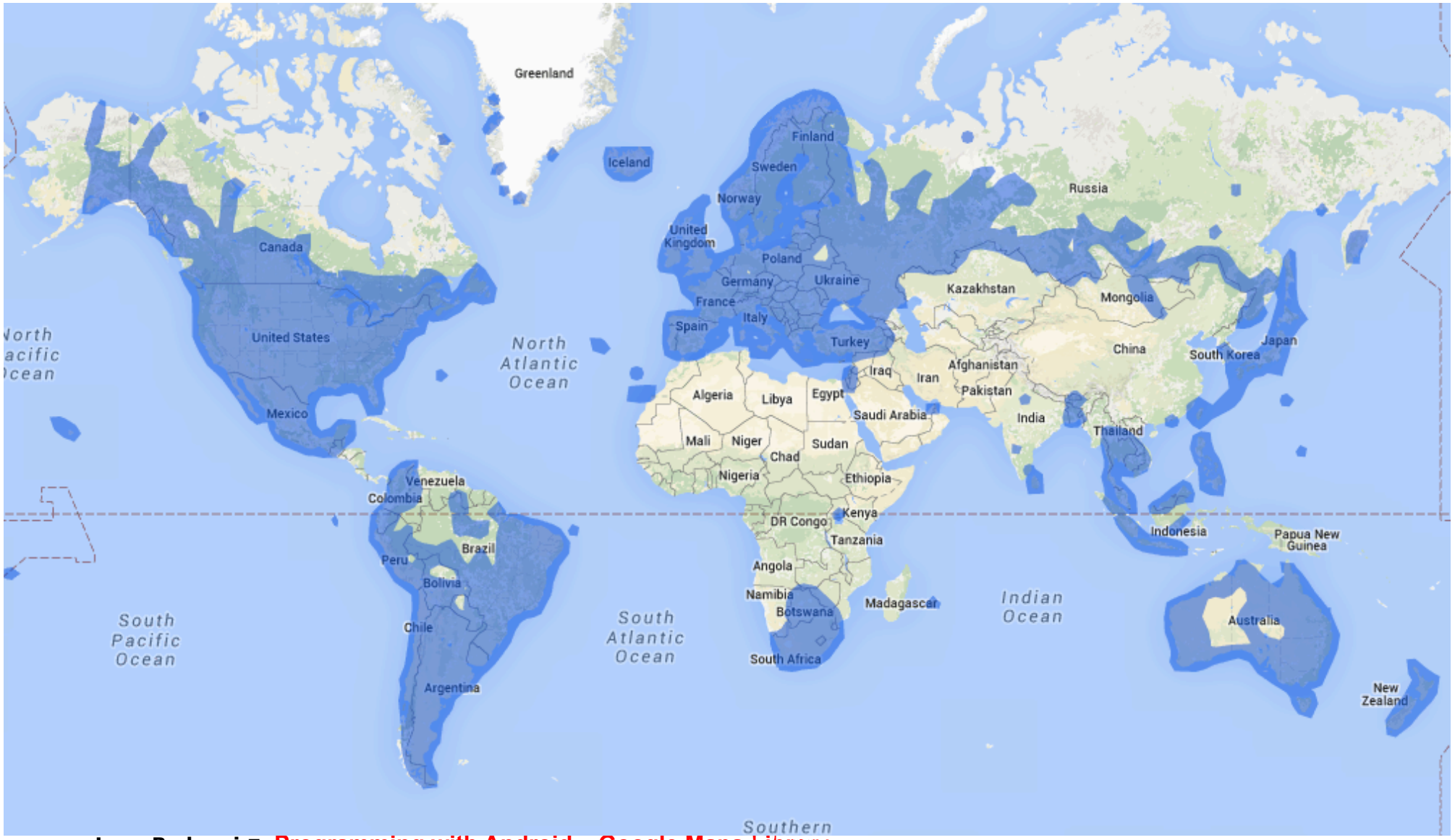
Android: Gmaps Important Dates …

- **2004** → Google Inc bought the australian company *Where 2 Technologies*, that developed a prototype WebMap system.
- **2005** (February) →Google Maps was announced
- **2006** → Google Maps updated to use the same satellite image database as Google Earth
- **2007** → Google Street View launched
- **2010** → On Christmas and New Years day, mobile usage of Google Maps surpassed desktop usage for the first time
- **NOW**: Google Maps, Google Sky, Google Moon, Google Mars, Google Transit, Google Aerial View, etc

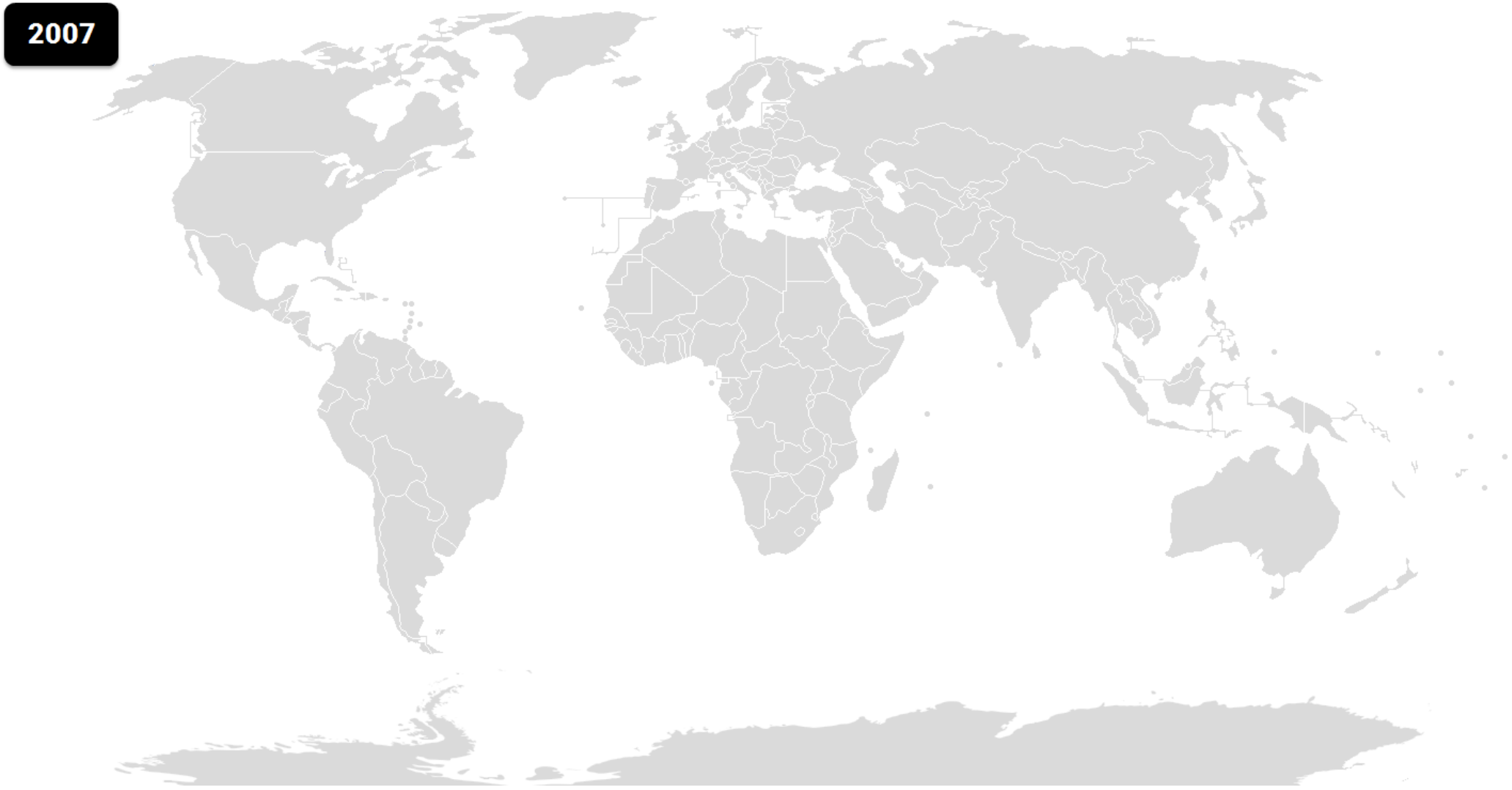
Android: Gmaps Stats and Information



Android: Gmaps Stats and Information



Android: Gmaps Stats and Information

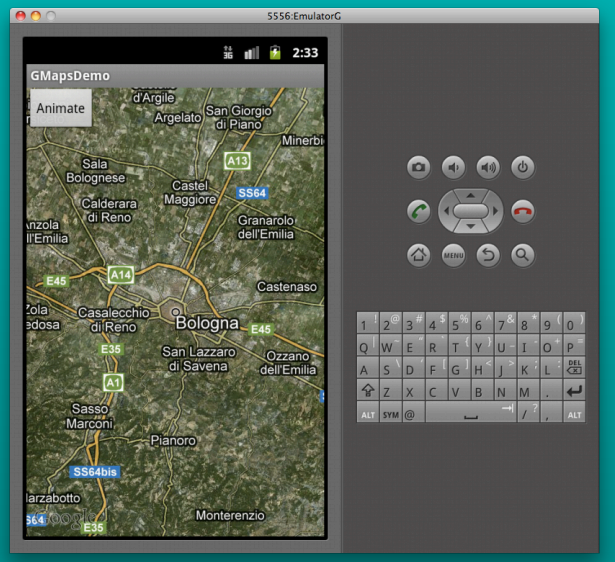


Android: Deploying Map-based Apps

Deploying **Map-based** Applications in Android

WebView +
Google Maps +
Web technologies

Hybrid Applications



Native Applications

Android: Deploying Map-based Apps

Two versions of Android Google Maps API

API v1

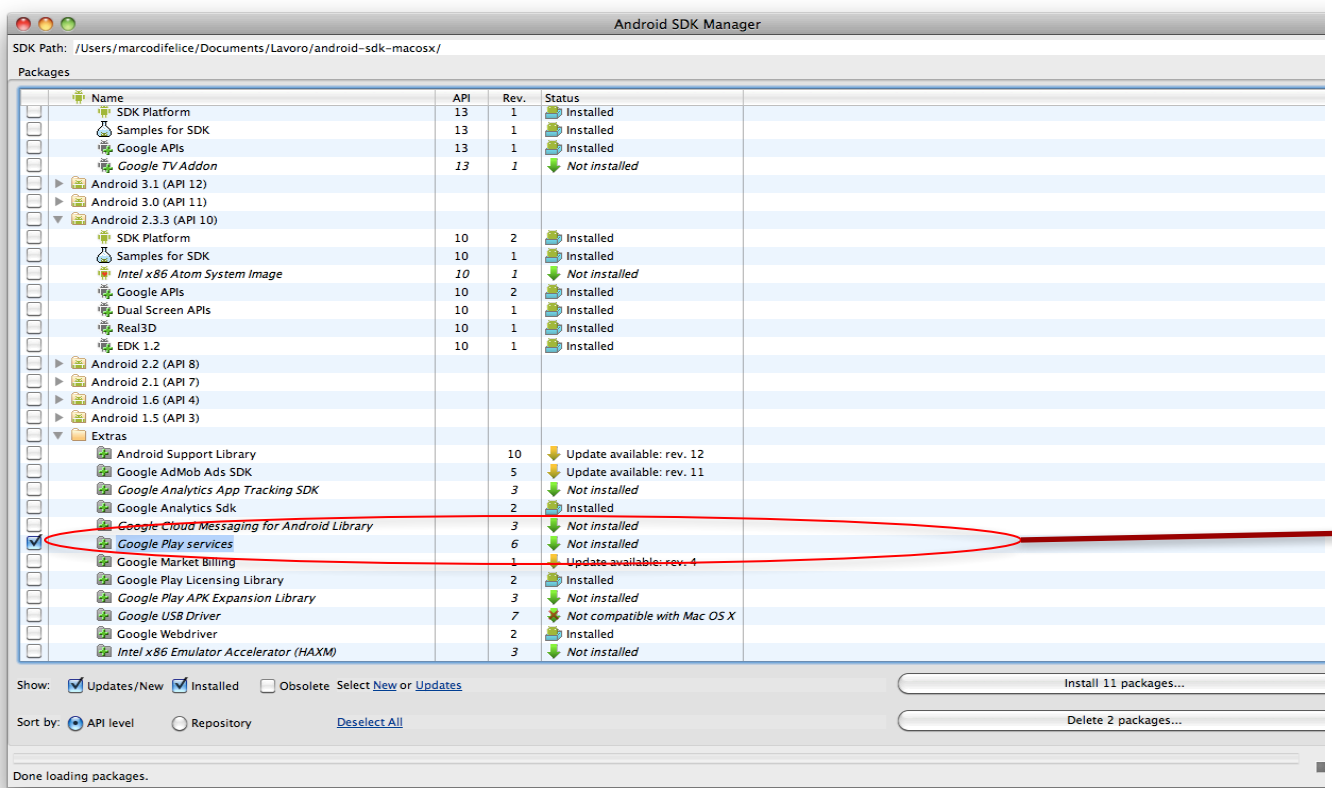
- Deprecated, not supported anymore since 18th March 2013.
- Still used for Android device with versions < 3.0 (unless API set is extended with support packages)

API v2

- Different installation procedures.
- Novel methods to insert a Map inside an Android app.
- Improved caching and visualization capabilities.

Android: Installing Google APIs

STEP -1: Install and Setup Google Play Service SDK



Window → Android SDK Manager
→Installed packages

Check Google Play and Google Repository are **installed**, or **install** them otherwise

http://developer.android.com/google/play-services/setup.html

Android: Getting a Google Play API Key

STEP 0: Get a valid Google Play **API Key** to utilize the Google Maps library.

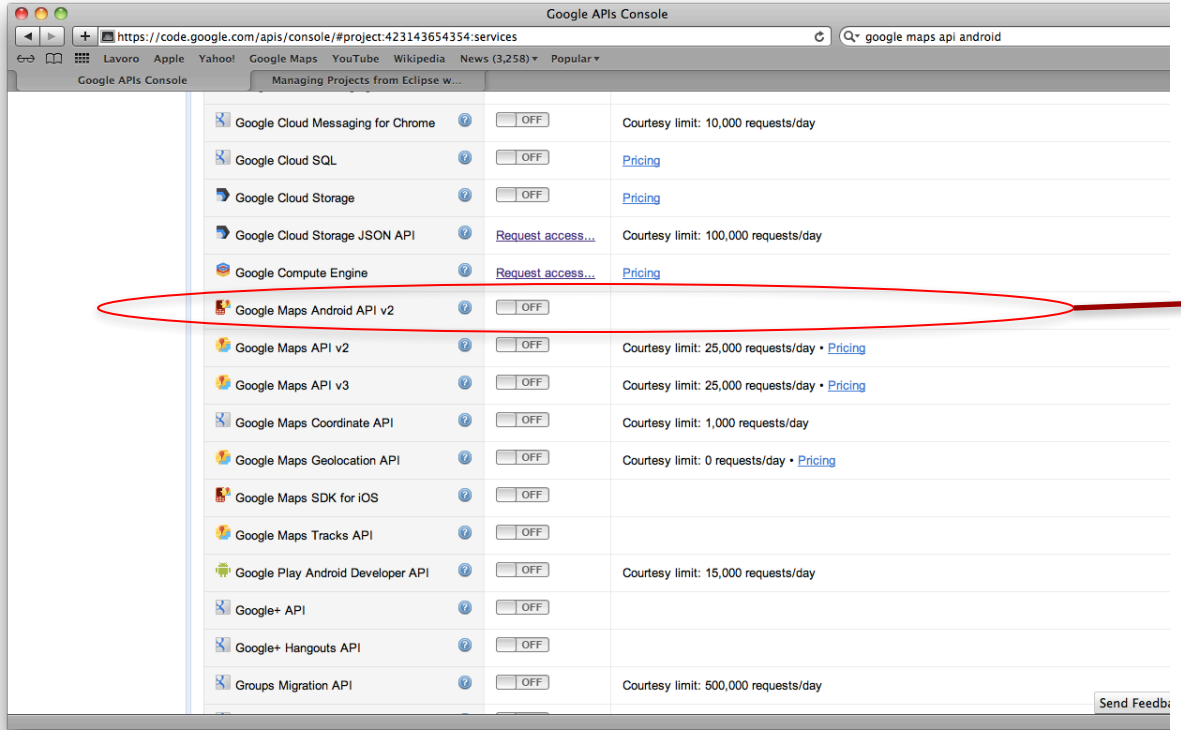
0.1: Retrieve the fingerprint SHA1 of the certificate used to sign the apps.

```
mylaptop:~ marco$ keytool -list -keystore
/Users/marcodifelice/.android/debug.keystore  -
storepass android -keypass android
…
androiddebugkey, Feb 1, 2011, PrivateKeyEntry,
Certificate fingerprint (SHA1):
A2:34:B1:A3:A5:BB:11:21:21:B3:20:56:92:12:AB:DB
```

Android: Getting a Google Play API Key

STEP 1: Navigate with a browser to https://accounts.google.com/

1.1: Select the Google service you intend to use for your apps.



Enable Google Maps Android v2 API

Android: Getting a Google Play API Key

STEP 1: Navigate with a browser to https://accounts.google.com/

1.2: Get an **Google Play API Activation Key**

- Select the API Access

- Insert the SHA1 Key, followed by the package's name:

BB:0D:AC:74:D3:21:E1:43:67:71:9B:62:91:AF:A1:66:6E:44:5D:75;
com.example.android.mapexample

-Generate and save the obtained Activation Key

-For each application/package → get a new Activation Key.

Android: Google MAPs library overview

What can I do with Google MAPs v2 library in Android?

1. **Integrate** a Google Map into an Android application
1. **Manage** the camera
1. **Add** information layers to the Map
1. **Manage** user events

Android: Inserting a Map inside the App

Permissions should be added to the AndroidManifest.xml, and the Activation Key must be specified in the meta-data.

- Internet Access
- Localization capabilities
- Access to Google Web services
- OpenGL ES version 2 libraries
- Access to network state

Android: Inserting a Map inside the App

Permissions should be added to the AndroidManifest.xml, and the Activation Key must be specified in the meta-data.

```
<meta-data
 android:name="com.google.android.maps.v2.API_KEY"
 android:value="API_activation_key"/>
```

```
<permission
android:name="com.example.mapdemo.permission.MAPS_RECEIVE"
android:protectionLevel="signature"/>
<uses-permission
android:name="com.example.mapdemo.permission.MAPS_RECEIVE"/>
<uses-feature
    android:glEsVersion="0x00020000"
    android:required="true"/>
```

Android: Inserting a Map inside the App

Permissions should be added to the AndroidManifest.xml, and the Activation Key must be specified in the meta-data.

```
<meta-data
 android:name="com.google.android.maps.v2.API_KEY"
 android:value="API_activation_key"/>
```

Specifically for the **Android Studio** projects:

```
<meta-data
    android:name="com.google.android.gms.version"
    android:value="@integer/
          google_play_services_version" />
```

Android: Inserting a Map inside the App

Permissions should be added to the AndroidManifest.xml, and the Activation Key must be specified in the meta-data.

```
<uses-permission android:name="android.permission.INTERNET"/>
<uses-permission
android:name="android.permission.ACCESS_NETWORK_STATE"/>
<uses-permission
android:name="android.permission.WRITE_EXTERNAL_STORAGE"/>
<uses-permission
android:name="com.google.android.providers.gsf.permission.READ_GSERVICES"/>
<uses-permission
android:name="android.permission.ACCESS_COARSE_LOCATION"/>
<uses-permission
android:name="android.permission.ACCESS_FINE_LOCATION"/>
```

Android: Fragments

Fragment → A portion of the user interface in an Activity.

Introduced from **Android 3.0** (API Level 11)

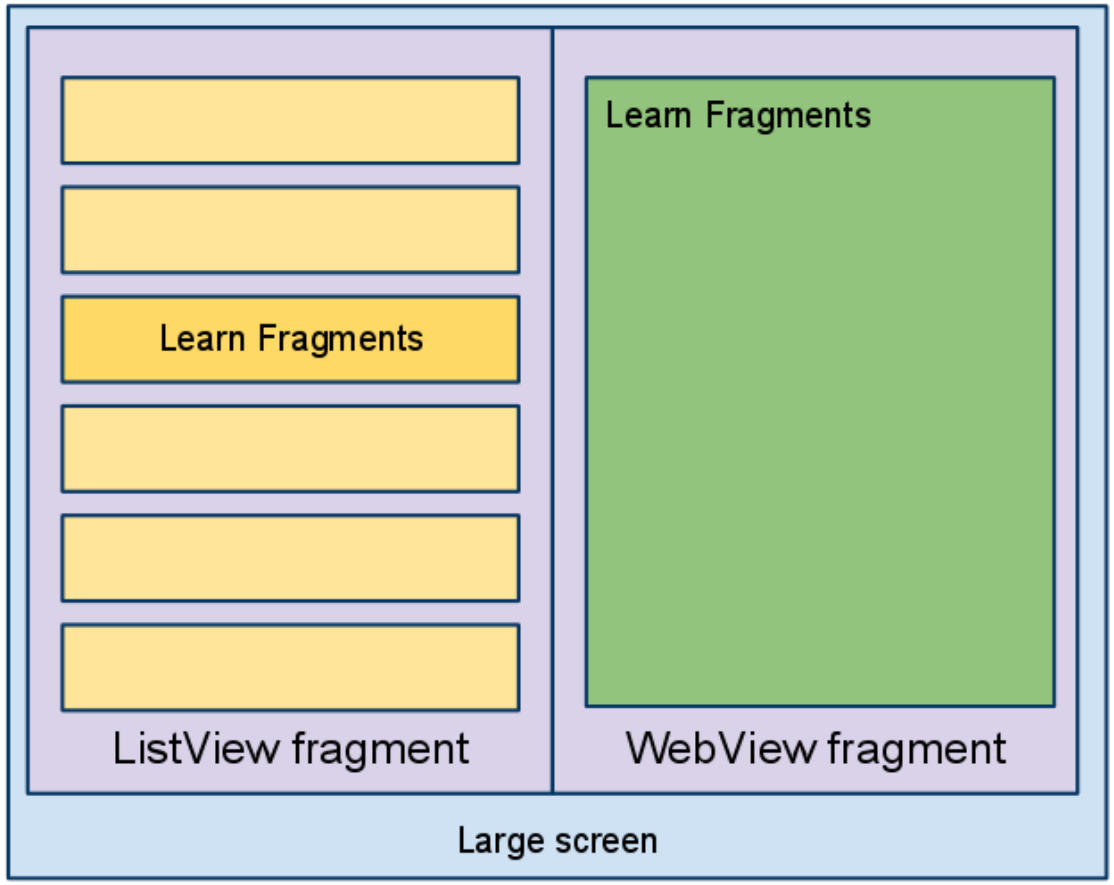
Practically, a Fragment is a modular section of an Activity.

DESIGN PHILOSOPHY

- **Structure** an Activity as a collection of Fragments.
- **Reuse** a Fragment on different Activities …

Android: Fragments Design Philosophy

EXAMPLE: Structuring an Application using 1 Activity and 2 Fragments.



Android: Inserting a Map inside the App

In order to insert a Google Map into a mobile Application:

- Add a **MapFragment** to the current Activity:

```
<?xml version="1.0" encoding="utf-8"?>
<fragment
  android:id="@+id/map"
  android:name="com.google.android.gms.maps.MapFra
gment"
  android:layout_width="match_parent"
  android:layout_height="match_parent" />
```

Android: Inserting a Map inside the App

A MapFragment is a container of the **GoogleMap** object, which is a View containing the map and managing the events.

```
private GoogleMap mMap;
...
mMap = ((MapFragment)
getFragmentManager().findFragmentById(R.id.map)).getMap();
```

Differences with **Android Maps v1 libs**:

- No need to use a MapActivity, use a regular Activity instead.
- Improved caching and drawing functionalities.

Android: Customize the Map

How to customize the Google Map?

- Define the **Map type**, governing the overall representation of the map

```
nMap.setMapType(GoogleMap.MAP_TYPE_HYBRID);
```

Normal → Typical road map.

Hybrid → Satellite photograph data with road maps added.

Satellite → Satellite photograph data. Road and feature labels are not visible.

Terrain → Topographic data. The map includes colors, contour lines and labels, and perspective shading.

None → no tiles, empty grid.

Android: Customize the Map

The **LatLng** class allows to define a point on the map, expressed through the latitude/longitude coordinates.

```
private static final LatLng BOLOGNA_POINT = new
LatLng(44.496781,11.356387);
```

```
private static final LatLng FLORENCE_POINT = new
LatLng(43.771373,11.248069);
```

LatLng class (API v2) → **Geopoint** class (API v1)

Android: Customize the Map

Q. How to customize the Google Map?

A. Define the **properties of the Camera** applied to the Map.

Location → expressed in forms of latitude/longitude coordinates.

Zoom → defines the scale levels of the map.

Bearing → defines the map orientation, i.e. the direction in which a vertical line on the map points, measured in degrees clockwise from north.

Tilt → viewing angle, measured as degrees from the nadir.

Android: Customize the Map

Camera properties can be set individually, or collectively through the **CameraPosition** object.

```
private static final LatLng BOLOGNA_POINT = new
LatLng(44.496781,11.356387);
```

```
CameraPosition cameraPosition = new CameraPosition.
     Builder()
    .target(BOLOGNA_POINT)
    .zoom(17)
    .bearing(90)
    .tilt(30)
    .build();
```

Android: Customize the Map

Two methods to modify the position of the camera:

```
mMap.moveCamera(cameraPosition);
```

- Update the camera properties immediately.

```
mMap.animateCamera(cameraPosition);
```

```
mMap.animateCamera(cameraPosition, duration, call);
```

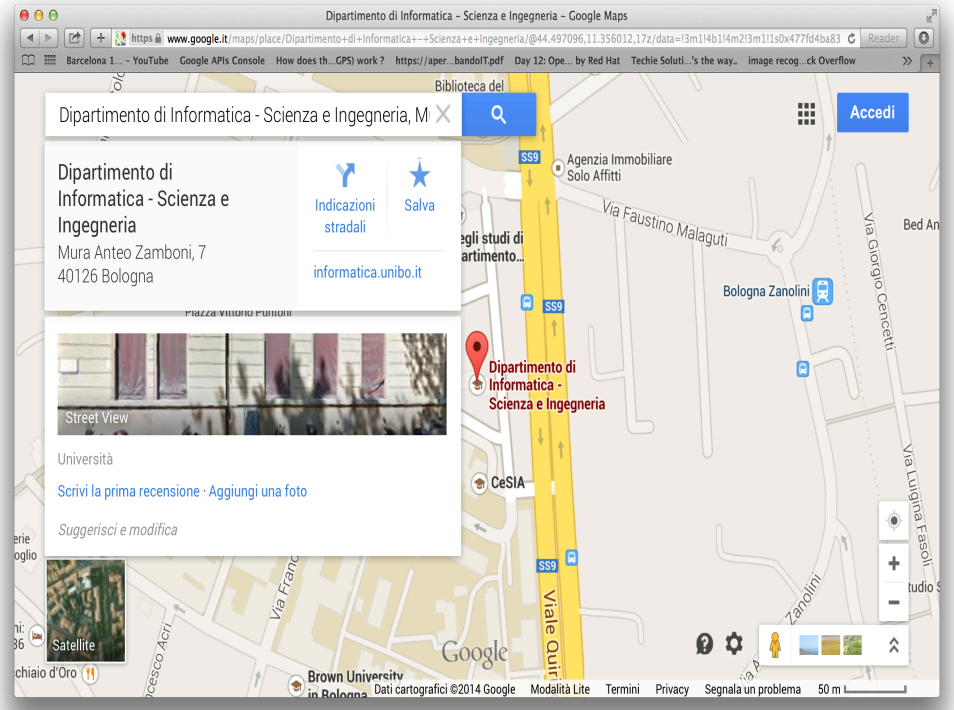
- Update the camera properties through an animation, eventually adding a delay and a callback to be invoked when the animation stops.

Android: Customize the Map

Markers can be used to identify locations on the GoogleMap.

Markers can be customized in terms of:

- **Icon** to be displayed
- **Position** of the marker on the map
- **Title** and text to be displayed
- **Events** to be managed



Android: Customize the Map

Markers can be used to identify locations on the GoogleMap.

`position` → Lat/Long coordinates

`title` → string displayed in the info window when the user taps the marker

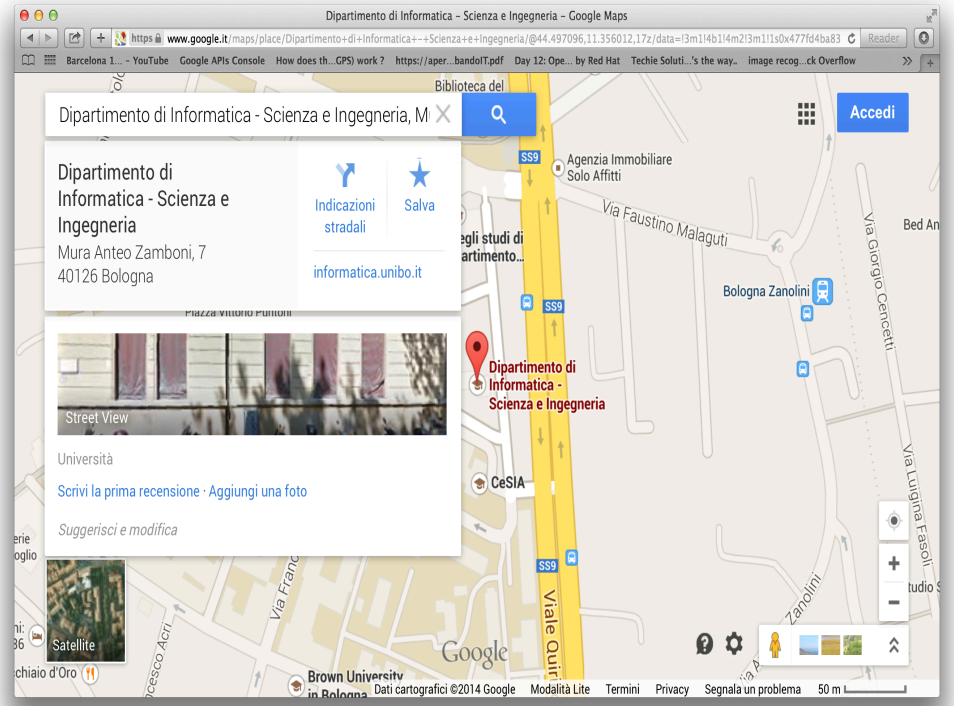
`snippet` → additional text in the info window

`icon` →image/color of the marker

`alpha` →opacity of the marker

`draggable` →(true/false)

`visible` → (true/false)



Android: Customize the Map

Markers can be used to identify locations on the GoogleMap.

```
private static final LatLng BOLOGNA_POINT = new
LatLng(44.496781,11.356387);

Marker bologna =
myMap.addMarker(newMarkerOptions().position(BOLOGNA_POI
NT));
```

```
Marker bologna= mMap.addMarker(new MarkerOptions()
                    .position(Bologna)
                    .title("Bologna downtown")
                    .snippet("Visit the city centre"));
```

Android: Customize the Map

Markers can be used to identify locations on the GoogleMap.

EVENTS associated to a Marker:

ClickEvents → implement the `OnMarkerClickListener` interface, and the `onMarkerClick(Marker)` method.

DragEvents → implement the `OnMarkerDragListener` interface, and the `onMarkerDragEnd(Marker)` method.

InfoWindow Click Events → implement the `OnInfoWindowClickListener` interface, and the `onInfoWindowClick(Marker)` method.

Android: Customize the Map

Developers can handle the **events** on the Google Map.

Events are managed through the **listener mechanism** seen so far …

CLICK events → Implement the `OnMapClickListener` interface and the `OnMapLongClickListener` method.

CAMERA events → Implement the `OnCameraChangeListener` interface and the `onCameraChange(CameraPosition)` method.

Android: Customize the Map

Developers can handle the **events** on the Google Map.

```
public class MainActivity extends Activity
                              implements OnMapClickListener {
private GoogleMap mMap;

protected void onCreate(Bundle savedInstanceState) {
…
mMap.setOnMapClickListener(this);
…
}

public void onMapClick(LatLng position) {
      // Handle the click events here …
}
```

Android: Customize the Map

Shapes can be used to identify sections of the GoogleMap.

Polylines → define a set of LatLong objects, and connect them through a set of lines. Possible to define the stroke and colors of the lines.

Polygons → define a set of LatLong objects, and connect them through a closed polygon. Possible to define the stroke and colors of the lines.

Circles → define a LatLong object and a radius, and draw a circle centered at the point. Define pen color/stroke as above.

Android: Customize the Map

Shapes can be used to identify sections of the GoogleMap.

```
PolygonOptions rectOptions = new PolygonOptions()
        .add(BOLOGNA_P1)
        .add(BOLOGNA_P2)
        .add(BOLOGNA_P3);
Polygon polyline = mMap.addPolygon(rectOptions);

CircleOptions circleOptions = new CircleOptions()
        .center(BOLOGNA_P1)
        .radius(1000)
        .strokeColor(Color.RED);

Circle circle = mMap.addCircle(circleOptions);
```

Android: Customize the Map

Google Direction API → services that calculates directions between a source and a destination, including different transportations modes (e.g. driving, walking, biking).

- **Remote Service**: send an HTTP request and get an HTTP reply
- **Activation key** needed from the Google API Console
- Subject to **usage limits**: 2500 directions/day for free API, 100000 directions/day for business API (8 vs 24 waypoints)
- Direction API data must be displayed on the Map
- It is not designed to support real-time navigation applications

Android: Customize the Map

- Direction API requests takes the following form:

```
http://maps.googleapis.com/maps/api/directions/output?parameters
```

JSON (recommended) or **XML**

REQUIRED

`origin` → latitude/longitude coordinates or address (**geocoding** performed)

`destination` →latitude/longitude coordinates or address

`sensor` → request comes from a device with location sensor (true/false)

`key` → **`API Key`** of the Google Direction Service

Android: Customize the Map

- Direction API requests takes the following form:

```
https://maps.googleapis.com/maps/api/directions/output?parameters
```

OPTIONAL

mode → transportation mode (driving, walking, bicycling, transit)
waypoints →array of waypoints which must appear on the route
alternatives → (true/false) decide to show single or multiple routes
avoid → avoid specific features (tolls, highways, ferries)
departure_time → desired time of departure
arrival_time → desired time of arrival
language→ language of the results (e.g. route indications)

Android: Customize the Map

- Example of Google Direction requests

```
https://maps.googleapis.com/maps/api/directions/json?origin=Bologna&destination=Modena&sensor=false&key={API_KEY}
```

```
https://maps.googleapis.com/maps/api/directions/json?origin=Bologna&destination=Modena&sensor=false&key={API_KEY}&avoid=highways&mode=transit
```

```
https://maps.googleapis.com/maps/api/directions/json?origin=Bologna&destination=Modena&waypoints=Vignola|Maranello&sensor=false&key={API_KEY}&avoid=highways&mode=transit
```

Android: Customize the Map

```
{
  "status": "OK",
  "routes": [ {
    "summary": "I-40 W",
    "legs": [ {
      "steps": [ {
        "travel_mode":
"DRIVING",
        "start_location": {
          "lat": 41.8507300,
          "lng": -87.6512600
        },
        "end_location": {
          "lat": 41.8525800,
          "lng": -87.6514100
        },
```

JSON result of the query

```
"polyline": {
          "points": "a~l~Fjk~uOwHJy@P"
        },
        "duration": {
          "value": 19,
          "text": "1 min"
        }
        "html_instructions": ”Head Morgan St",
        "distance": {
          "value": 207,
          "text": "0.1 mi"
        }
      },
.......
```

Android: Google Maps library overview

GeoCoding → Technique to convert an Address into a Geo (lat/long) point, or viceversa (reverse geocoding)…

Implemented by the Geocoder class

```
public Geocoder(Context contex)
```

Main methods:

- public **List<Address> getFromLocation**(double latitude, double longitude, int maxResults)
- public **List<Address> getFromLocationName**(String locationName, int maxResults)