CS 528 Mobile and Ubiquitous Computing

Lecture 5: Widget Catalog, SQLite Databases and Sensors

Emmanuel Agu

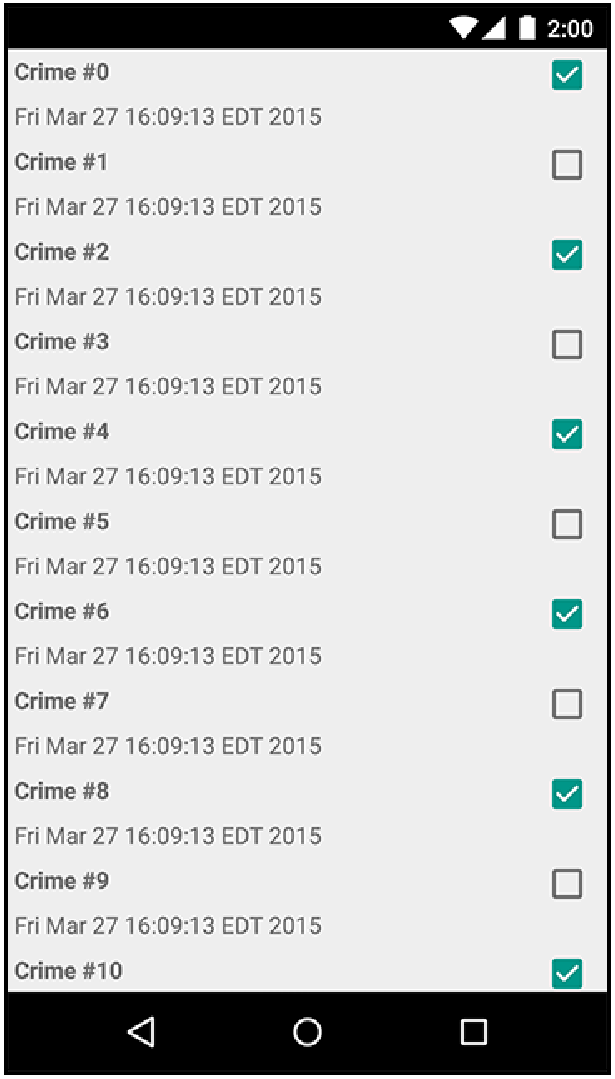
Paper sign up

- Students present papers in weeks 7-8, 10-13
- Previously 1 student per paper
- Too many students (42)
- So, 2 students per paper this time
- Everyone should sign up
- First presentations in 2 weeks

Skipped Android Nerd Ranch CriminalIntent Chapters

Chapter 9: Displaying Lists with RecyclerView

- RecyclerView allows view of large dataset
- Allows crimes in **CriminalIntent** to be listed
- Users can check box to indicate if crime has been solved/not solved



2:00

Crime #0 ☑
Fri Mar 27 16:09:13 EDT 2015

Crime #1 ☐
Fri Mar 27 16:09:13 EDT 2015

Crime #2 ☑
Fri Mar 27 16:09:13 EDT 2015

Crime #3 ☐
Fri Mar 27 16:09:13 EDT 2015

Crime #4 ☑
Fri Mar 27 16:09:13 EDT 2015

Crime #5 ☐
Fri Mar 27 16:09:13 EDT 2015

Crime #6 ☑
Fri Mar 27 16:09:13 EDT 2015

Crime #7 ☐
Fri Mar 27 16:09:13 EDT 2015

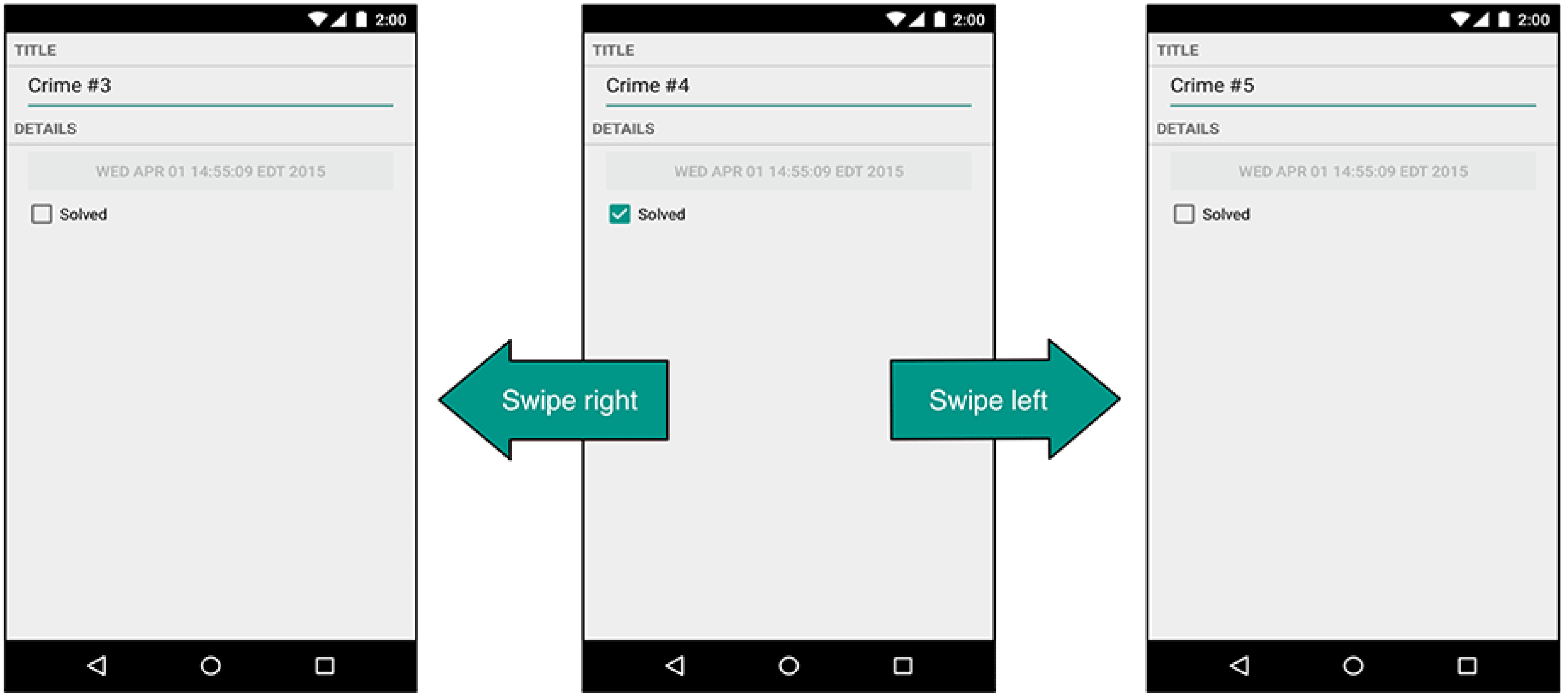
Crime #8 ☑
Fri Mar 27 16:09:13 EDT 2015

Crime #9 ☐
Fri Mar 27 16:09:13 EDT 2015

Crime #10 ☑

Chapter 11: Using ViewPager

- ViewPager allows users swipe between screens (e.g. Tinder?)
- Allows users swipe between Crimes in CriminalIntent



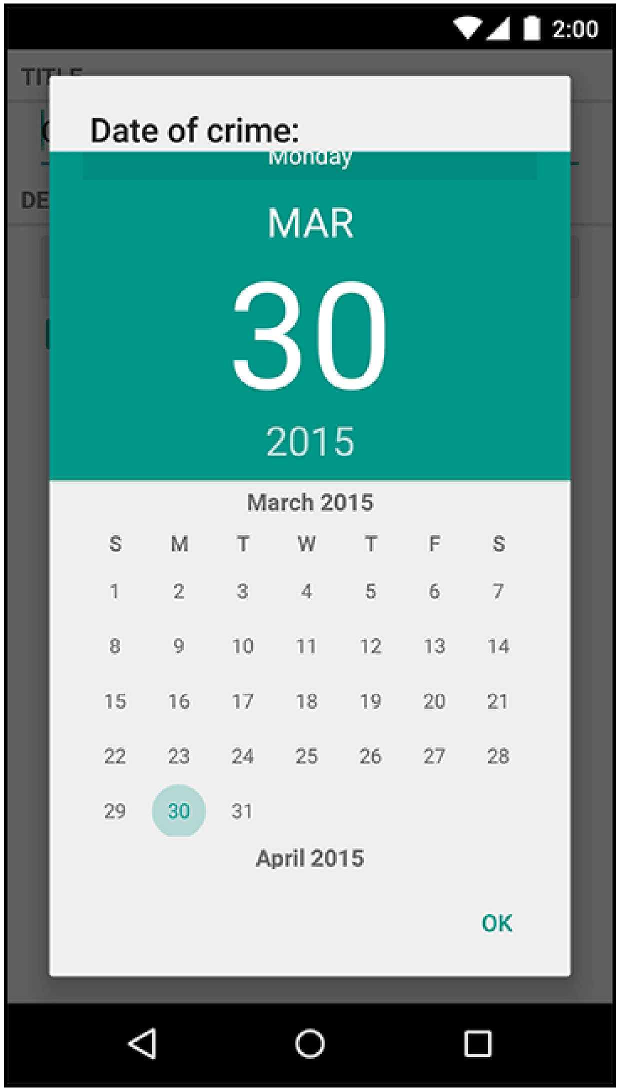
TITLE
Crime #3
DETAILS
WED APR 01 14:55:09 EDT 2015
☐ Solved

TITLE
Crime #4
DETAILS
WED APR 01 14:55:09 EDT 2015
☑ Solved

TITLE
Crime #5
DETAILS
WED APR 01 14:55:09 EDT 2015
☐ Solved

Chapter 12: Dialogs

- Dialogs present users with a choice or important information
- E.g. DatePicker allows users pick date
- Allows users to pick a date on which a crime occurred in **CriminalIntent**



2:00

Date of crime:

Monday

MAR

30

2015

March 2015

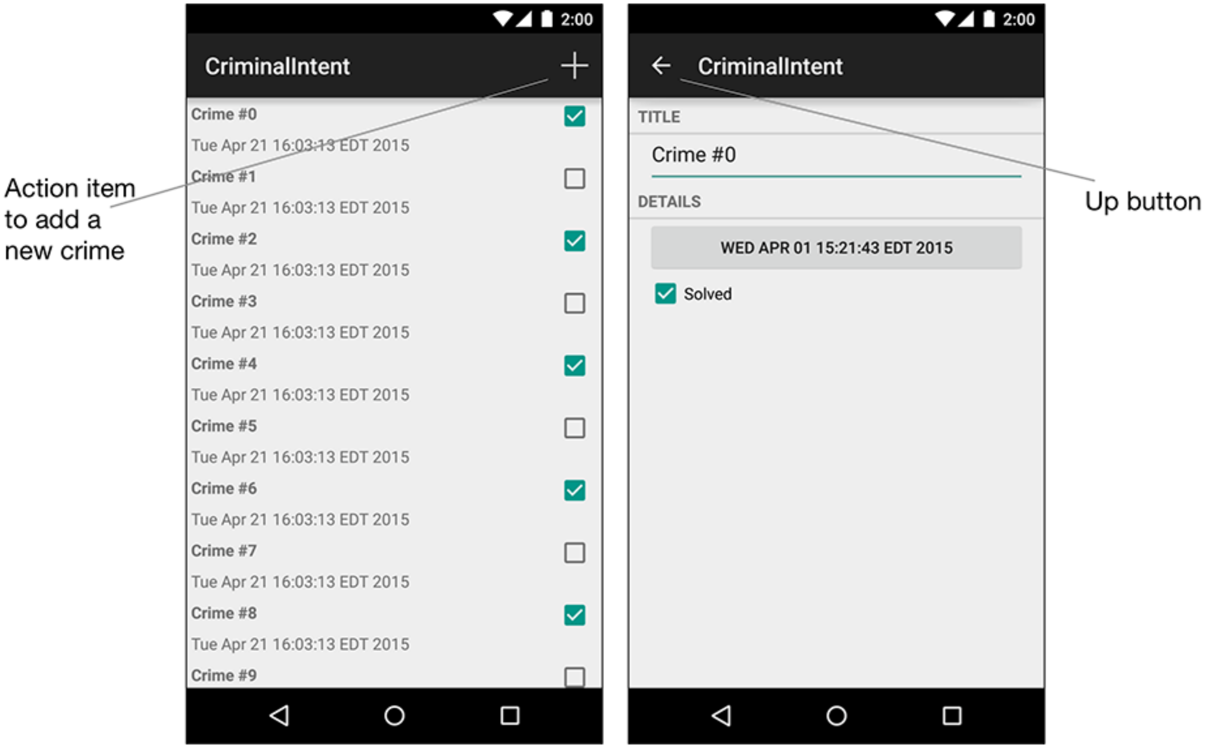
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

April 2015

OK

Chapter 13: The Toolbar

- Many Android apps include a toolbar
- Toolbar includes actions user can take
- In CriminalIntent, menu items for adding crime, navigate up the screen hierarchy



CriminalIntent

Crime #0 ☑
Tue Apr 21 16:03:13 EDT 2015

Crime #1 ☐
Tue Apr 21 16:03:13 EDT 2015

Crime #2 ☑
Tue Apr 21 16:03:13 EDT 2015

Crime #3 ☐
Tue Apr 21 16:03:13 EDT 2015

Crime #4 ☑
Tue Apr 21 16:03:13 EDT 2015

Crime #5 ☐
Tue Apr 21 16:03:13 EDT 2015

Crime #6 ☑
Tue Apr 21 16:03:13 EDT 2015

Crime #7 ☐
Tue Apr 21 16:03:13 EDT 2015

Crime #8 ☑
Tue Apr 21 16:03:13 EDT 2015

Crime #9 ☐

CriminalIntent

TITLE

Crime #0

DETAILS

WED APR 01 15:21:43 EDT 2015

☑ Solved

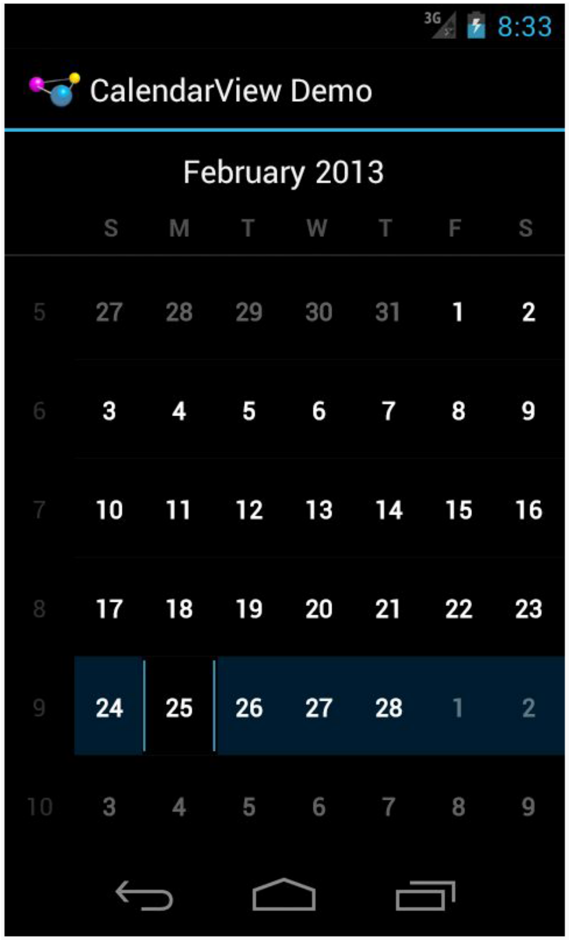
Widget Catalog

What Widget Catalog?

- Several larger widgets are available
- Can use easily just like smaller widgets, to make your apps look nice and professional
- Examples:
  - CalendarView
  - DatePicker
  - TimePicker
  - SeekBar
- Will not explain coding here. Check books, Android documentation

CalendarView

- Allows user pick a date from a displayed calendar



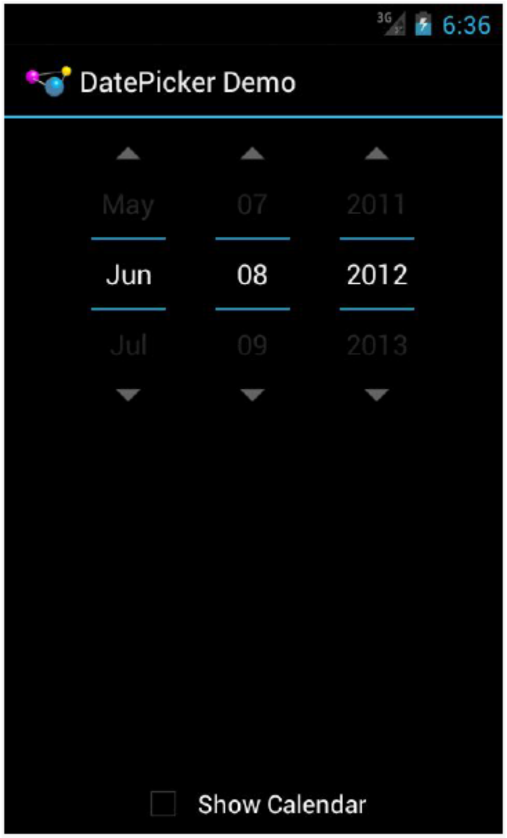
February 2013

	S	M	T	W	T	F	S
5	27	28	29	30	31	1	2
6	3	4	5	6	7	8	9
7	10	11	12	13	14	15	16
8	17	18	19	20	21	22	23
9	24	25	26	27	28	1	2
10	3	4	5	6	7	8	9

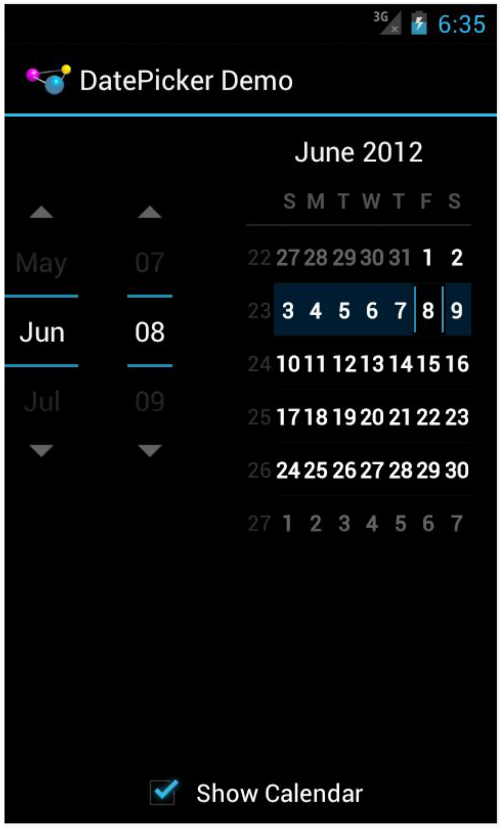
CalendarView Android 4.0

DatePicker

- Allows user pick a date
- Uses date wheel
- Can display a CalenderView as well



DatePicker without CalendarView Android 4.0

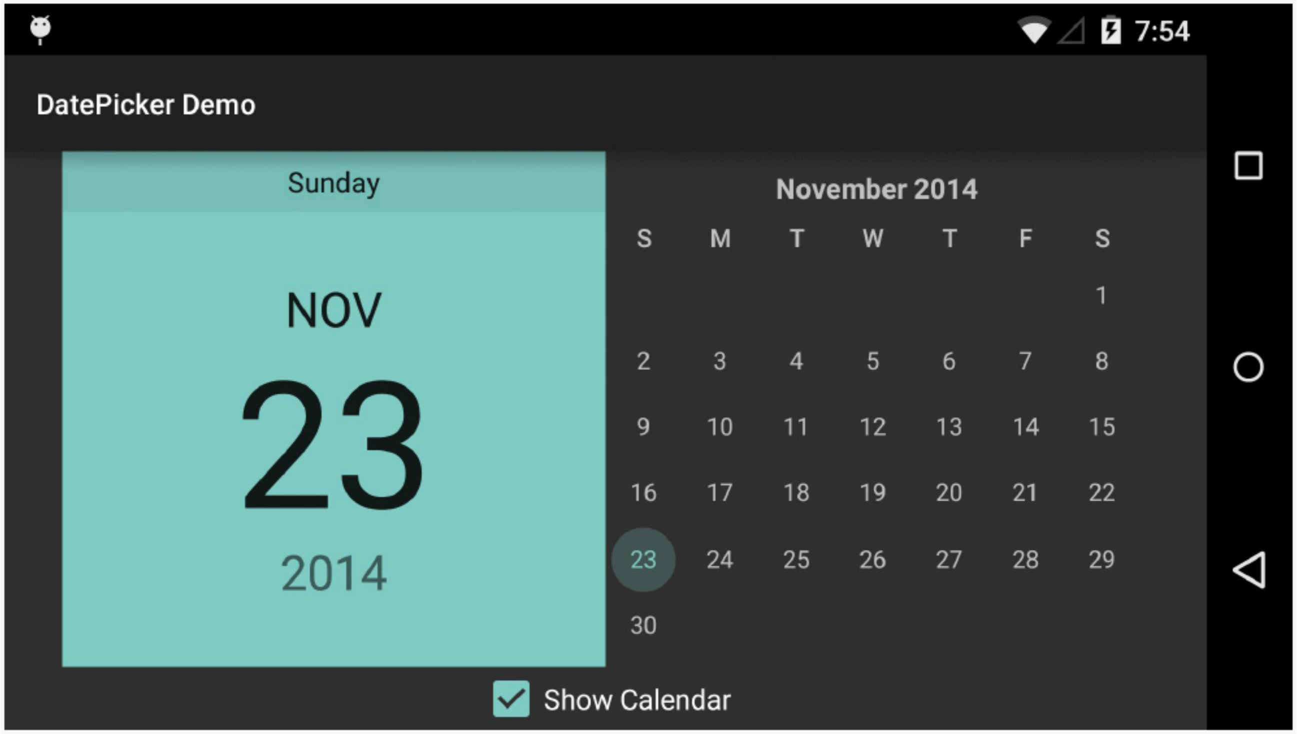


June 2012

	S	M	T	W	T	F	S
22	27	28	29	30	31	1	2
23	3	4	5	6	7	8	9
24	10	11	12	13	14	15	16
25	17	18	19	20	21	22	23
26	24	25	26	27	28	29	30
27	1	2	3	4	5	6	7

DatePicker with CalendarView Android 4.0

DatePicker

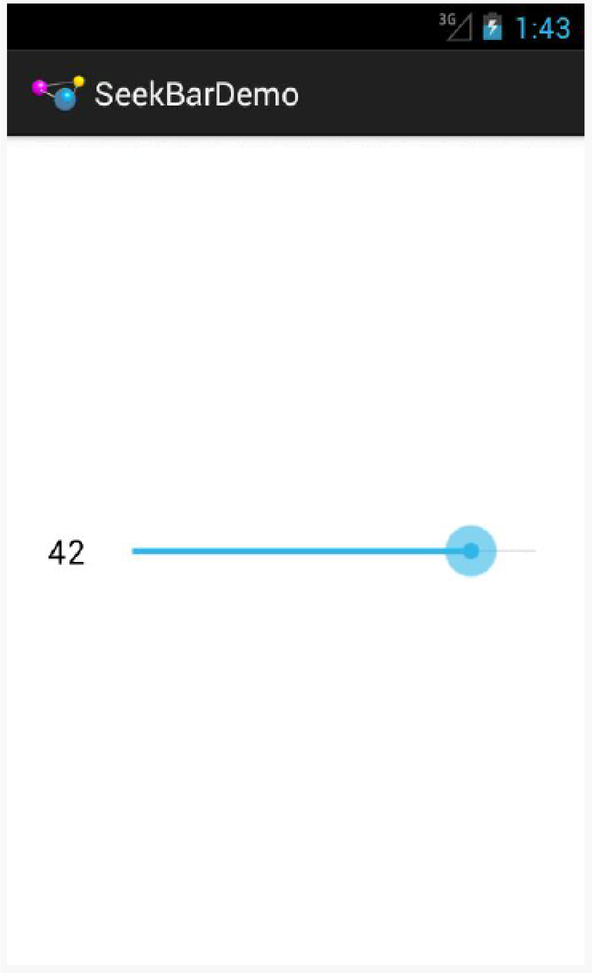


S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

DatePicker with CalendarView Android 5.0, landscape

SeekBar

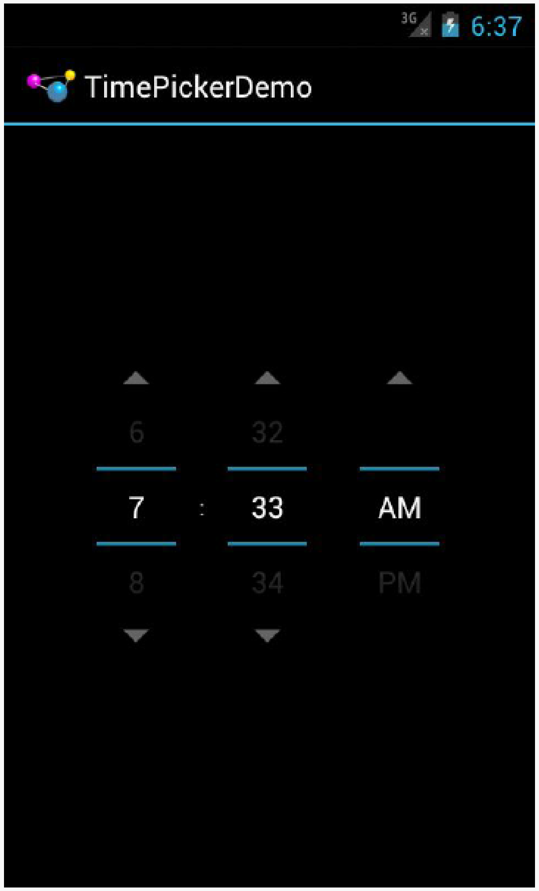
- Allows user choose a value on a continuous range by sliding a "thumb" along a horizontal line



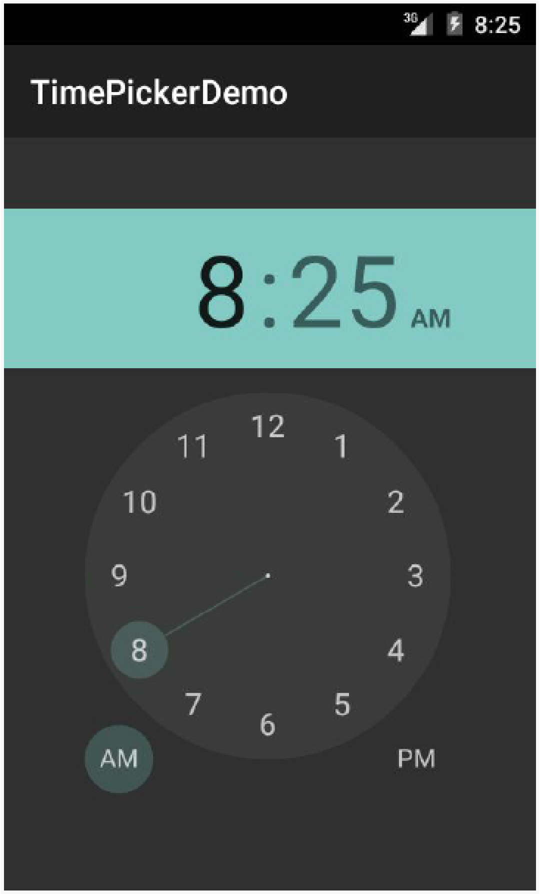
SeekBar Android 4.1

TimePicker

- Allows user pick a time



TimePicker Android 4.1

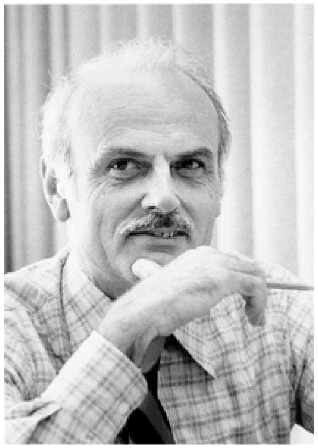


TimePicker Android 5.0

Android Nerd Ranch Ch 14
SQLite Databases

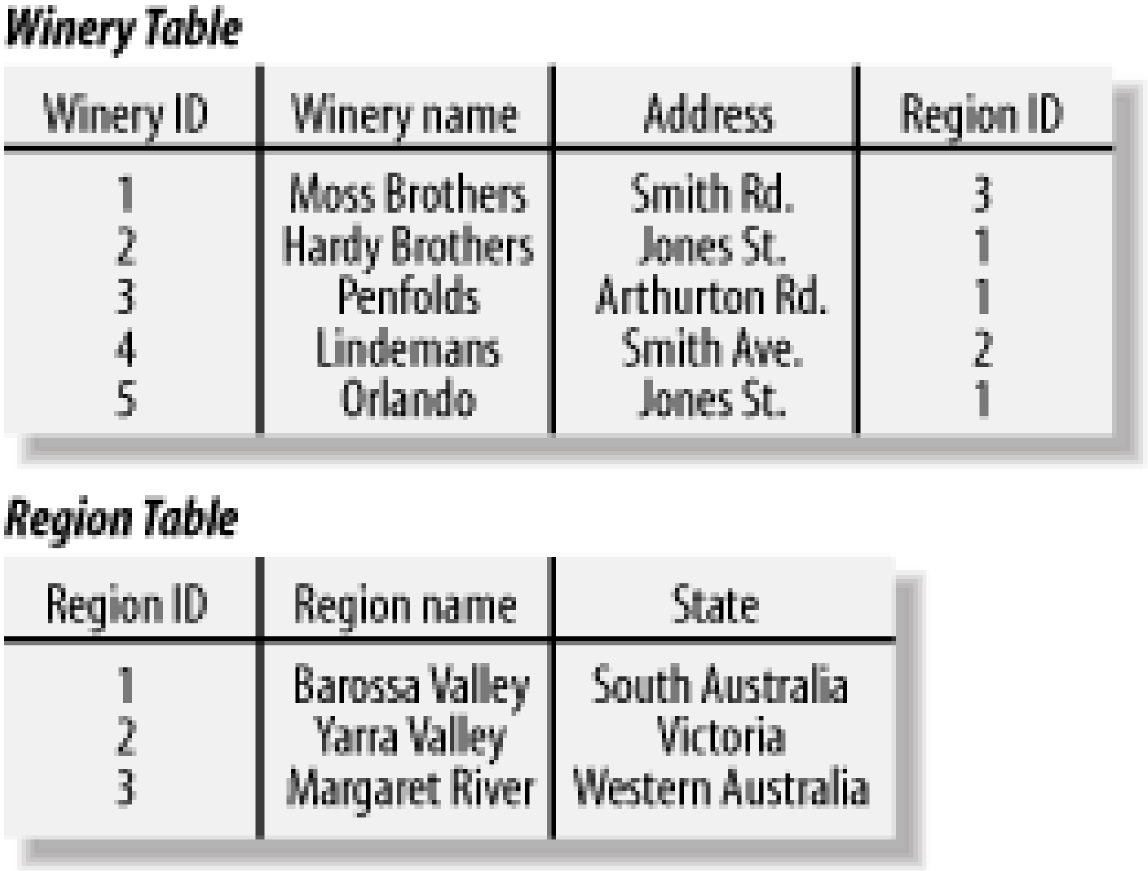
Background on Databases

- RDBMS
  - relational data base management system
- Relational databases introduced by E. F. Codd
  - Turing Award Winner
- Relational Database
  - data stored in tables
  - relationships among data stored in tables
  - data can be accessed and viewed in different ways



Example Database

- Wines



Winery Table

Winery ID	Winery name	Address	Region ID
1	Moss Brothers	Smith Rd.	3
2	Hardy Brothers	Jones St.	1
3	Penfolds	Arthurton Rd.	1
4	Lindemans	Smith Ave.	2
5	Orlando	Jones St.	1

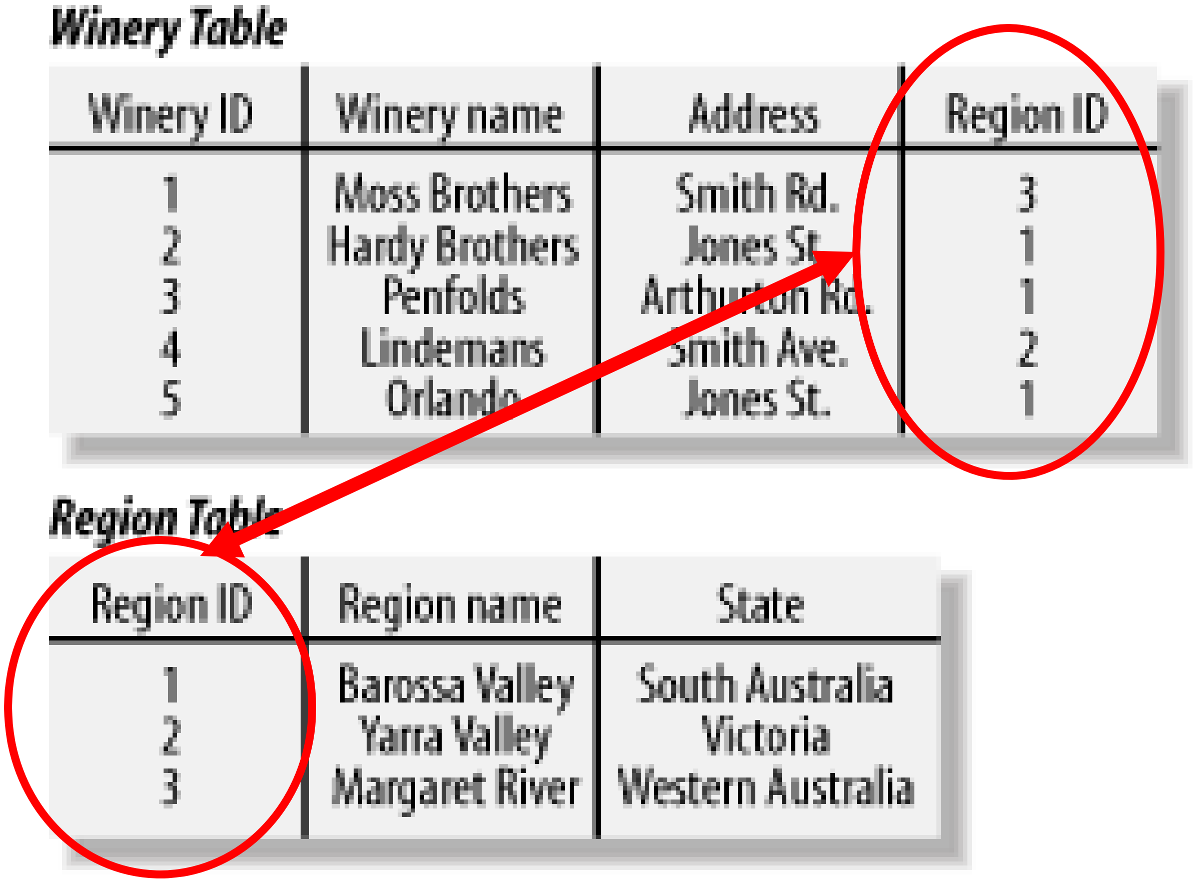
Region Table

Region ID	Region name	State
1	Barossa Valley	South Australia
2	Yarra Valley	Victoria
3	Margaret River	Western Australia

Ref: Web Database Applications with PHP and MySQL, 2nd Edition , by Hugh E. Williams, David Lane

Relational Data

- Data in different tables can be related



Winery Table

Winery ID	Winery name	Address	Region ID
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Region Table

Region ID	Region name	State
1	Barossa Valley	South Australia
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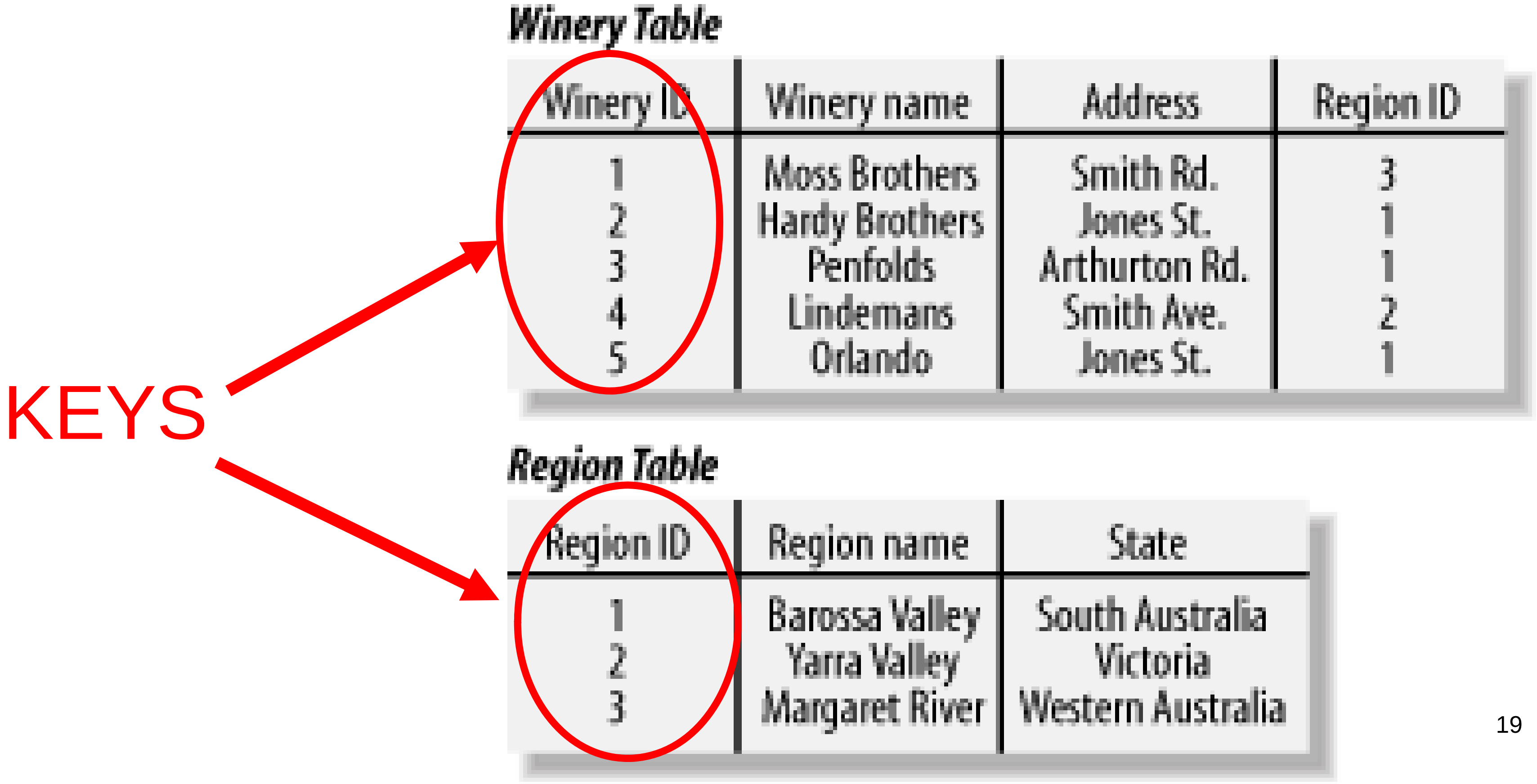
Keys

- Each table has a key
- Column used to uniquely identify each row



KEYS

Winery Table

Winery ID	Winery name	Address	Region ID
1	Moss Brothers	Smith Rd.	3
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4	Lindemans	Smith Ave.	2
5	Orlando	Jones St.	1

Region Table

Region ID	Region name	State
1	Barossa Valley	South Australia
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3	Margaret River	Western Australia

SQL and Databases

- SQL is the language used to manipulate and manage information in a relational database management system (RDBMS)
- SQL Commands:
  - **CREATE TABLE** - creates new database table
  - **ALTER TABLE** - alters a database table
  - **DROP TABLE** - deletes a database table
  - **CREATE INDEX** - creates an index (search key)
  - **DROP INDEX** - deletes an index

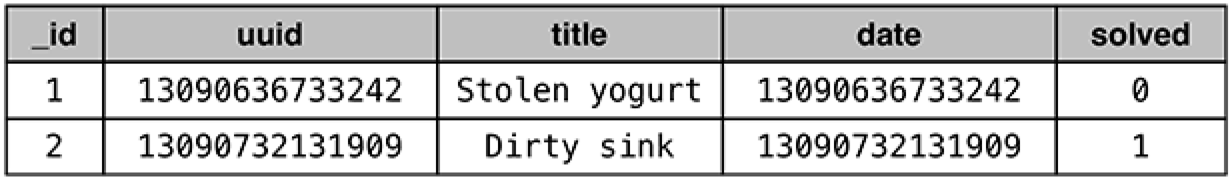
SQL Commands

- **SELECT** - get data from a database table
- **UPDATE** - change data in a database table
- **DELETE** - remove data from a database table
- **INSERT INTO** - insert new data in a database table

- SQLite implements most, but not all of SQL
  - http://www.sqlite.org/

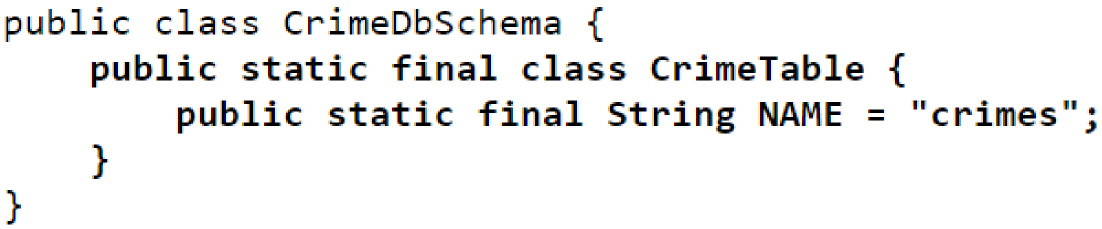
CriminalIntent Database

- **SQLite** is open source relational database
- Android includes SQLite database in its standard library
- **Goal:** Store crimes in CriminalIntent in a database
- First step, define database table of **crimes**



_id	uuid	title	date	solved
1	13090636733242	Stolen yogurt	13090636733242	0
2	13090732131909	Dirty sink	13090732131909	1

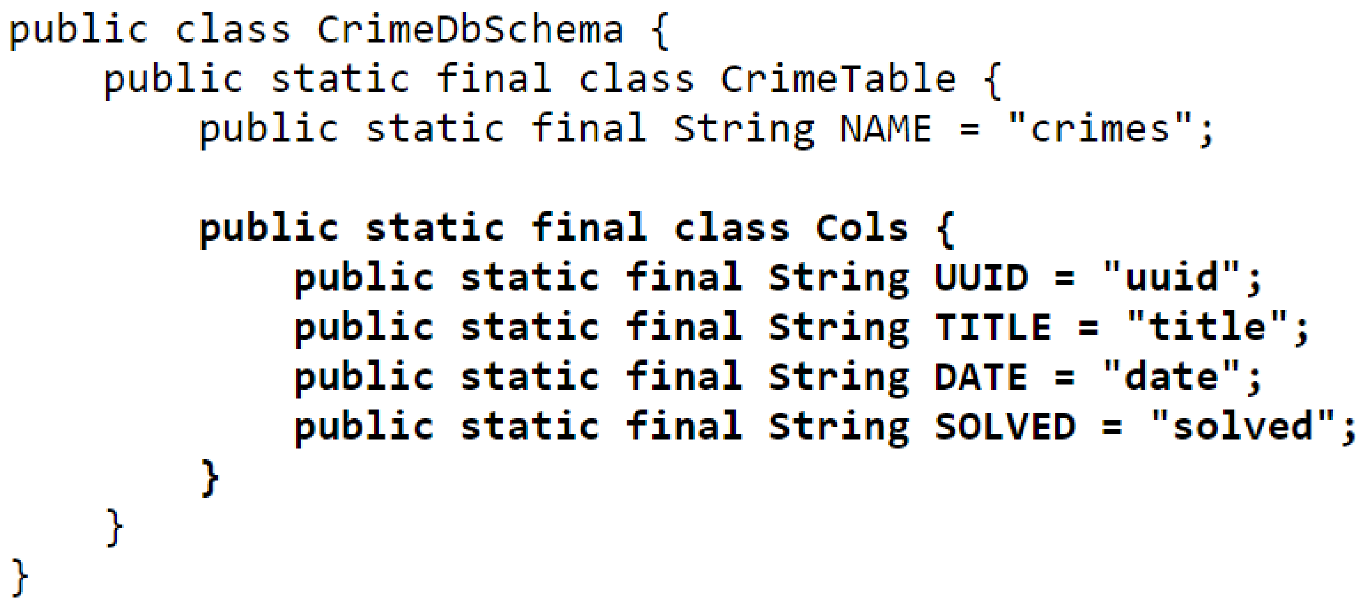
- Create **CrimeDbSchema** class to put **crime** database in



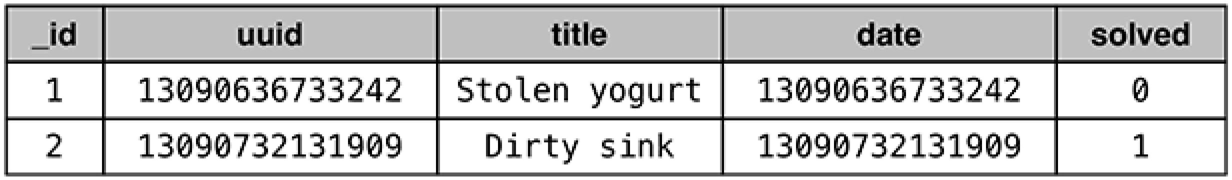
```
public class CrimeDbSchema {
    public static final class CrimeTable {
        public static final String NAME = "crimes";
    }
}
```

CriminalIntent Database

- Next, define the columns of the Crimes database table



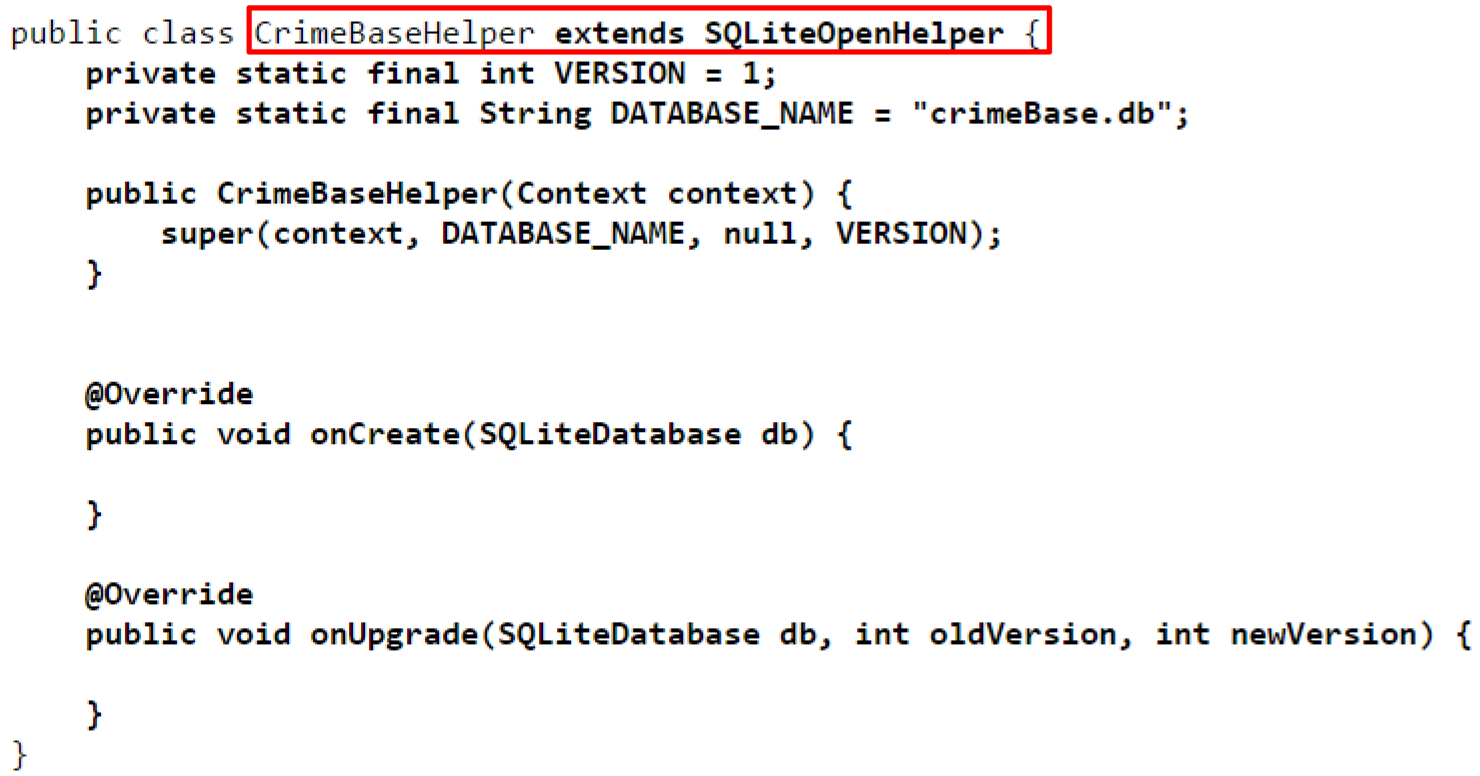
```
public class CrimeDbSchema {
    public static final class CrimeTable {
        public static final String NAME = "crimes";

        public static final class Cols {
            public static final String UUID = "uuid";
            public static final String TITLE = "title";
            public static final String DATE = "date";
            public static final String SOLVED = "solved";
        }
    }
}
```



_id	uuid	title	date	solved
1	13090636733242	Stolen yogurt	13090636733242	0
2	13090732131909	Dirty sink	13090732131909	1

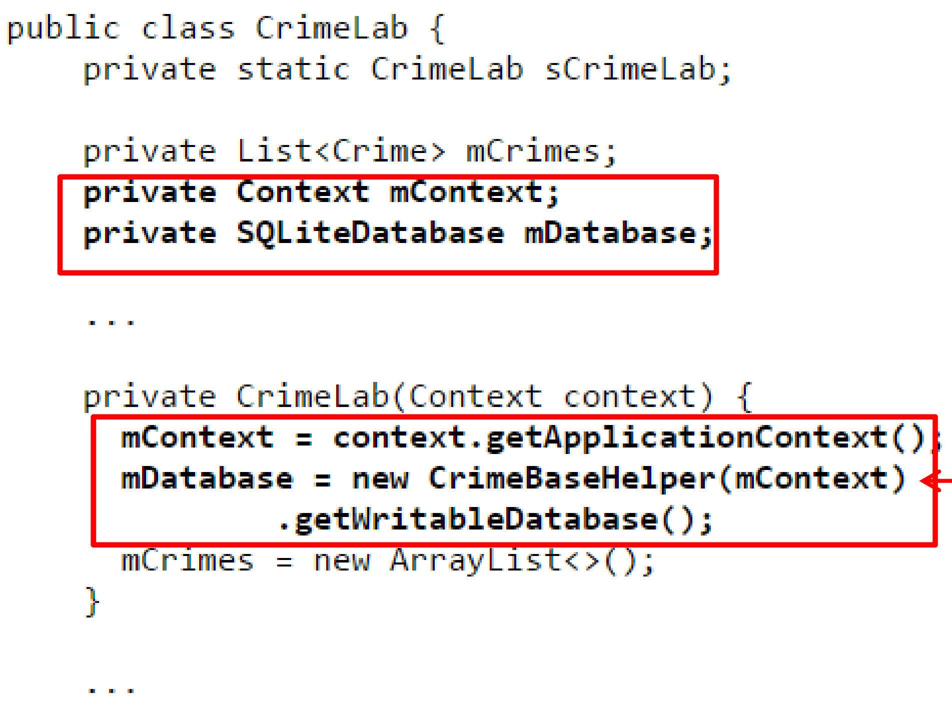
SQLiteOpenHelper

- **SQLiteOpenHelper** encapsulates database creation, opening and updating
- In **CriminalIntent**, create subclass of **SQLiteOpenHelper** called **CrimeBaseHelper**



```java
public class CrimeBaseHelper extends SQLiteOpenHelper {
    private static final int VERSION = 1;
    private static final String DATABASE_NAME = "crimeBase.db";

    public CrimeBaseHelper(Context context) {
        super(context, DATABASE_NAME, null, VERSION);
    }


    @Override
    public void onCreate(SQLiteDatabase db) {

    }

    @Override
    public void onUpgrade(SQLiteDatabase db, int oldVersion, int newVersion) {

    }
}
```

Use CrimeBaseHelper to open SQLite Database

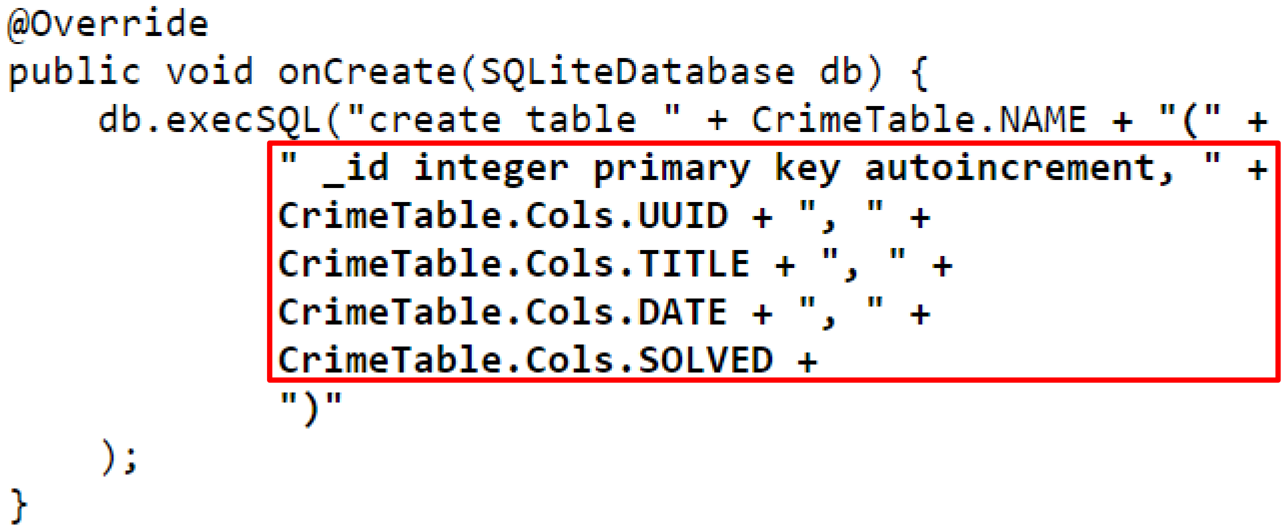


```
public class CrimeLab {
    private static CrimeLab sCrimeLab;

    private List<Crime> mCrimes;
    private Context mContext;
    private SQLiteDatabase mDatabase;

    ...

    private CrimeLab(Context context) {
      mContext = context.getApplicationContext();
      mDatabase = new CrimeBaseHelper(mContext)
              .getWritableDatabase();
      mCrimes = new ArrayList<>();
    }

    ...
```

Opens new writeable Database

Create CrimeTable in onCreate( )

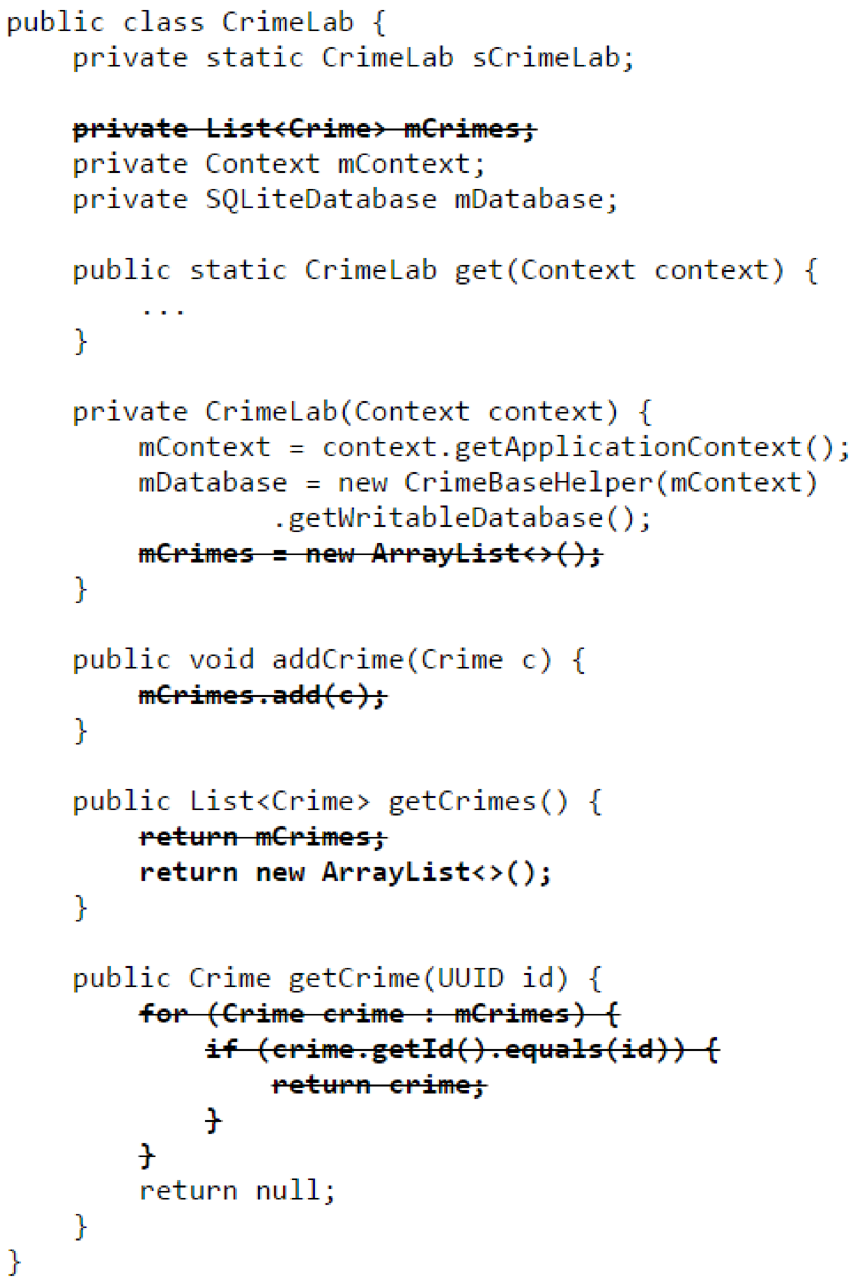
- Create CrimeTable in onCreate( )



```
@Override
public void onCreate(SQLiteDatabase db) {
    db.execSQL("create table " + CrimeTable.NAME + "(" +
            " _id integer primary key autoincrement, " +
            CrimeTable.Cols.UUID + ", " +
            CrimeTable.Cols.TITLE + ", " +
            CrimeTable.Cols.DATE + ", " +
            CrimeTable.Cols.SOLVED +
            ")"
    );
}
```

Use Database

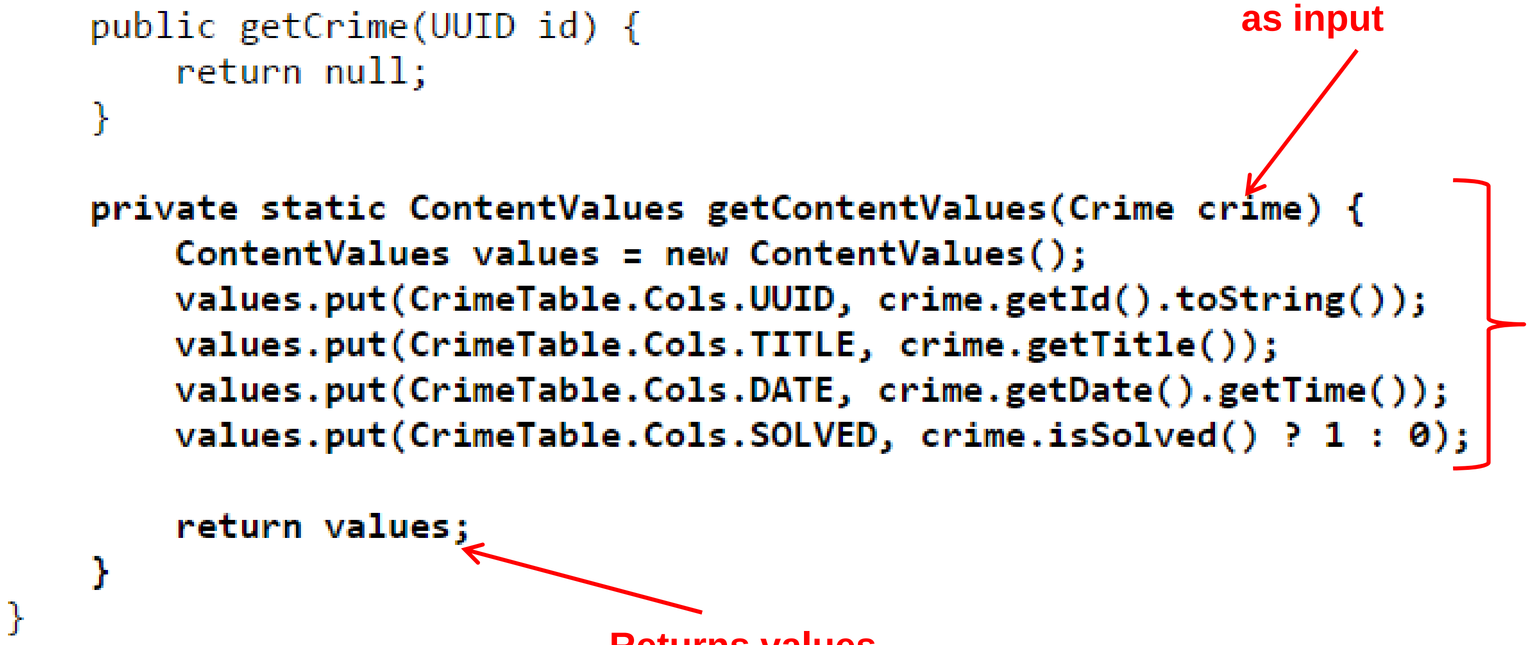
- **CriminalIntent,** previously used arrayLists
- Modify to use SQLiteDatabase



```
public class CrimeLab {
    private static CrimeLab sCrimeLab;

    ~~private List<Crime> mCrimes;~~
    private Context mContext;
    private SQLiteDatabase mDatabase;

    public static CrimeLab get(Context context) {
        ...
    }

    private CrimeLab(Context context) {
        mContext = context.getApplicationContext();
        mDatabase = new CrimeBaseHelper(mContext)
                .getWritableDatabase();
        ~~mCrimes = new ArrayList<>();~~
    }

    public void addCrime(Crime c) {
        ~~mCrimes.add(c);~~
    }

    public List<Crime> getCrimes() {
        ~~return mCrimes;~~
        return new ArrayList<>();
    }

    public Crime getCrime(UUID id) {
        ~~for (Crime crime : mCrimes) {~~
            ~~if (crime.getId().equals(id)) {~~
                ~~return crime;~~
            ~~}~~
        ~~}~~
        return null;
    }
}
```

Writing to the Database using ContentValues

- In Android, writing to databases is done using class **ContentValues**
- **ContentValues** is key-value pair (like Bundle)
- Create method to create **ContentValues** instance from a **Crime**



```
    public getCrime(UUID id) {
        return null;
    }

    private static ContentValues getContentValues(Crime crime) {
        ContentValues values = new ContentValues();
        values.put(CrimeTable.Cols.UUID, crime.getId().toString());
        values.put(CrimeTable.Cols.TITLE, crime.getTitle());
        values.put(CrimeTable.Cols.DATE, crime.getDate().getTime());
        values.put(CrimeTable.Cols.SOLVED, crime.isSolved() ? 1 : 0);

        return values;
    }
}
```

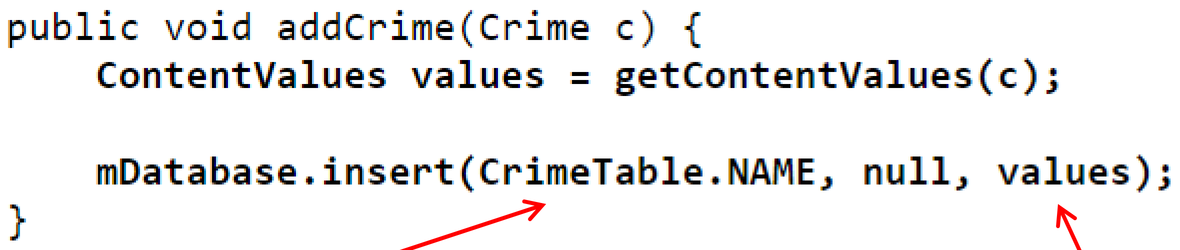
Takes Crime as input

Converts Crime to ContentValues

Returns values as output

Inserting and Updating Rows

- Modify **addCrime** to insert Crime into database



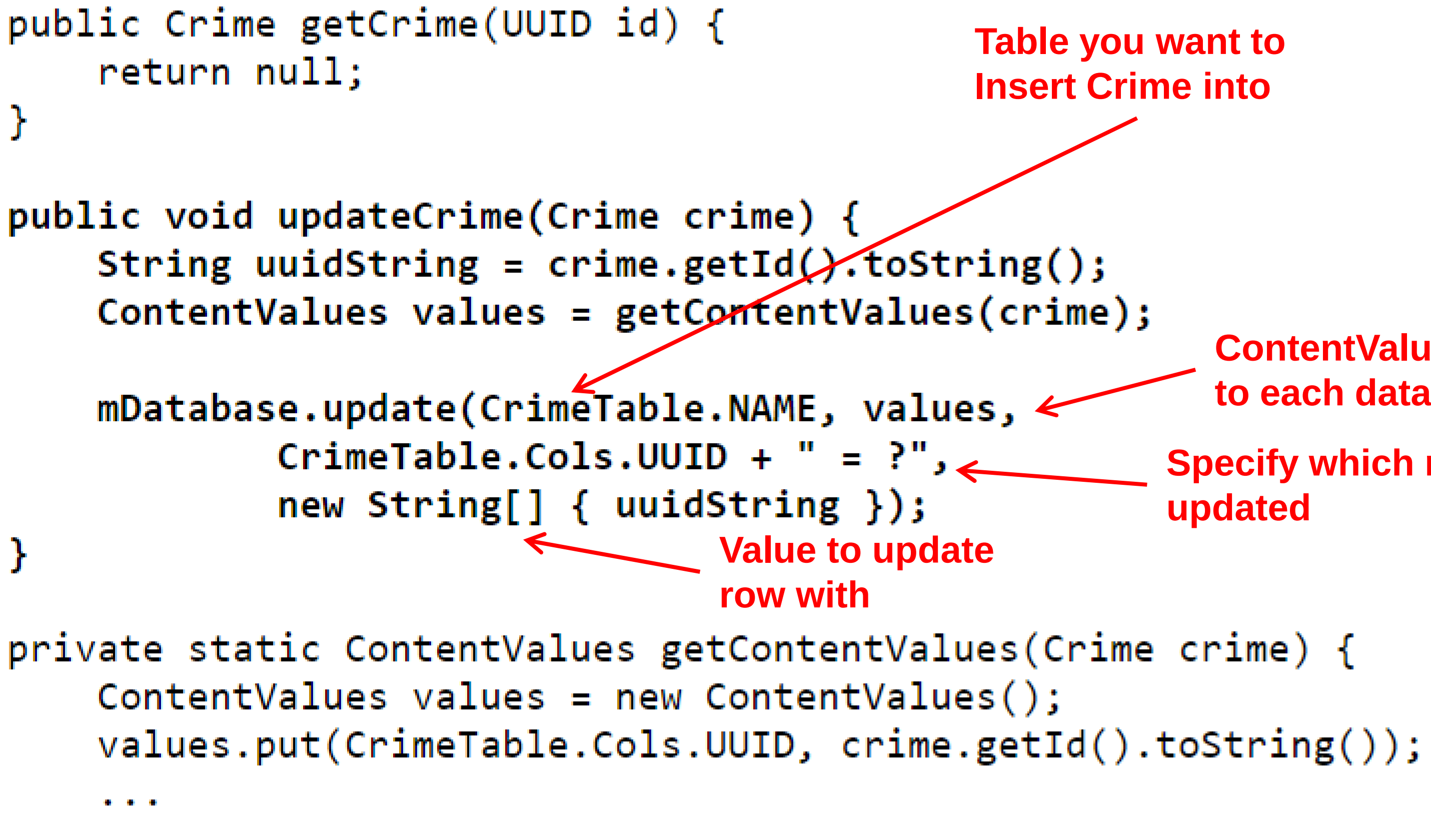
```
public void addCrime(Crime c) {
    ContentValues values = getContentValues(c);

    mDatabase.insert(CrimeTable.NAME, null, values);
}
```

Table you want to
Insert Crime into

ContentValue data
to insert into database

Inserting and Updating Rows

- Update rows by using ContentValues



```
public Crime getCrime(UUID id) {
    return null;
}

public void updateCrime(Crime crime) {
    String uuidString = crime.getId().toString();
    ContentValues values = getContentValues(crime);

    mDatabase.update(CrimeTable.NAME, values,
            CrimeTable.Cols.UUID + " = ?",
            new String[] { uuidString });
}

private static ContentValues getContentValues(Crime crime) {
    ContentValues values = new ContentValues();
    values.put(CrimeTable.Cols.UUID, crime.getId().toString());
    ...
```

Table you want to Insert Crime into

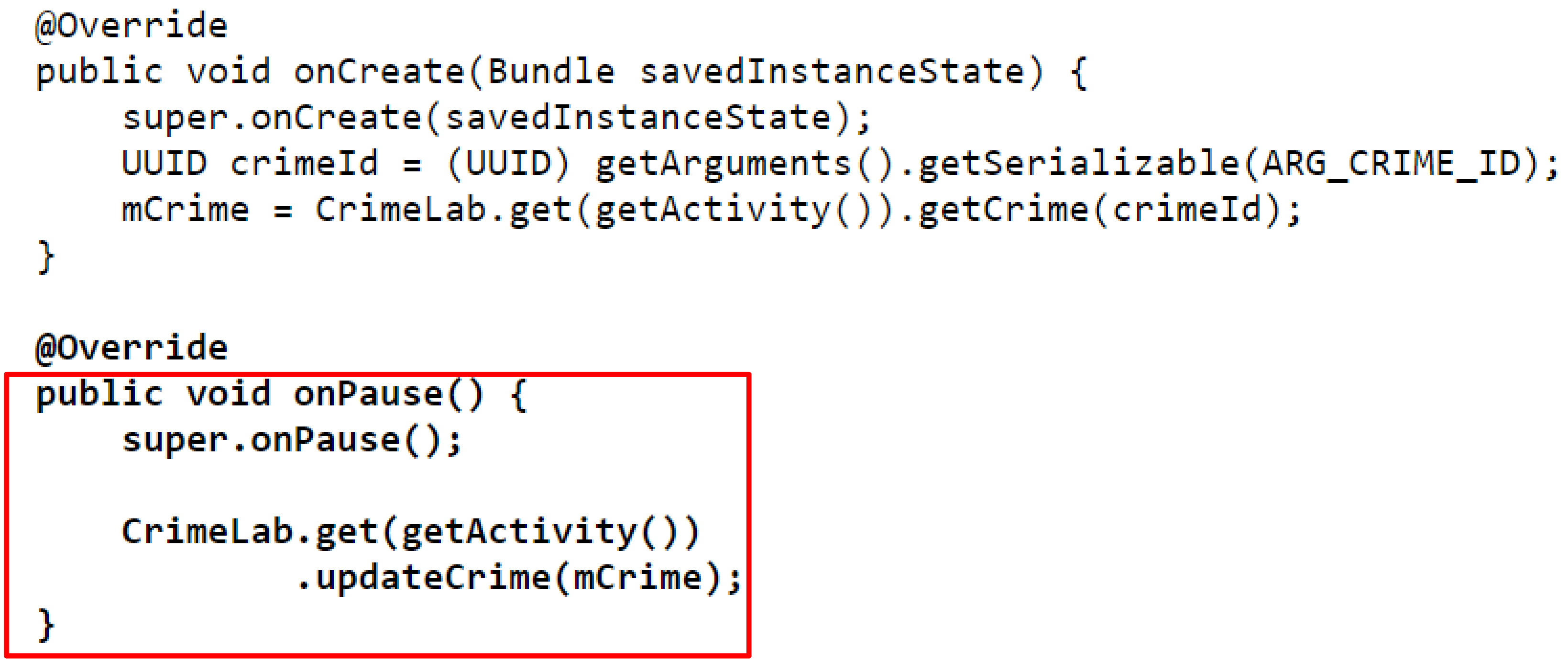
ContentValue data to assign to each database row

Specify which rows should be updated

Value to update row with

Pushing Updates

- Push updates in onPause( ) method of CrimeFragment



```
@Override
public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    UUID crimeId = (UUID) getArguments().getSerializable(ARG_CRIME_ID);
    mCrime = CrimeLab.get(getActivity()).getCrime(crimeId);
}

@Override
public void onPause() {
    super.onPause();

    CrimeLab.get(getActivity())
            .updateCrime(mCrime);
}
```

More in Text

- See Android Nerd Ranch (2nd edition), chapter 14 for more
  - The rest of the example,
  - How to query the database
  - The rest of the code

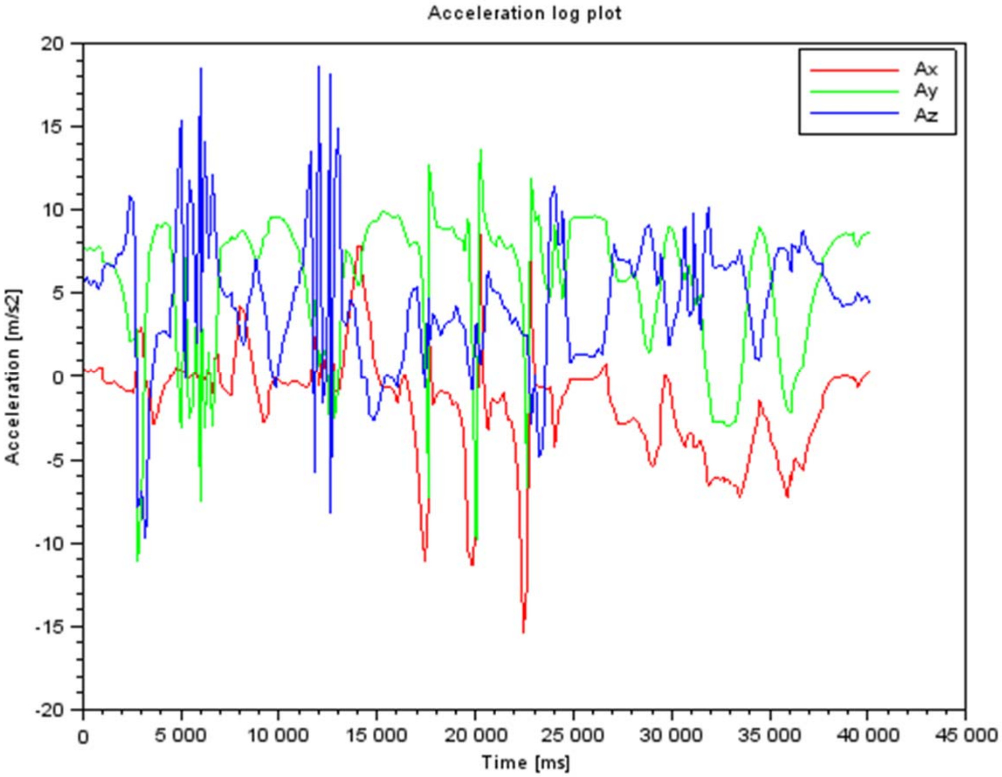
Alternatives to sqlite

- SQLite is low level ("Down in the weeds“)
- Various alternatives to work higher up the food chain
- Object Relational Mappers - ORM
- Higher level wrappers for dealing with sql commands and sqlite databases
- Many ORMs exist

Android Sensors

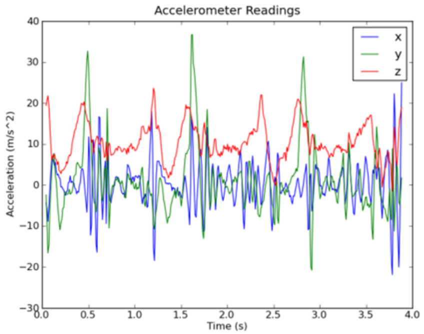
What is a Sensor?

- Converts some physical quantity (e.g. light, acceleration, magnetic field) into a signal
- **Example:** accelerometer converts acceleration along X,Y,Z axes into signal

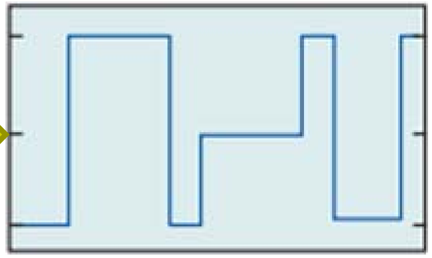


So What?

- Raw sensor data can be processed into meaningful info
- Example: Raw accelerometer data can be processed to infer user's activity (e.g. walking running, etc)



Raw accelerometer readings



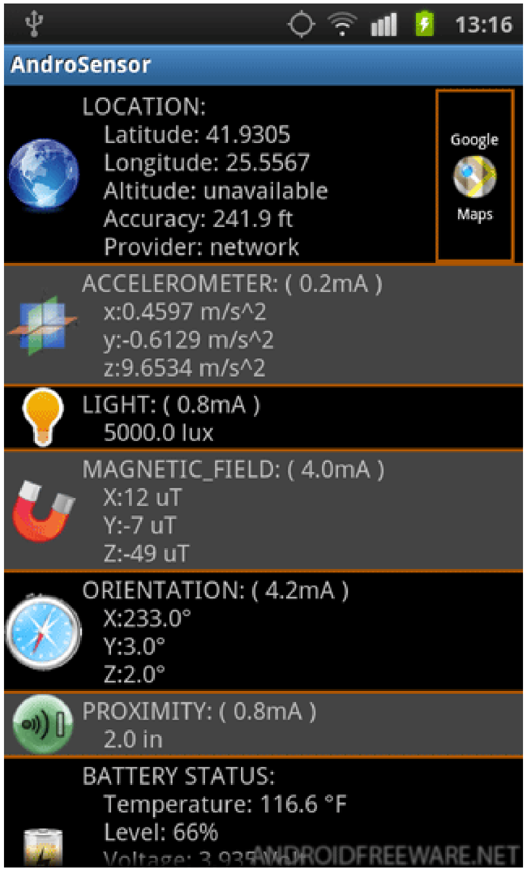
Machine learning
Feature extraction
and classification

Walking
Running
Jumping
Step count
Calories burned
Falling

Android Sensors

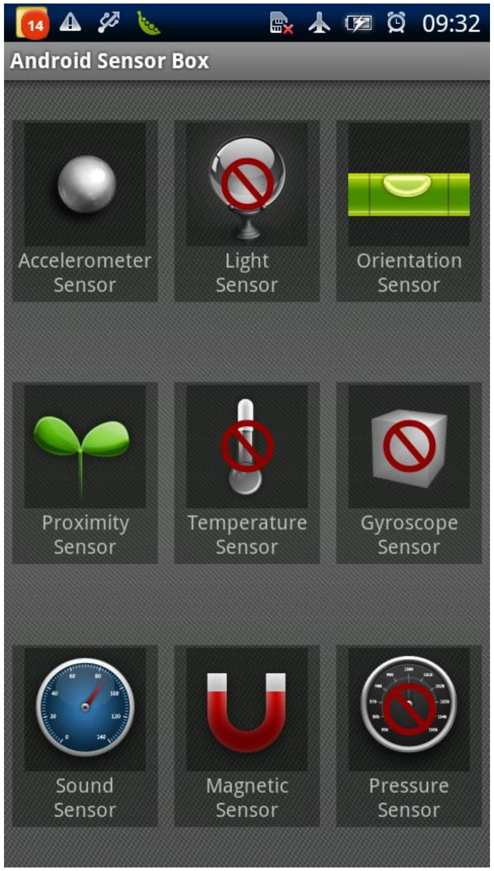
- Microphone (sound)
- Camera
- Temperature
- Location (GPS, A-GPS)
- Accelerometer
- Gyroscope (orientation)
- Proximity
- Pressure
- Light

- **Different phones do not have all sensor types!!**



```
13:16
AndroSensor
LOCATION:
  Latitude: 41.9305
  Longitude: 25.5567
  Altitude: unavailable
  Accuracy: 241.9 ft
  Provider: network
ACCELEROMETER: ( 0.2mA )
  x:0.4597 m/s^2
  y:-0.6129 m/s^2
  z:9.6534 m/s^2
LIGHT: ( 0.8mA )
  5000.0 lux
MAGNETIC_FIELD: ( 4.0mA )
  X:12 uT
  Y:-7 uT
  Z:-49 uT
ORIENTATION: ( 4.2mA )
  X:233.0°
  Y:3.0°
  Z:2.0°
PROXIMITY: ( 0.8mA )
  2.0 in
BATTERY STATUS:
  Temperature: 116.6 °F
  Level: 66%
  Voltage: 3.93
```

AndroSensor



Android Sensor Box

Android Sensor Framework

- Enables apps to:
  - Access sensors available on device and
  - Acquire raw sensor data

- Specifically, using the Android Sensor Framework, you can:
  - Determine which sensors are available
  - Determine capabilities of individual sensors (e.g. max. range, manufacturer, power requirements, resolution)
  - Acquire raw sensor data and define data rate
  - Register and unregister sensor event listeners

http://developer.android.com/guide/topics/sensors/sensors_overview.html

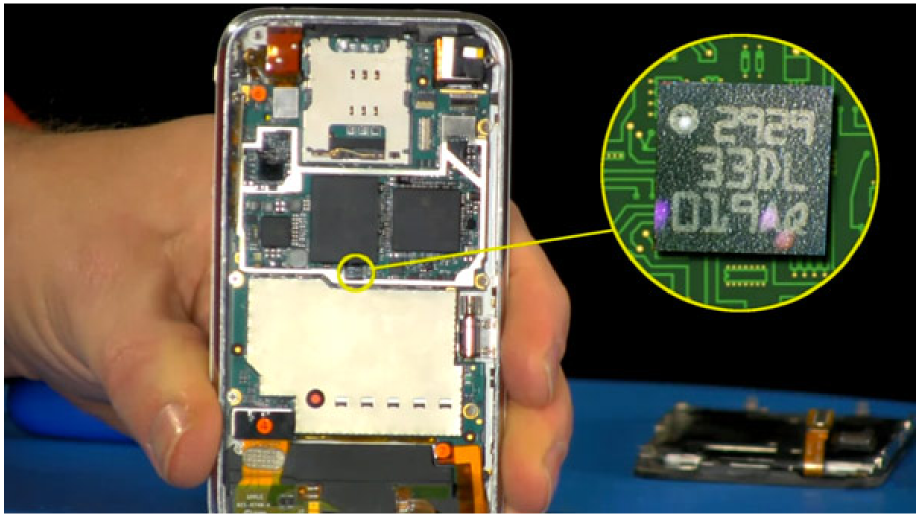
Android Sensor Framework

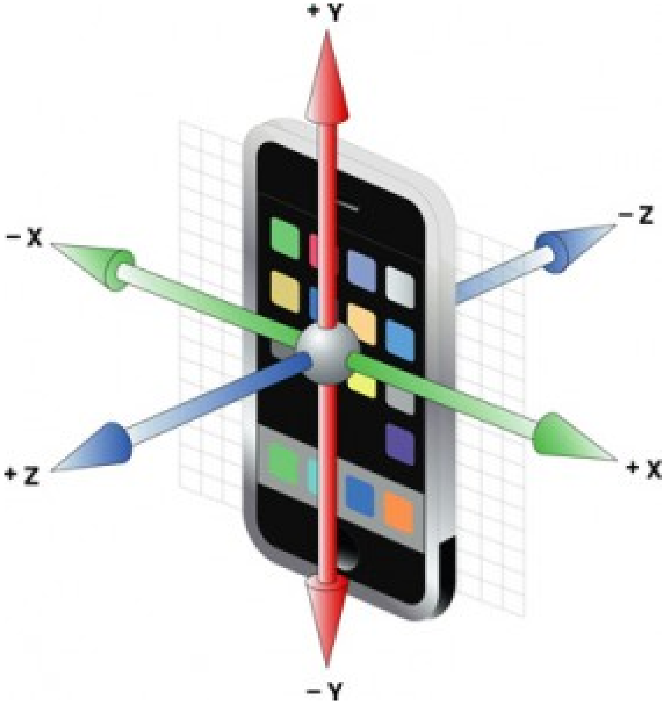
- Android sensors can be either hardware or software
- **Hardware sensor:**
  - physical components built into phone,
  - Measure specific environmental property. E.g. temperature

- **Software sensor (or virtual sensor):**
  - Not physical device
  - Derives their data from one or more hardware sensors
  - **Example:** gravity sensor

Accelerometer Sensor

- Acceleration is **rate of change of velocity**
- Accelerometers
  - Measure **change** of speed in a direction
  - Do not measure velocity
- Phone's accelerometer measures acceleration along its X,Y,Z axes





Sensor Types Supported by Android

- TYPE_ACCELEROMETER
  - **Type:** hardware
  - Measures device acceleration force along X,Y,Z axes **including gravity** in m/s^2
  - **Common uses:** motion detection (shake, tilt, etc)

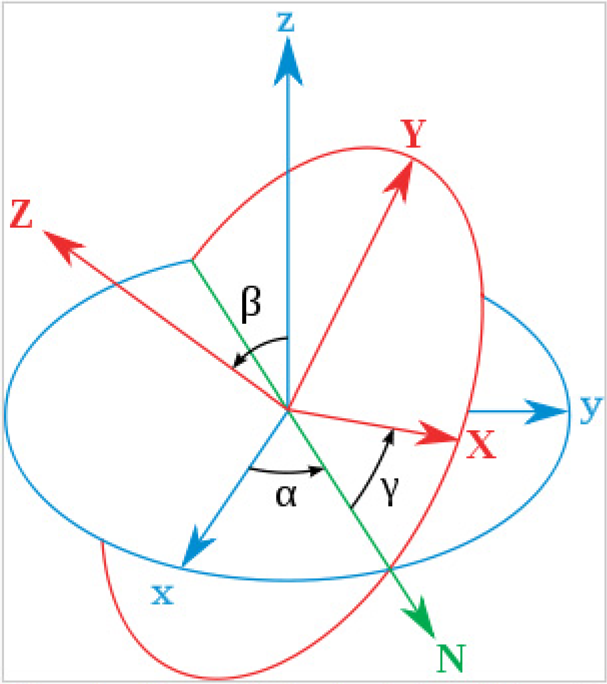
- TYPE_LINEAR_ACCELEROMETER
  - **Type:** software or hardware
  - Measures device acceleration force along X,Y,Z axes **excluding gravity** in m/s^2
  - **Common uses:** monitoring acceleration along single axis

Sensor Types Supported by Android

- TYPE_GRAVITY
  - **Type:** Software or hardware
  - Measures **force of gravity along X,Y,Z axes** in m/s^2
  - **Common uses:** motion detection (shake, tilt, etc)

Sensor Types Supported by Android

- TYPE_ROTATION_VECTOR
  - **Type:** Software or hardware
  - Measures **device’s orientation** by providing 3 rotation vectors
  - **Common uses:** motion detection and rotation

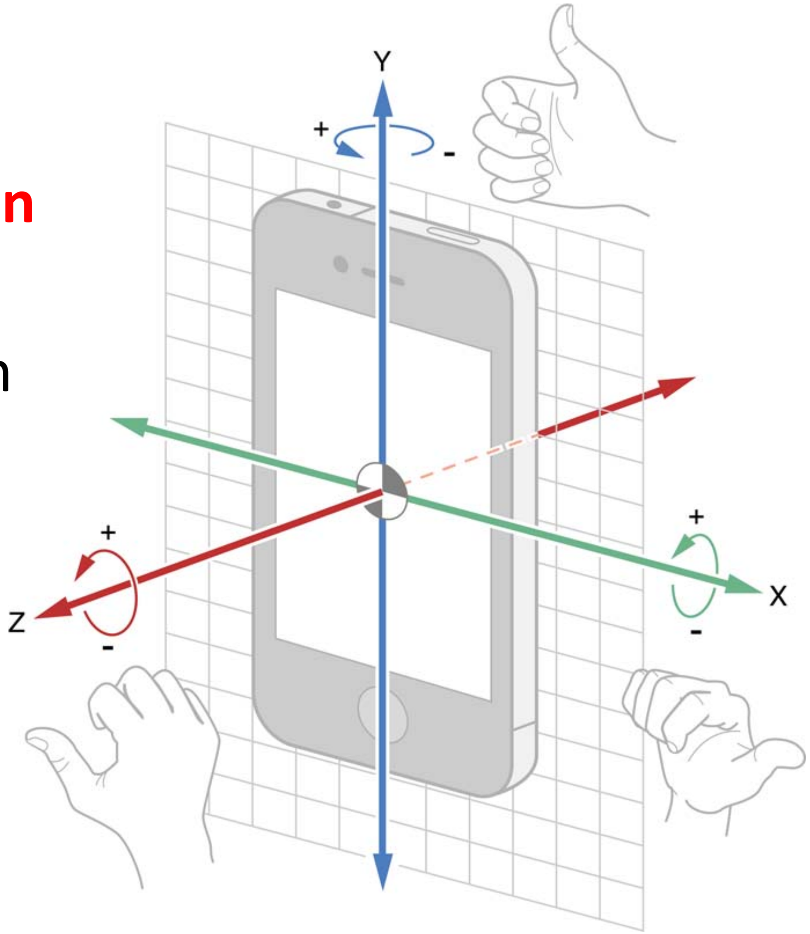


Euler angles – The xyz (fixed) system is shown in blue, the XYZ (rotated) system is shown in red. The line of nodes, labeled N, is shown in green.

Blue: Fixed reference axes
Red: Rotated axes

Sensor Types Supported by Android

- TYPE_GYROSCOPE
  - **Type:** hardware
  - Measures device's **rate of rotation** around X,Y,Z axes in rad/s
  - **Common uses:** rotation detection (spin, turn, etc)



Sensor Types Supported by Android

- TYPE_AMBIENT_TEMPERATURE
  - **Type:** hardware
  - Measures ambient **room temperature** in degrees Celcius
  - **Common uses:** monitoring room air temperatures

- TYPE_LIGHT
  - **Type:** hardware
  - Measures ambient **light level (illumination)** in lux
  - Lux is SI measure of illuminance
    - Measures luminous flux per unit area
  - **Common uses:** controlling screen brightness

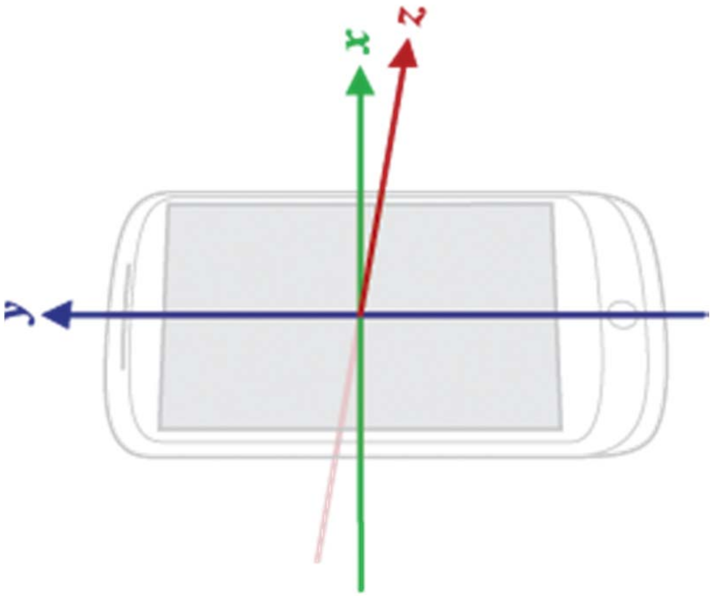
Sensor Types Supported by Android

- TYPE_MAGNETIC_FIELD
  - **Type:** hardware
  - Measures **magnetic field** for X,Y,Z axes in μT
  - **Common uses:** Creating a compass

- TYPE_PRESSURE
  - **Type:** hardware
  - Measures ambient **air pressure** in hPa or mbar
  - Force per unit area
  - **Common uses:** monitoring air pressure changes

Sensor Types Supported by Android

- TYPE_ORIENTATION
  - **Type:** software
  - Measures degrees of **rotation about X,Y,Z axes**
  - **Common uses:** Determining device position



Sensor Types Supported by Android

- TYPE_PROXIMITY
  - **Type:** hardware
  - Measures an **object's proximity to device's screen** in cm
  - **Common uses:** to determine whether a handset is being held up to a person's ear

Sensor Types Supported by Android

- TYPE_RELATIVE HUMIDITY
  - **Type:** hardware
  - Measures relative ambient humidity in percent (%)
  - Expresses **% of max possible humidity currently present in air**
  - **Common uses:** monitoring dewpoint, absolute, and relative humidity

- TYPE_TEMPERATURE
  - **Type:** hardware
  - Measures **temperature of phone (or device)** in degrees Celsius.
  - Replaced by TYPE_AMBIENT_TEMPERATURE in API 14
  - **Common uses:** monitoring temperatures

2 New Hardware Sensor in Android 4.4

- TYPE_STEP_DETECTOR
  - **Type:** hardware
  - Triggers a sensor event each time user takes a step
  - Delivered event has value of 1.0 and timestamp of step

- TYPE_STEP_COUNTER
  - **Type:** hardware
  - Also triggers a sensor event each time user takes a step
  - Delivers total ***accumulated number of steps since this sensor was first registered by an app***, tries to eliminate false positives
- **Common uses:** Both used in step counting, pedometer apps
- Requires hardware support, available in Nexus 5

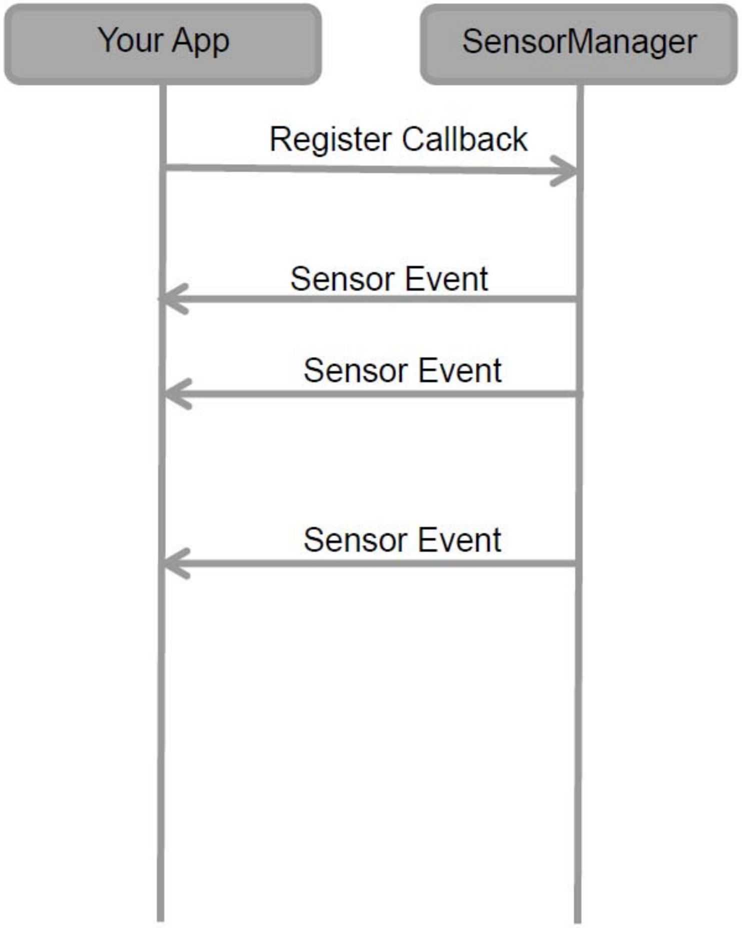
Sensor Programming

- Sensor framework is part of **android.hardware**
- Classes and interfaces include:
  - **SensorManager**
  - **Sensor**
  - **SensorEvent**
  - **SensorEventListener**
- These sensor-APIs used for 2 main tasks:
  - Identifying sensors and sensor capabilities
  - Monitoring sensor events

Sensor Events and Callbacks

- App sensors send events asynchronously, when new data arrives

- General approach:
  - App registers callbacks
  - SensorManager notifies app of sensor event whenever new data arrives (or accuracy changes)



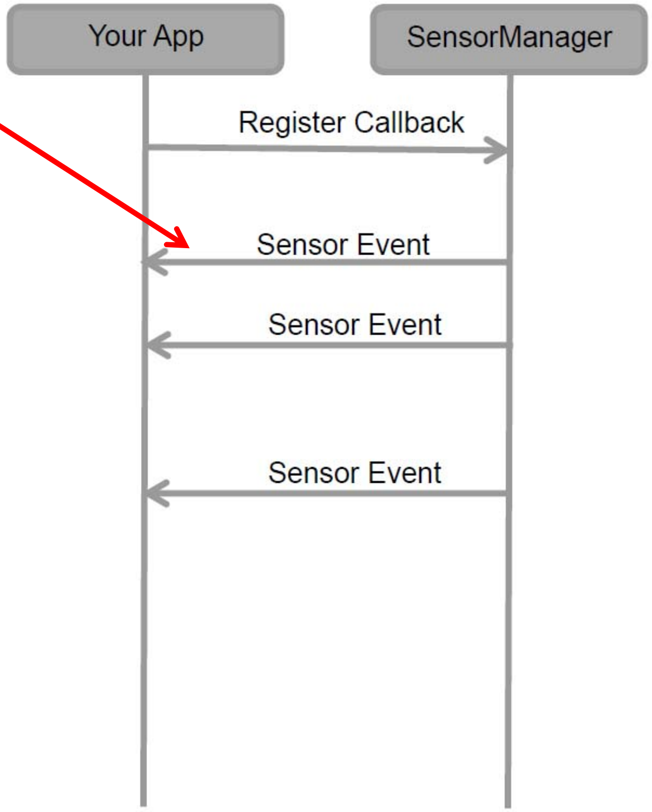
Sensor

- A class that provides methods used to determine a sensor’s capabilities
- Can be used to create instance of a specific sensor

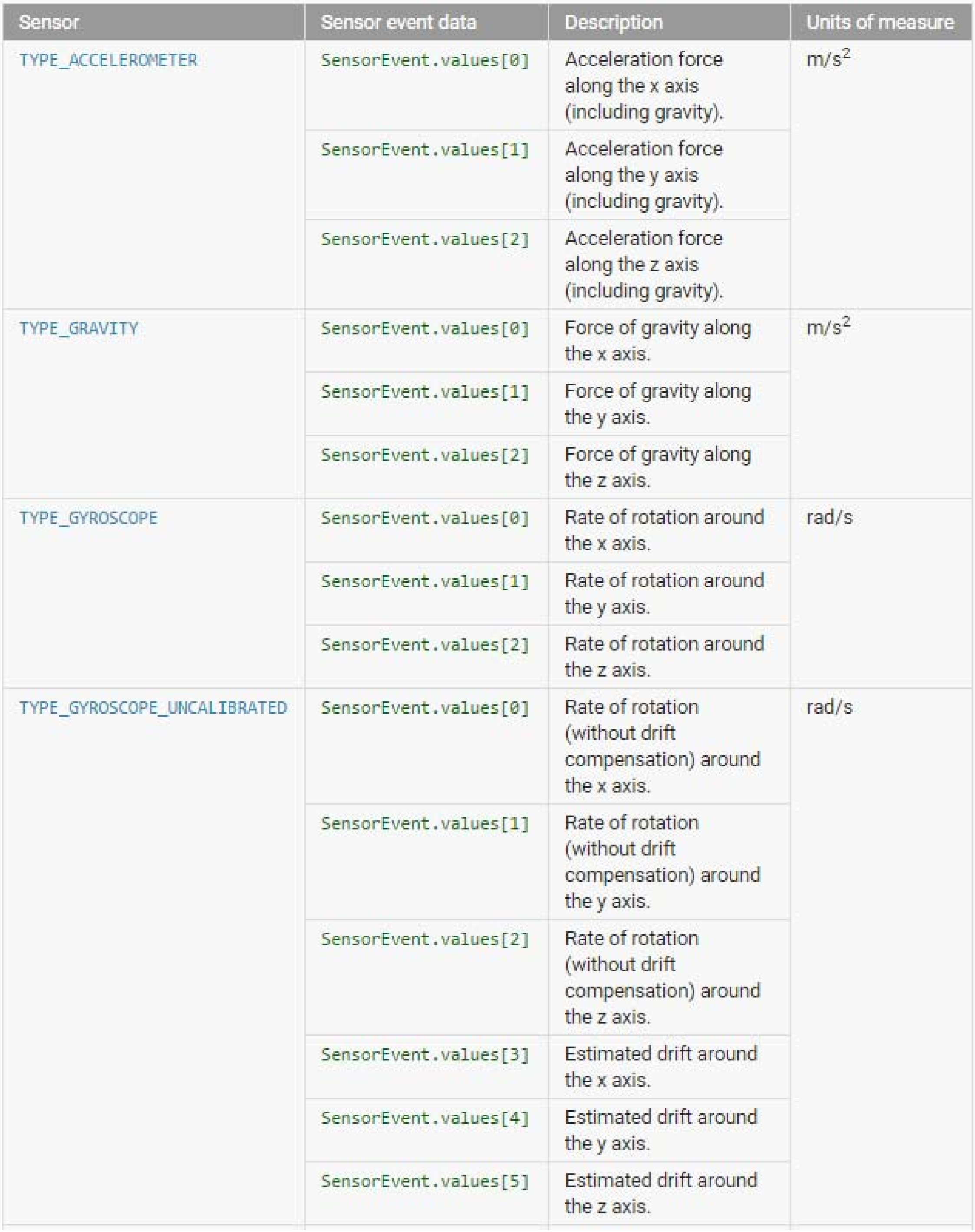
SensorEvent

- Android system provides information about a sensor event as a **sensor event object**

- **Sensor event object** includes:
  - ***Values:*** Raw sensor data
  - ***Sensor:*** Type of sensor that generated the event
  - ***Accuracy:*** Accuracy of the data
  - ***Timestamp:*** Event timestamp

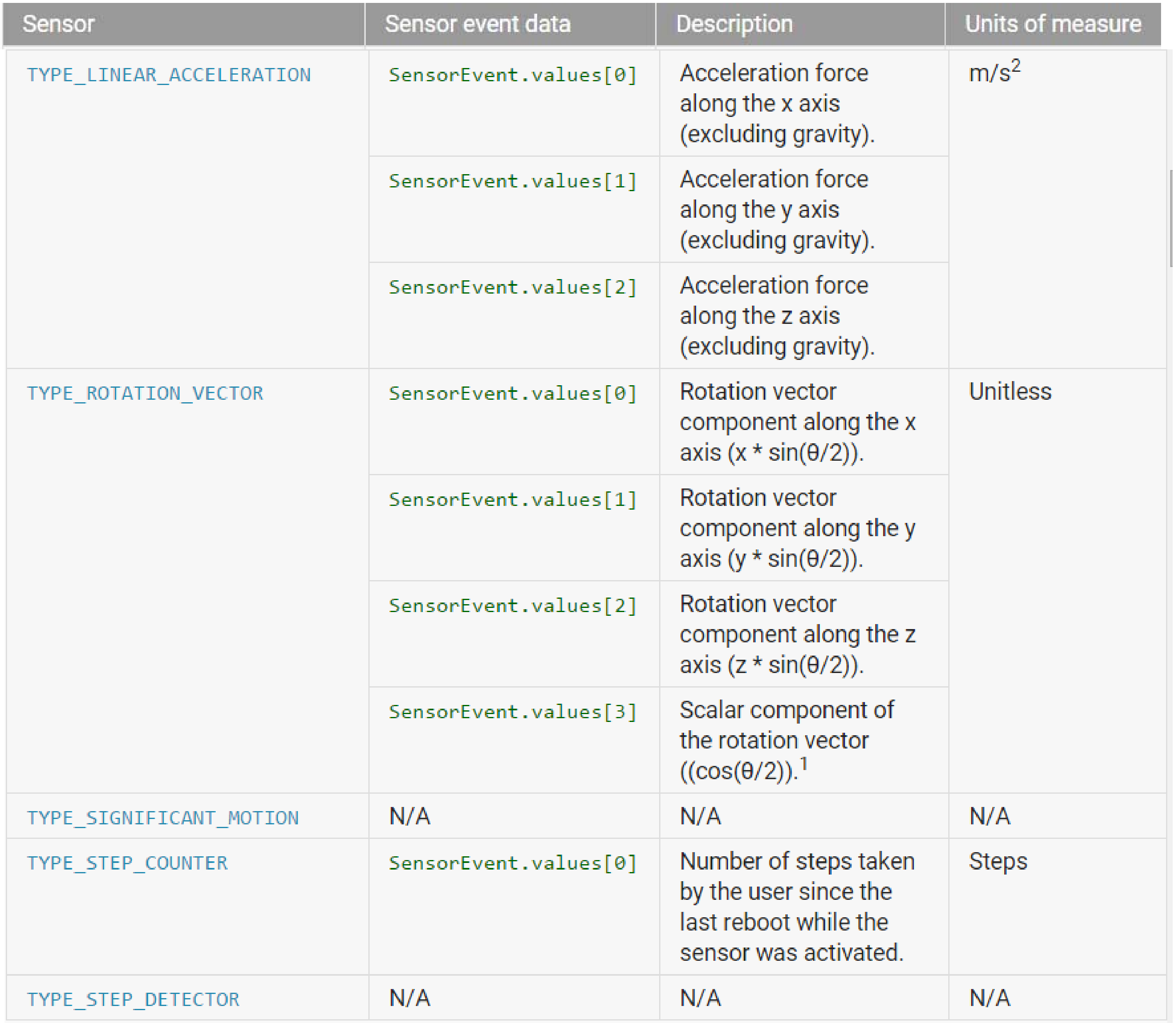


Sensor Values Depend on Sensor Type



Sensor	Sensor event data	Description	Units of measure
TYPE_ACCELEROMETER	SensorEvent.values[0]	Acceleration force along the x axis (including gravity).	m/s^2
	SensorEvent.values[1]	Acceleration force along the y axis (including gravity).	
	SensorEvent.values[2]	Acceleration force along the z axis (including gravity).	
TYPE_GRAVITY	SensorEvent.values[0]	Force of gravity along the x axis.	m/s^2
	SensorEvent.values[1]	Force of gravity along the y axis.	
	SensorEvent.values[2]	Force of gravity along the z axis.	
TYPE_GYROSCOPE	SensorEvent.values[0]	Rate of rotation around the x axis.	rad/s
	SensorEvent.values[1]	Rate of rotation around the y axis.	
	SensorEvent.values[2]	Rate of rotation around the z axis.	
TYPE_GYROSCOPE_UNCALIBRATED	SensorEvent.values[0]	Rate of rotation (without drift compensation) around the x axis.	rad/s
	SensorEvent.values[1]	Rate of rotation (without drift compensation) around the y axis.	
	SensorEvent.values[2]	Rate of rotation (without drift compensation) around the z axis.	
	SensorEvent.values[3]	Estimated drift around the x axis.	
	SensorEvent.values[4]	Estimated drift around the y axis.	
	SensorEvent.values[5]	Estimated drift around the z axis.	

Sensor Values Depend on Sensor Type



Sensor	Sensor event data	Description	Units of measure
TYPE_LINEAR_ACCELERATION	SensorEvent.values[0]	Acceleration force along the x axis (excluding gravity).	m/s^2
	SensorEvent.values[1]	Acceleration force along the y axis (excluding gravity).	
	SensorEvent.values[2]	Acceleration force along the z axis (excluding gravity).	
TYPE_ROTATION_VECTOR	SensorEvent.values[0]	Rotation vector component along the x axis (x * sin(θ/2)).	Unitless
	SensorEvent.values[1]	Rotation vector component along the y axis (y * sin(θ/2)).	
	SensorEvent.values[2]	Rotation vector component along the z axis (z * sin(θ/2)).	
	SensorEvent.values[3]	Scalar component of the rotation vector ((cos(θ/2)).[1]	
TYPE_SIGNIFICANT_MOTION	N/A	N/A	N/A
TYPE_STEP_COUNTER	SensorEvent.values[0]	Number of steps taken by the user since the last reboot while the sensor was activated.	Steps
TYPE_STEP_DETECTOR	N/A	N/A	N/A

SensorEventListener

- An interface used to create 2 callbacks that receive notifications (sensor events) when:
  - Sensor values change **(onSensorChange( ))** or
  - When sensor accuracy changes **(onAccuracyChanged( ))**

SensorManager

- A class that provides methods for:
  - Accessing and listing sensors
  - Registering and unregistering sensor event listeners
  - Acquiring orientation information
- Can be used to create instance of sensor service
- Also provides sensor **constants** used to:
  - Report sensor accuracy
  - Set data acquisition rates
  - Calibrate sensors

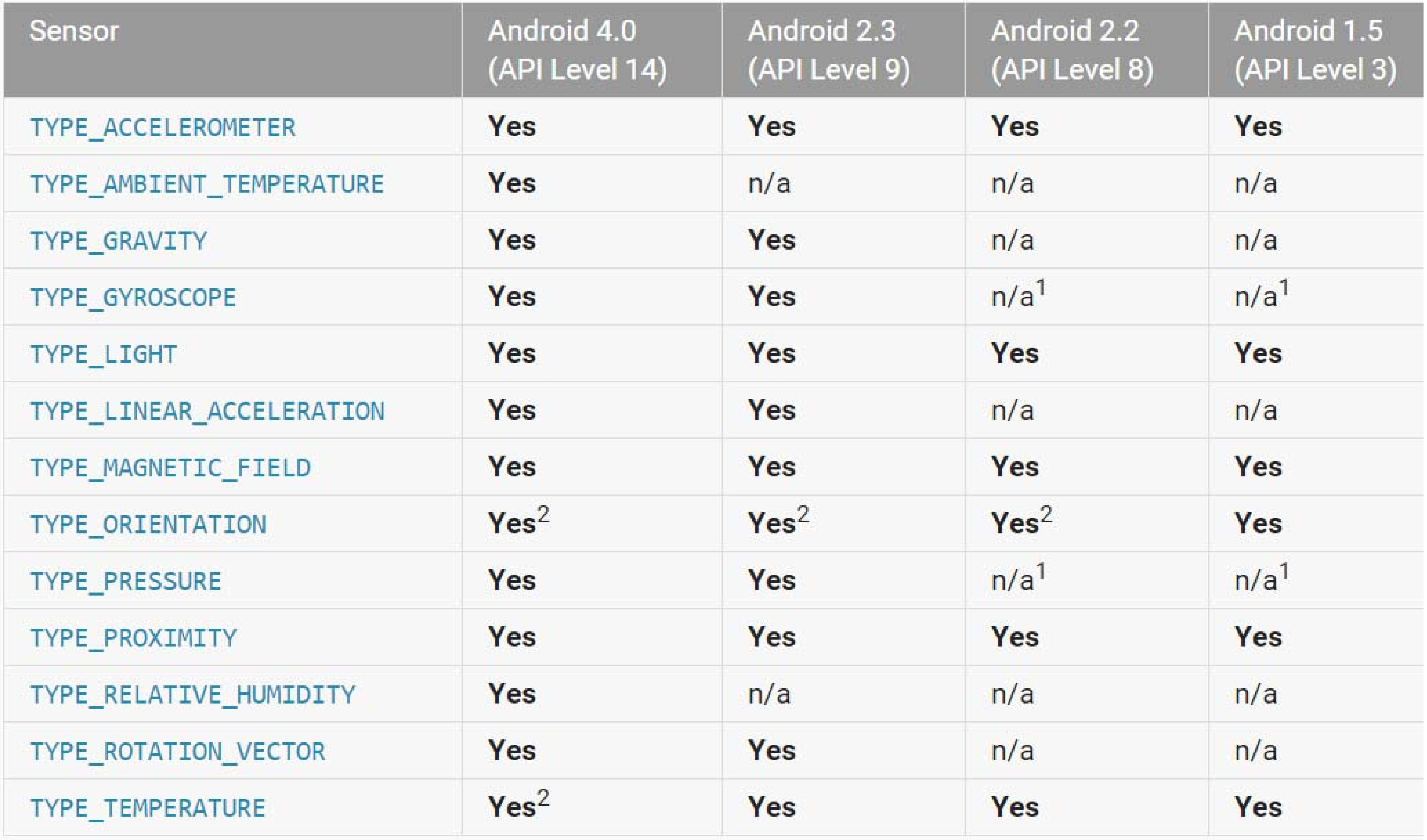
Sensor API Tasks

- **Sensor API Task 1: Identifying sensors and their capabilities**
- Why identify sensor and their capabilities at runtime?
  - Disable app features using sensors not present, or
  - Choose sensor implementation with best performance

- **Sensor API Task 2: Monitor sensor events**
- Why monitor sensor events?
  - To acquire raw sensor data
  - Sensor event occurs every time sensor detects change in parameters it is measuring

Sensor Availability

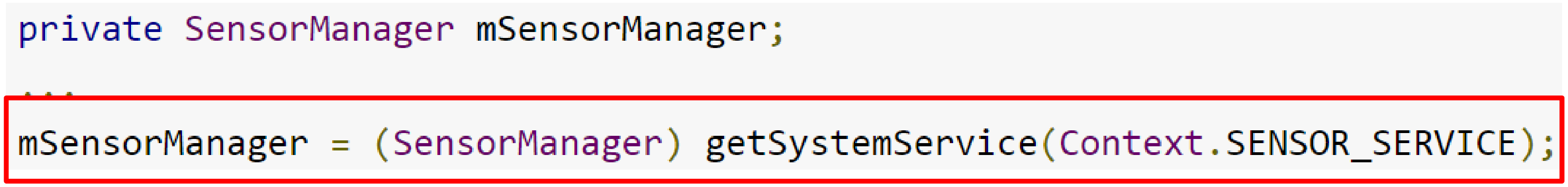
- Different sensors are available on different **Android versions**



Sensor	Android 4.0 (API Level 14)	Android 2.3 (API Level 9)	Android 2.2 (API Level 8)	Android 1.5 (API Level 3)
TYPE_ACCELEROMETER	**Yes**	**Yes**	**Yes**	**Yes**
TYPE_AMBIENT_TEMPERATURE	**Yes**	n/a	n/a	n/a
TYPE_GRAVITY	**Yes**	**Yes**	n/a	n/a
TYPE_GYROSCOPE	**Yes**	**Yes**	n/a[1]	n/a[1]
TYPE_LIGHT	**Yes**	**Yes**	**Yes**	**Yes**
TYPE_LINEAR_ACCELERATION	**Yes**	**Yes**	n/a	n/a
TYPE_MAGNETIC_FIELD	**Yes**	**Yes**	**Yes**	**Yes**
TYPE_ORIENTATION	**Yes**[2]	**Yes**[2]	**Yes**[2]	**Yes**
TYPE_PRESSURE	**Yes**	**Yes**	n/a[1]	n/a[1]
TYPE_PROXIMITY	**Yes**	**Yes**	**Yes**	**Yes**
TYPE_RELATIVE_HUMIDITY	**Yes**	n/a	n/a	n/a
TYPE_ROTATION_VECTOR	**Yes**	**Yes**	n/a	n/a
TYPE_TEMPERATURE	**Yes**[2]	**Yes**	**Yes**	**Yes**

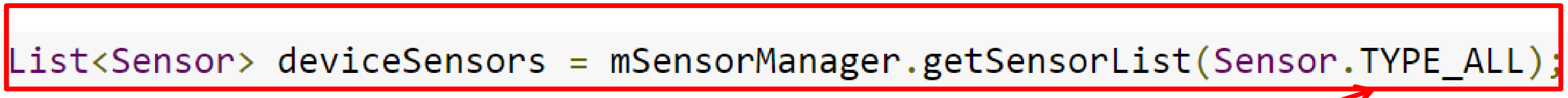
Identifying Sensors and Sensor Capabilities

- Need a reference to the sensor service.
- How? First create instance of **SensorManager** by calling **getSystemService( )** and passing in SENSOR_SERVICE argument



```java
private SensorManager mSensorManager;
...
mSensorManager = (SensorManager) getSystemService(Context.SENSOR_SERVICE);
```

- Then list sensors available on device by calling **getSensorList( )**



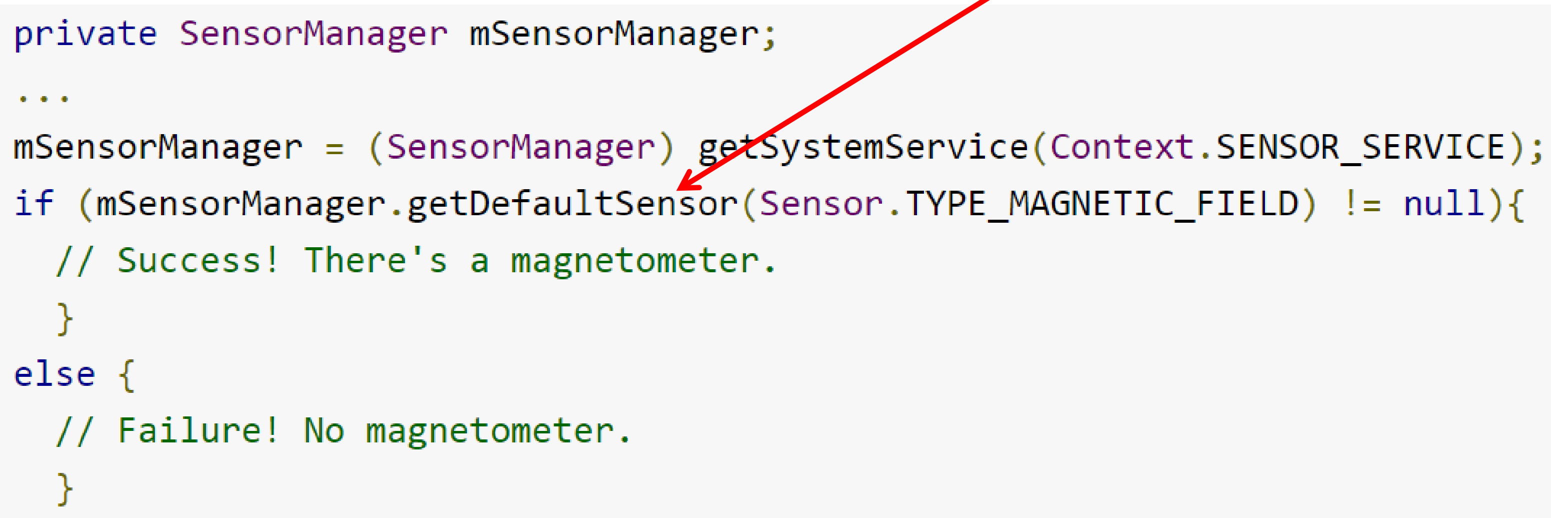
```java
List<Sensor> deviceSensors = mSensorManager.getSensorList(Sensor.TYPE_ALL);
```

- To list particular type, use **TYPE_GYROSCOPE, TYPE_GRAVITY**, etc

http://developer.android.com/guide/topics/sensors/sensors_overview.html

Determing if Device has at least one of particular Sensor Type

- Device may have multiple sensors of a particular type.
  - E.g. multiple magnetometers
- If multiple sensors of a given type exist, one of them must be designated “the default sensor” of that type
- To determine if specific sensor type exists use **getDefaultSensor( )**
- **Example:** To check whether device has a magnetometer



```
private SensorManager mSensorManager;
...
mSensorManager = (SensorManager) getSystemService(Context.SENSOR_SERVICE);
if (mSensorManager.getDefaultSensor(Sensor.TYPE_MAGNETIC_FIELD) != null){
  // Success! There's a magnetometer.
  }
else {
  // Failure! No magnetometer.
  }
```

Determining Capabilities of Sensors

- Some useful methods of **Sensor** class methods:
  - **getResolution( ):** get sensor’s resolution
  - **getMaximumRange( ):** get maximum measurement range
  - **getPower( ):** get sensor’s power requirements
  - **getMinDelay( ):** min time interval (in microseconds) sensor can use to sense data. Return values:
    - **0 value:** Non-streaming sensor, reports data only if sensed parameters change
    - **Non-zero value:** streaming sensor

Monitoring Sensor Events

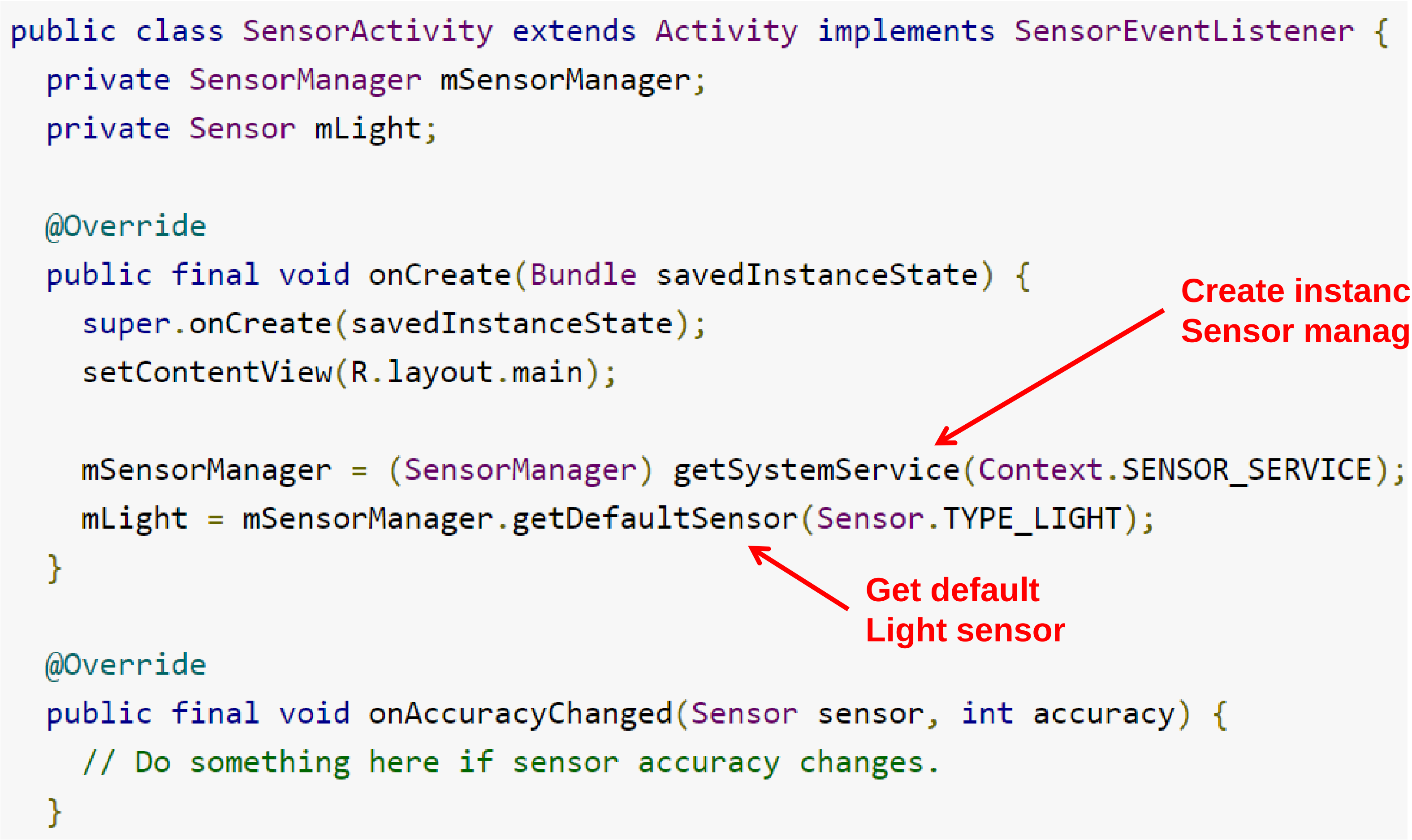
- To monitor raw sensor data, 2 callback methods exposed through **SensorEventListener** interface need to be implemented:
- **onSensorChanged:**
  - Invoked by Android system to report new sensor value
  - Provides **SensorEvent** object containing information about new sensor data
  - New sensor data includes:
    - **Accuracy:** Accuracy of data
    - **Sensor:** Sensor that generated the data
    - **Timestamp:** Times when data was generated
    - **Data:** New data that sensor recorded

Monitoring Sensor Events

- **onAccuracyChanged:**
  - invoked when accuracy of sensor being monitored changes
  - Provides reference to **sensor object** that changed and the new accuracy of the sensor
  - Accuracy represented as status constants SENSOR_STATUS_ACCURACY_LOW, SENSOR_STATUS_ACCURACY_MEDIUM,
  - SENSOR_STATUS_ACCURACY_HIGH,
  - SENSOR_STATUS_UNRELIABLE

Example: Monitoring Light Sensor Data

- **Goal:** Monitor light sensor data using **onSensorChanged( )**, display it in a **TextView** defined in main.xml

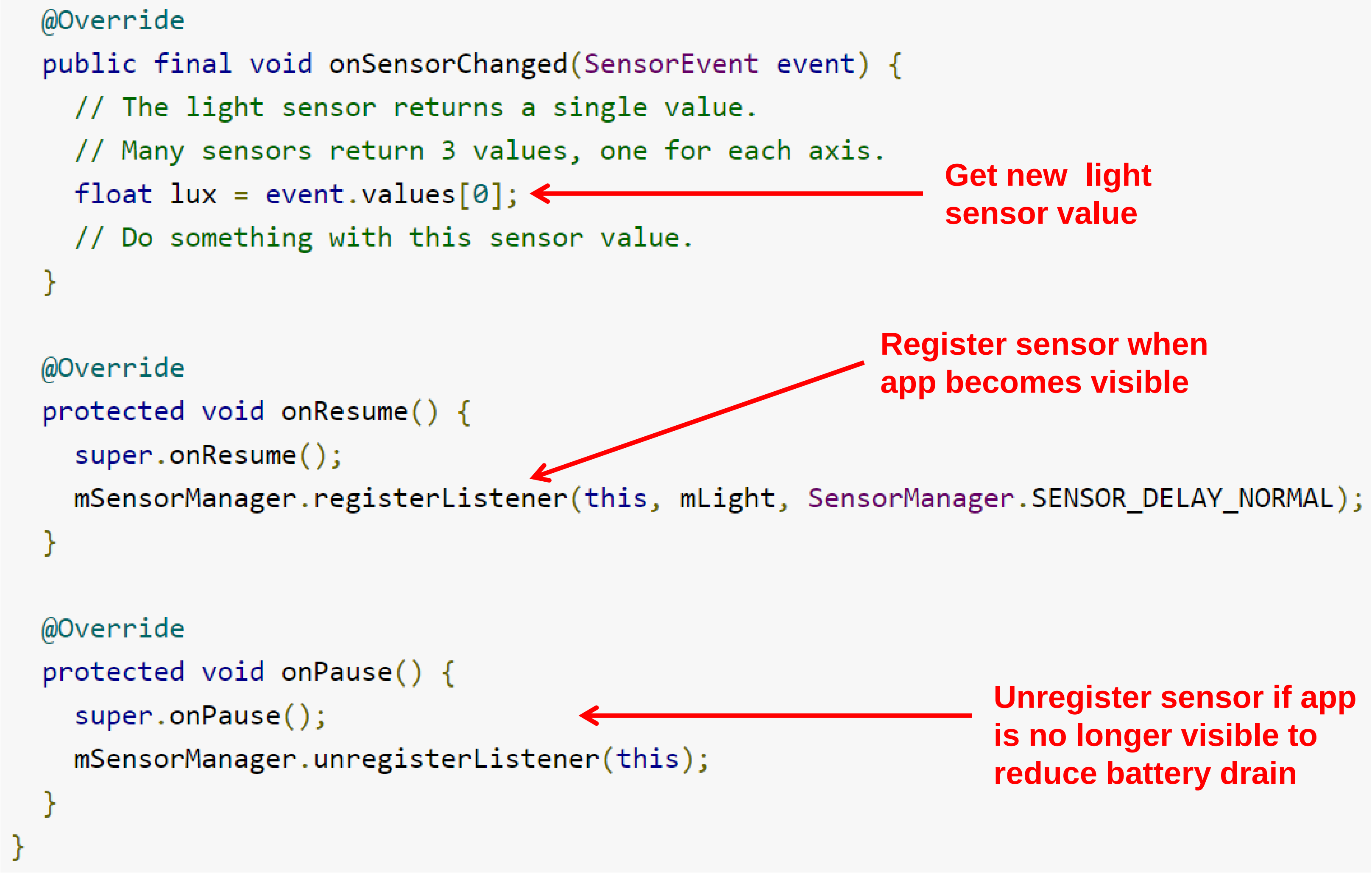


```
public class SensorActivity extends Activity implements SensorEventListener {
  private SensorManager mSensorManager;
  private Sensor mLight;

  @Override
  public final void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);

    mSensorManager = (SensorManager) getSystemService(Context.SENSOR_SERVICE);
    mLight = mSensorManager.getDefaultSensor(Sensor.TYPE_LIGHT);
  }

  @Override
  public final void onAccuracyChanged(Sensor sensor, int accuracy) {
    // Do something here if sensor accuracy changes.
  }
```

Create instance of Sensor manager

Get default Light sensor

Example: Monitoring Light Sensor Data (Contd)



```
  @Override
  public final void onSensorChanged(SensorEvent event) {
    // The light sensor returns a single value.
    // Many sensors return 3 values, one for each axis.
    float lux = event.values[0];
    // Do something with this sensor value.
  }

  @Override
  protected void onResume() {
    super.onResume();
    mSensorManager.registerListener(this, mLight, SensorManager.SENSOR_DELAY_NORMAL);
  }

  @Override
  protected void onPause() {
    super.onPause();
    mSensorManager.unregisterListener(this);
  }
}
```

Get new light sensor value

Register sensor when app becomes visible

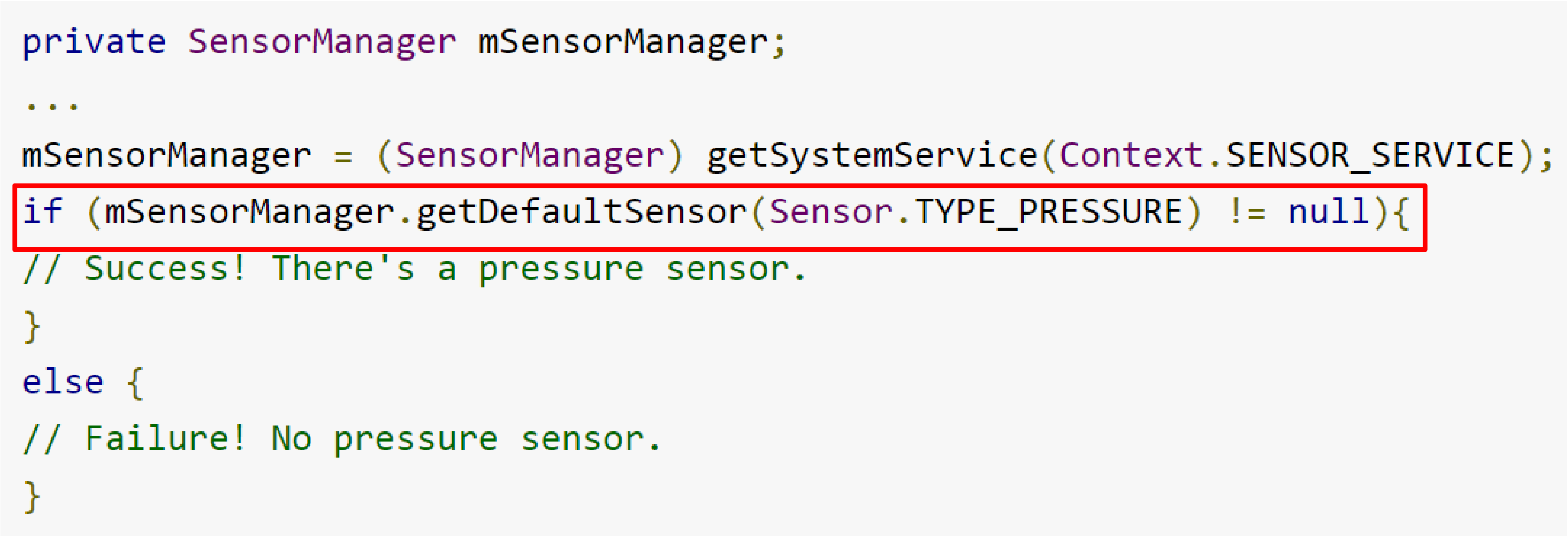
Unregister sensor if app is no longer visible to reduce battery drain

Handling Different Sensor Configurations

- Different phones have different sensors built in
- **E.g.** Motorola Xoom has pressure sensor, Samsung Nexus S doesn’t
- If app uses a specific sensor, how to ensure this sensor exists on target device? Two options
  - **Option 1:** Detect device sensors at runtime, enable/disable app features as appropriate
  - **Option 2:** Use Google Play filters so only devices possessing required sensor can download app

Option 1: Detecting Sensors at Runtime

- Following code checks if device has a pressure sensor

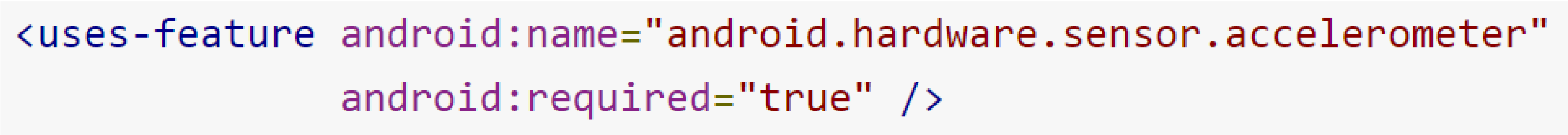


```
private SensorManager mSensorManager;
...
mSensorManager = (SensorManager) getSystemService(Context.SENSOR_SERVICE);
if (mSensorManager.getDefaultSensor(Sensor.TYPE_PRESSURE) != null){
// Success! There's a pressure sensor.
}
else {
// Failure! No pressure sensor.
}
```

Option 2: Use Google Play Filters to Target Specific Sensor Configurations

- Can use **<uses-feature>** element in AndroidManifest.xml to filter your app from devices without required sensors

- **Example:** following manifest entry ensures that only devices with accelerometers will see this app on Google Play

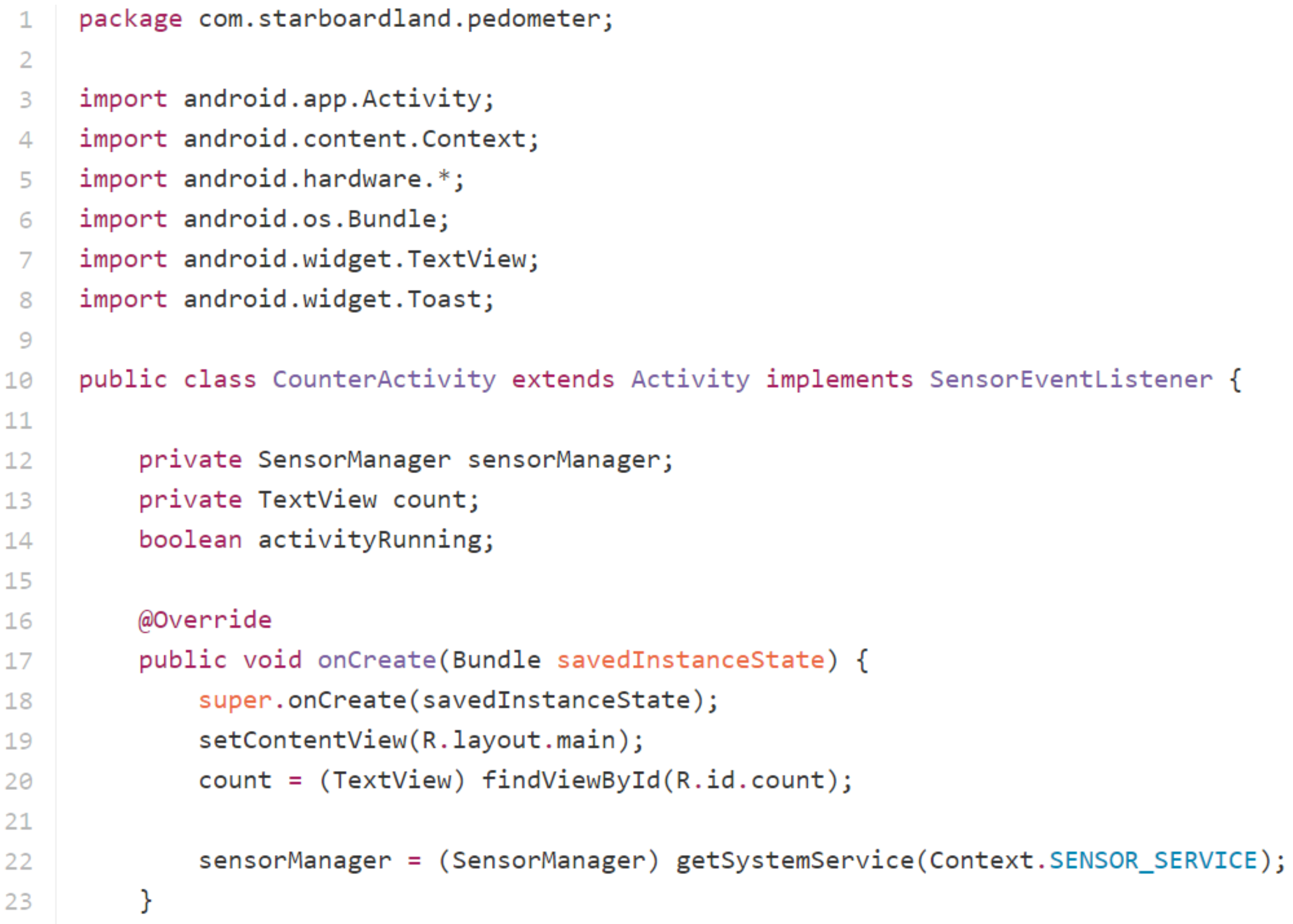


```
<uses-feature android:name="android.hardware.sensor.accelerometer"
              android:required="true" />
```

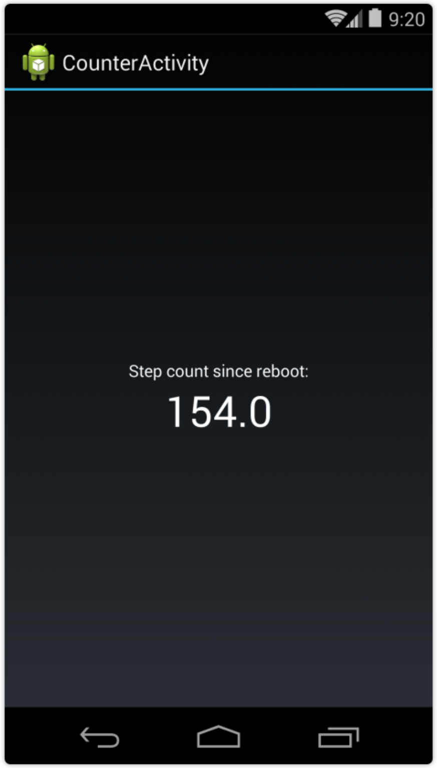
- **Can list** accelerometers, barometers, compass (geomagnetic field), gyroscope, light and proximity using this approach

Example Step Counter App

- **Goal:** Track user’s steps, display it in TextView
- **Note:** Phone hardware must support step counting



```
package com.starboardland.pedometer;

import android.app.Activity;
import android.content.Context;
import android.hardware.*;
import android.os.Bundle;
import android.widget.TextView;
import android.widget.Toast;

public class CounterActivity extends Activity implements SensorEventListener {

    private SensorManager sensorManager;
    private TextView count;
    boolean activityRunning;

    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.main);
        count = (TextView) findViewById(R.id.count);

        sensorManager = (SensorManager) getSystemService(Context.SENSOR_SERVICE);
    }
```

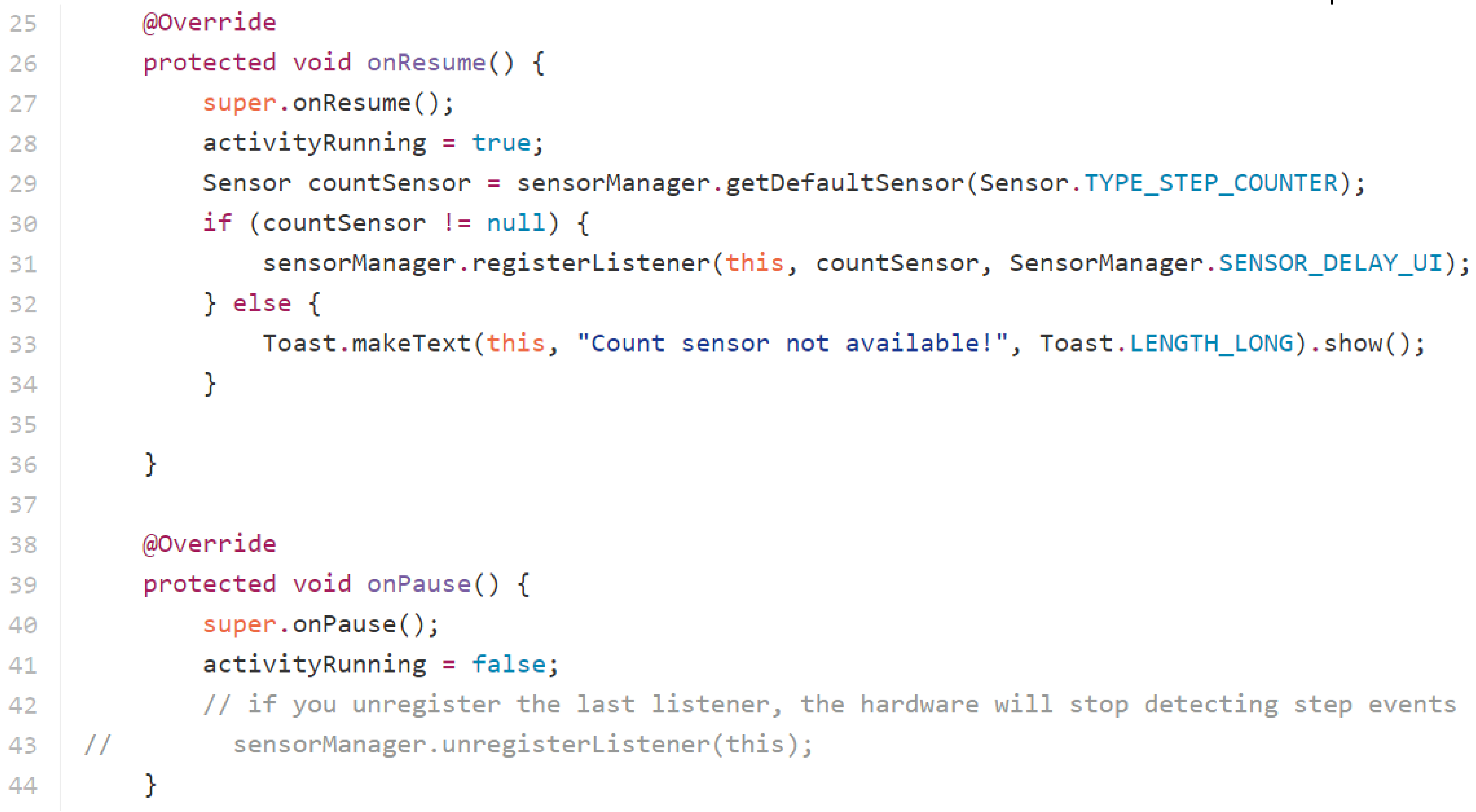


Step count since reboot:

154.0

https://theelfismike.wordpress.com/2013/11/10/android-4-4-kitkat-step-detector-code/

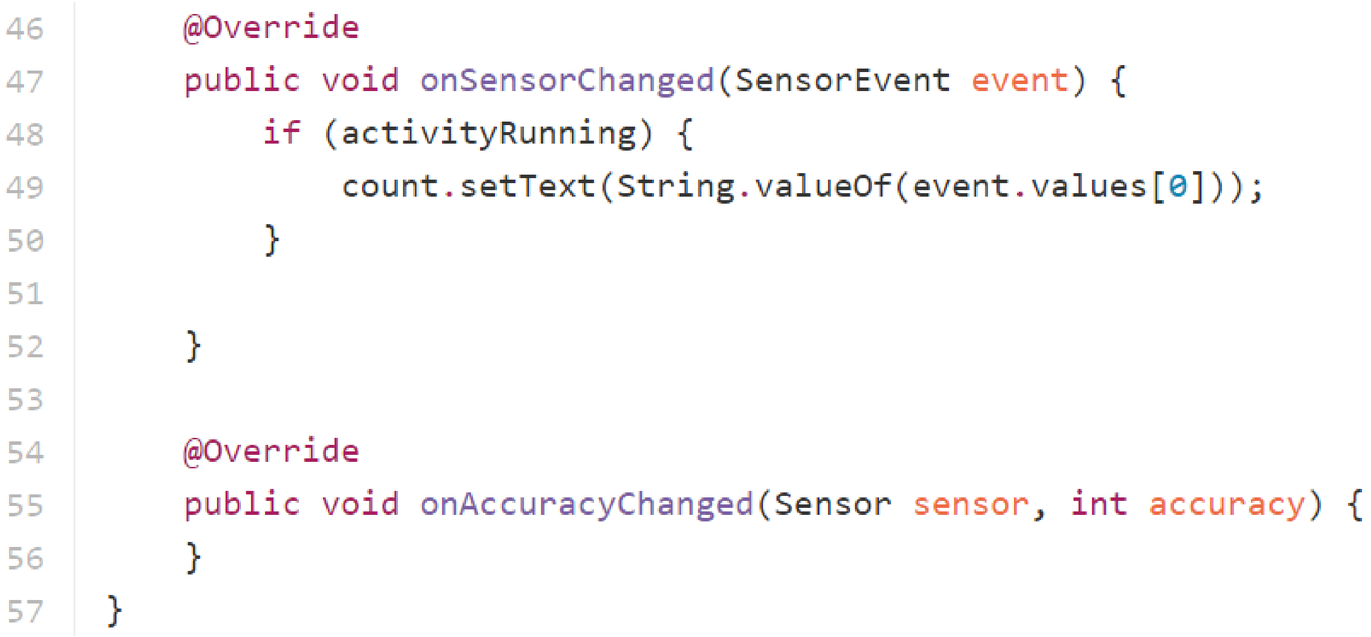
Example Step Counter App (Contd)



```
    @Override
    protected void onResume() {
        super.onResume();
        activityRunning = true;
        Sensor countSensor = sensorManager.getDefaultSensor(Sensor.TYPE_STEP_COUNTER);
        if (countSensor != null) {
            sensorManager.registerListener(this, countSensor, SensorManager.SENSOR_DELAY_UI);
        } else {
            Toast.makeText(this, "Count sensor not available!", Toast.LENGTH_LONG).show();
        }

    }

    @Override
    protected void onPause() {
        super.onPause();
        activityRunning = false;
        // if you unregister the last listener, the hardware will stop detecting step events
//        sensorManager.unregisterListener(this);
    }
```

https://theelfismike.wordpress.com/2013/11/10/android-4-4-kitkat-step-detector-code/

Example Step Counter App (Contd)



```java
    @Override
    public void onSensorChanged(SensorEvent event) {
        if (activityRunning) {
            count.setText(String.valueOf(event.values[0]));
        }

    }

    @Override
    public void onAccuracyChanged(Sensor sensor, int accuracy) {
    }
}
```

https://theelfismike.wordpress.com/2013/11/10/android-4-4-kitkat-step-detector-code/

Best Practices for Sensor Usage

1. **Unregister sensor listeners:** when done using sensor or when app is paused
   - Otherwise sensor continues to acquire data, draining battery

2. **Don’t test sensor code on emulator**
   - Must test sensor code on physical device, emulator doesn’t support sensors

Best Practices for Sensor Usage (Contd)

3. **Don’t block onSensorChange( ) method:**
   - Android system may call onsensorChanged( ) often
   - So… don’t block it
   - Perform any heavy processing (filtering, reduction of sensor data) outside **onSensorChanged( )** method

4. **Avoid using deprecated methods or sensor types:**
   - TYPE_ORIENTATION sensor type deprecated, use **getOrientation( )** method instead

   - TYPE_TEMPERATURE sensor type deprecated, use TYPE_AMBIENT_TEMPERATURE sensor type instead

Best Practices for Sensor Usage (Contd)

5. **Verify sensors before you use them:**
   - Don’t assume sensor exists on device, check first before trying to acquire data from it

6. **Choose sensor delays carefully:**
   - Sensor data rates can be very high
   - Choose delivery rate that is suitable for your app or use case
   - Choosing a rate that is too high sends extra data, wastes system resources and battery power

References

- Busy Coder’s guide to Android version 6.3
- CS 65/165 slides, Dartmouth College, Spring 2014
- CS 371M slides, U of Texas Austin, Spring 2014