Programming with Android: Notifications, Threads, Services

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Outline

- Notification Services: **Status Bar** Notifications
- Notification Services: **Toast** Notifications
- **Thread Management** in Android
- Thread: **Handler and Looper**
- **Services: Local** Services
- **Services: Remote** Services
- **Broadcast Receivers**

Android: Where are we now …

TILL NOW → Android Application structured as a single **Activity** or as a group of Activities …

- **Intents** to call other activities
- **Layout** and **Views** to setup the GUI
- **Events** to manage the interactions with the user

Activities executed only in **foreground** …

- What about *background* activities?
- What about *multi-threading* functionalities?
- What about *external events* handling?

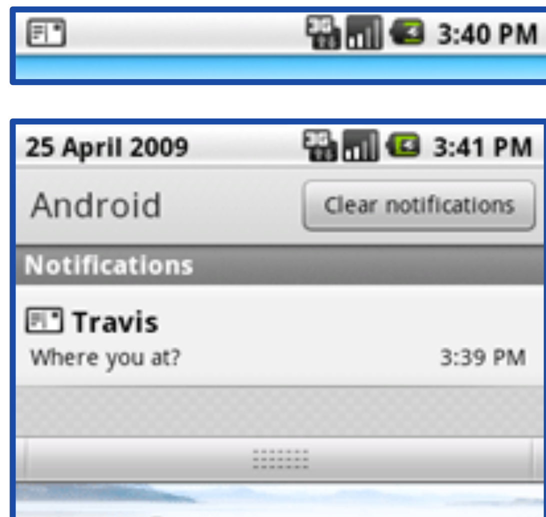
Android: Where are we now …

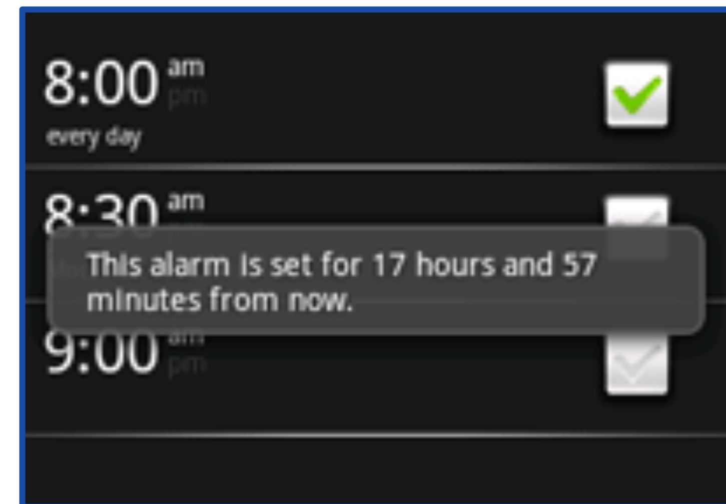
EXAMPLE: A simple application of *Instantaneous Messaging* (**IM**)

- Setup of the application **GUI** √
- GUI **event** management √
- Application **Menu** and **Preferences** √
- *Network functionalities* (send/receive messages) √
- Updates in **background** mode ✗
- **Notifications** in case of message reception in background mode ✗

Android: Service Notifications Types

Service Notifications: *Mechanism to notify information to the end-user on the occurrence of specific events ....*





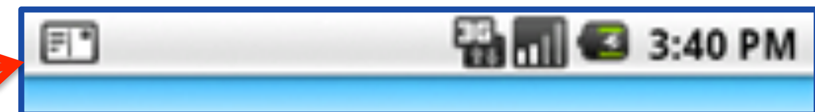
Status Bar Notifications

Toast Notifications

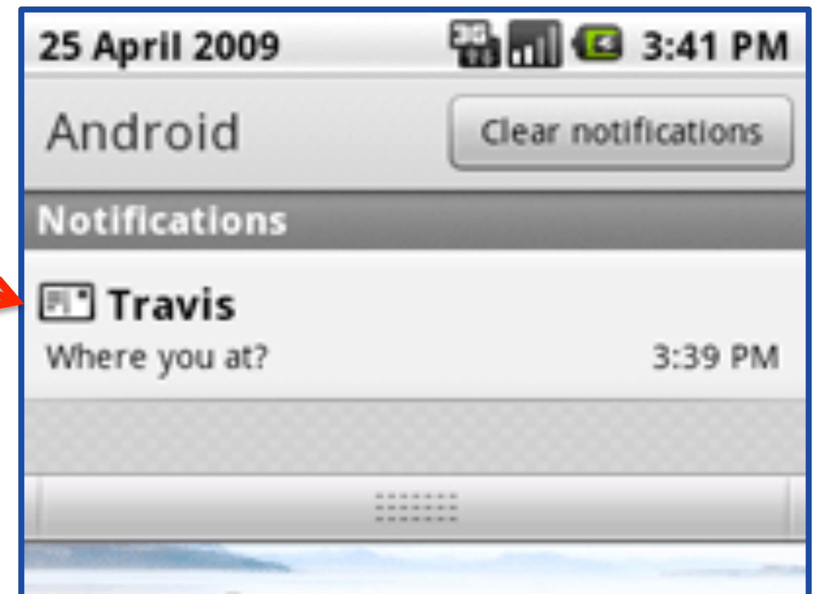
Android: Status Bar Notifications

- Used by *background services* to notify the occurrence of an event that requires a **response** … without *interrupting the operations of the foreground activities*!

- Display an **icon** on the Status Bar (top screen)



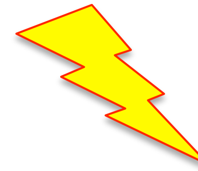
- Display a **message** in the Notification Window



- Fire an **event** in case the user selects the notification

Android: Status Bar Notifications

STATUS BAR



Notification

- **Icon** for the status bar
- **Title** and **message**
- **PendingIntent** to be fired when notification is selected

Notification Manager

Android system component
Responsible for notification management
And status bar updates

OPTIONs:

- Ticket-text message
- Alert-sound
- Vibrate setting
- Flashing LED setting
- Customized layout

Android: Status Bar Notifications

- Follow these steps to send a Notification:

1. Get a **reference** to the **Notification Manager**

NotificationManager nm=(NotificationManager) **getSystemService**(Context.NOTIFICATION_SERVICE)

2. **Build** the Notification message

public **Notification**(int icon, CharSequence tickerText, long when)

public void **setLatestEvent**(Context context, CharSequence contentTitle, CharSequence contentText, PendingIntent intent)

3. **Send** the notification to the Notification Manager

public void **notify**(int id, Notification notification)

Android: Status Bar Notifications

Build the notification object

```
// Specificy icon, ticket message and time
Notification notification = new Notification(R.drawable.icon, "This is a very basic Notification to catch your attention!", System.currentTimeMillis());
```

Define what will happen in case the user selects the notification

```
// Build an explicit intent to NotificationActivity
Intent intent = new Intent(this, NotificationActivity.class);
PendingIntent pIntent = PendingIntent.getActivity(this, 0, intent,
PendingIntent.FLAG_CANCEL_CURRENT);
```

Android: Status Bar Notifications

Add (optional) flags for notification handling

```
// Specificy that notification will disappear when handled
notification.flags |= Notification.FLAG_AUTO_CANCEL;
```

Send the notification to the Notification Manager

```
// Set short and long message to be displayed on the notification window
// Set the PendingIntent
notification.setLatestEventInfo(this, "Notification", "Click to launch
NotificationActivity", pIntent);
notificationManager.notify(SIMPLE_NOTIFICATION_ID, notification);
```

Android: Status Bar Notifications

Add a **sound** to the notification

```
// Use a default sound
notification.defaults |= Notification.DEFAULT_SOUND;
```

Pass an **URI** to the sound field to set a different sound

```
notification.sound = Uri.parse(file://sdcard/path/ringer.mp3);
```

Use FLAG_INSISTENT to play the sound till notification is handled

```
notification.flags |= Notification.FLAG_INSISTENT;
```

Android: Status Bar Notifications

Add **flashing lights** to the notification

```
// Use a default LED
notification.defaults |= Notification.DEFAULT_LIGHTS;
```

Define *color and pattern* of the flashing lights

```
notification.ledARGB = 0xff00ff00;
notification.ledOnMS = 300;
notification. ledOffMS = 1000;
notification.flags |= Notification.FLAG_SHOW_LIGHTS;
```

Android: Status Bar Notifications

Add **vibrations** to the notification

```
// Use a default vibration
notification.defaults |= Notification.DEFAULT_VIBRATE;
```

Define *the vibration pattern*

```
// Set two vibrations, one starting at time 0 and with duration equal to 100ms
long[] vibrate={0,100,200,300};
notification.vibrate = vibrate;
```

Android: Status Bar Notifications

Some **flags** that can be used (see the documentation)

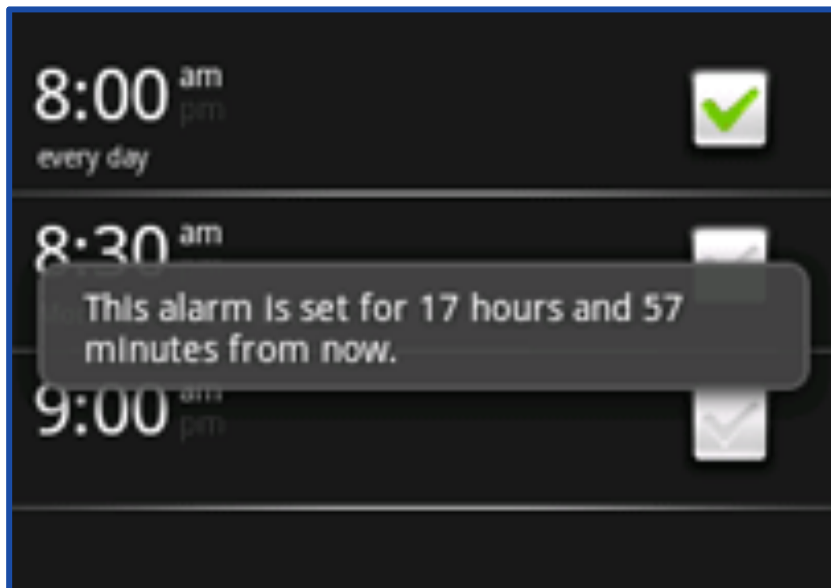
- **FLAG_NO_CLEAR**: Notification is not canceled
- **FLAG_ONGOING_EVENT**: Notify ongoing events (e.g. a call)
- **FLAG_AUTO_CANCEL**: Notification disappears as handled
- **FLAG_INSISTENT**: Reproduce sound till notification is handled
- **FLAG_FOREGROUND_SERVICE**: Notification from an active service

… Also **PendingIntents** can have flags

- **FLAG_CANCEL_CURRENT**: PendingIntents are ovewritten
- **FLAG_UPDATE_CURRENT**: PendingIntents are updated (*extra field*)

Android: Toast Notifications

A **Toast Notification** is a message that pops up on the surface of the window, and automatically fades out.



- Typically created by the *foreground* activity.
- *Display* a message text and then fades out
- **Does not accept events**! (use *Status Bar Notifications* instead)

Android: Toast Notifications

A **Toast Notification** is a message that pops up on the surface of the window, and automatically fades out.

```
Context context=getApplicationContext();

// Define text and duration of the notification
CharSequence text="This is a Toast Notification!";
int duration=Toast.LENGTH_SHORT;

Toast toast=Toast.makeText(context, text, duration);

// Send the notification to the screen
toast.show();
```

Android: Processes and Threads

- By default, all components of the same application run in the same process and thread (called "**main** thread" or "**UI**" thread).

- In **Manifest.xml**, it is possible to specify the process in which a component (e.g. an activity) should run through the attribute **android:process**.

- Processes might be killed by the system to reclaim memory.
  - **Processes' hierarchy** to decide the importance of a process.
  - Five *types*: Foreground, Visible, Service, Background, Empty.

Android: Thread Management

- Android natively supports a **multi-threading** environment.

- An Android application can be composed of multiple *concurrent* threads.

- How to create a thread in Android? … Like in Java!

  - extending the **Thread** class **OR**
  - implementing the **Runnable** interface
  - **run**() method executed when MyThread.**start**() is launched.

Android: Thread Management

```
public class MyThread extends Thread {

    public MyThread() {
        super ("My Threads");
    }

    public void run() {
        // do something
    }
}
```

```
myThread m=new MyThread();
m.start();
```

Android: Thread Management

The **UI** or **main** thread is in charge of dispatching events to the user interface widgets, and of drawing the elements of the UI.

- Do not block the UI thread.
- Do not access the Android UI components from outside the UI thread.

QUESTIONS:

How to update the UI components from worker threads?

Android: AsyncTask

AsyncTask is a Thread helper class (Android only).

- Computation running on a **background** thread.
- Results are published on the **UI** thread.

RULES

- AsyncTask must be created on the UI thread.
- AsyncTask can be executed only once.
- AsyncTask must be canceled to stop the execution.

Android: AsyncTask

```
private class MyTask extends AsyncTask<Par, Prog, Res>
```

Par → type of parameters sent to the AsyncTask
Prog → type of progress units published during the execution
Res → type of result of the computation

EXAMPLES

```
private class MyTask extends AsyncTask<Void,Void,Void>
```

```
private class MyTask extends AsyncTask<Integer,Void,Integer>
```

Android: AsyncTask

EXECUTION of the ASYNCTASK

The UI Thread invokes the **execute** method of the AsyncTask:

(new Task()).**execute**(param1, param2 … paramN)

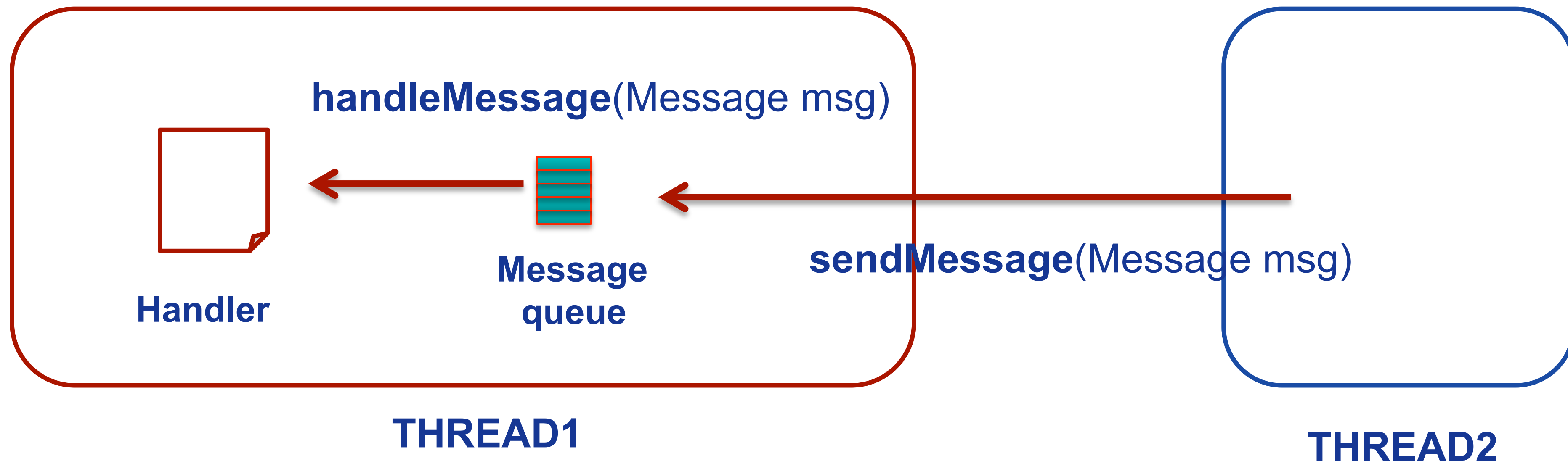
After **execute** is invoked, the task goes through four steps:

1. **onPreExecute**() → invoked on the UI thread
2. **doInBackground**(Params…) →computation of the AsyncTask
   - can invoke the publishProgress(Progress…) method
3. **onProgressUpdate**(Progress …) → invoked on the UI thread
4. **onPostExecute**(Result) → invoked on the UI thread

Android: Thread Management

Message-passing like mechanisms for Thread communication.

MessageQueue → Each thread is associated a queue of messages
Handler → Handler of the message associated to the thread
Message → Parcelable Object that can be sent/received



Android: Thread Management

Message loop is implicitly defined for the **UI** thread … but it must be explicitly defined for worker threads.

HOW? Use **Looper** objects …

```
public void run() {
        Looper.prepare();
        handler=new Handler() {
            public void handleMessage(Message msg) {
                // do something
            }
        }
        Looper.loop();
```

Android: Services

A **Service** is an application that can perform *long-running operations in background* and *does not provide a user interface*.

- **Activity** → UI, can be disposed when it loses visibility
- **Service** → No UI, disposed when it terminates or when it is terminated by other components

A Service provides a robust environment for background tasks …

Android: Services

- A Service is started when an application component starts it by calling **startService(**Intent**)**.

- Once started, a Service can run in **background**, even if the component that started it is destroyed.

- *Termination* of a Service:

    1. **selfStop**() → self-termination of the service
    2. **stopService**(Intent) → terminated by others
    3. System-decided termination (i.e. memory shortage)

Android: Service Lifetime

OnCreate() executed only once when the Service is created.

OnCreate() ← **startService()**

OnStartCommand() ← **startService()**

RUNNING

startService() might cause the execution of OnCreate +OnStartCommand, or only of OnStartCommand, depending whether the Service is already running …

onDestroy() ← **stopService()** **selfStop()**

Android: Foreground Services

COMMON **MISTAKES**

- A **Service** provides only a **robust environment** where to host separate threads of our application.
  - A Service is not a separate process.
  - A Service is not a separate Thread (i.e. it runs in the main thread of the application that hosts it).
  - A Service does nothing except executing what listed in the **OnCreate**() and **OnStartCommand**() methods.
  - Behaviors of Local/Bound Services can be different.

Android: Foreground Services

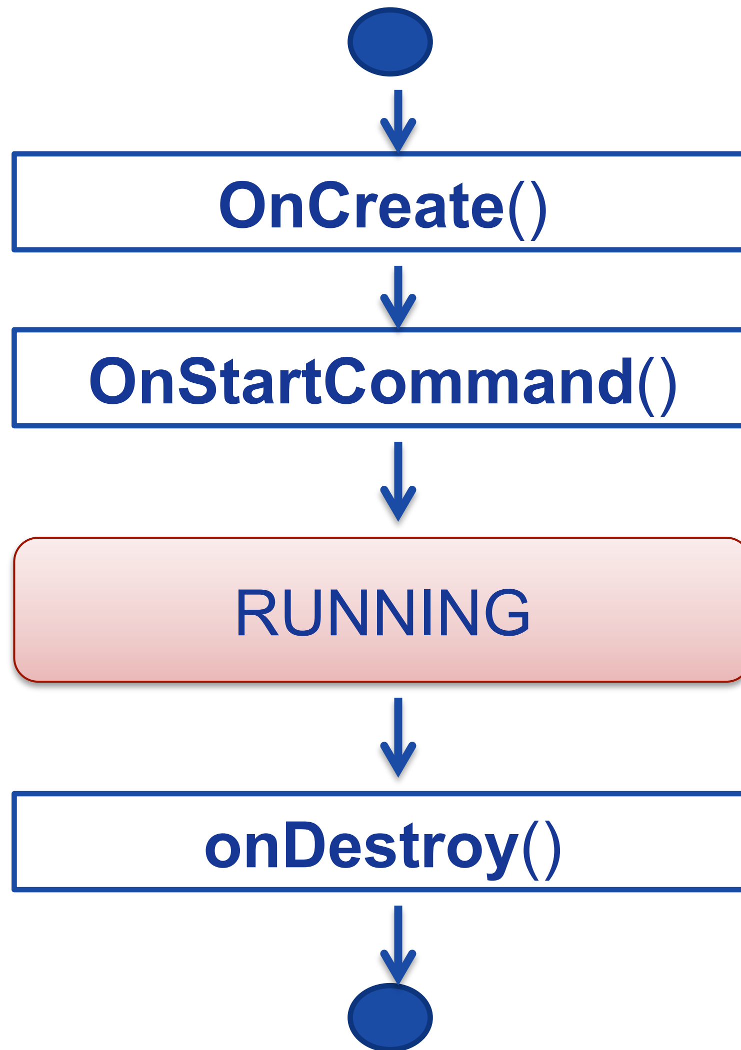
- A **Foreground** Service is a service that is continuously active in the Status Bar, and thus it is not a good candidate to be killed in case of low memory.

- The Notification appears between **ONGOING** pendings.

- To create a Foreground Service:
  1. Create a **Notification** object
  2. Call **startForeground**(id, notification) from onStartCommand()

- Call **stopForeground**() to stop the Service.

Android: Service Lifetime



Two Types of **Services**:

1. **Local** Services: Start-stop lifecycle as the one shown.

2. **Remote/Bound** Services: Bound to application components. Allow interactions with them, send requests, get results, IPC facilities.

Android: Bound Service

OnCreate()

OnBind()

Client interacts with the Service …

onUnbind()

onRebind()

onDestroy()

- A **Bound** Service allows components (e.g. Activity) to **bind** to the services, **send** requests, **receive** response.
- A **Bound** Service can serve components running on different processes (**IPC**).

Android: Bound Service

- Through the **IBinder**, the Component can send requests to the Service .

bindService(Intent, ServiceConnection, flags)

Android: Bound Service

➢ When creating a Service, an **IBinder** must be created to provide an Interface that clients can use to interact with the Service … HOW?

1. **Extending** the Binder class (local Services only)
   - Extend the Binder class and return it from **onBind**()
   - Only for a Service used by the same application

2. **Using** the Android Interface Definition Language (**AIDL**)
   - Allow to access a Service from different applications.

Android: Bound Service

```
public class LocalService extends Service {
    // Binder given to clients
    private final IBinder sBinder=(IBinder) new SimpleBinder();

    @Override
    public IBinder onBind(Intent arg0) {
        // TODO Auto-generated method stub
        return sBinder;
    }

    class SimpleBinder extends Binder {
        LocalService getService() {
            return LocalService.this;
        }
    }
}
```

Android: Bound Service

```
ublic class MyActivity extends Activity {
    LocalService lService;
    private ServiceConnection mConnection=new ServiceConnection() {

        @Override
        public void onServiceConnected(ComponentName arg0, IBinder bind) {
            SimpleBinder sBinder=(SimpleBinder) bind;
            lService=sBinder.getService();
            ….
        }

        @Override
        public void onServiceDisconnected(ComponentName arg0) {
        }
        … bindService(new  Intent(this,LocalService.class),mConnection,BIND_AUTO_CREATE);

};
```

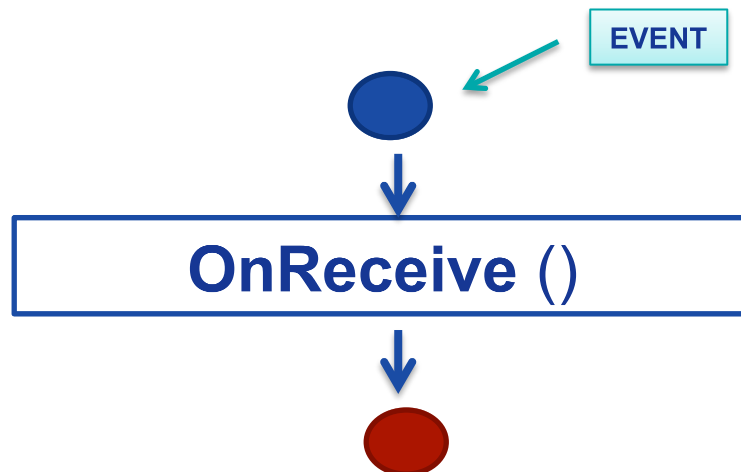
Android: Broadcast Receiver

A **Broadcast Receiver** is a component that is activated only when specific events occur (i.e. SMS arrival, phone call, etc).

- **Registration** of the Broadcast Receiver to the event …
  1. Event → **Intent**
  2. Registration through **XML** code
  3. Registration through **Java** code
- **Handling** of the event.

Android: Broadcast Receiver

A **Broadcast Receiver** is a component that is activated only when specific events occur (i.e. SMS arrival, phone call, etc).



- Single-state component …
- **onReceive**() is invoked when the registered event occurs
- After handling the event, the Broadcast Receiver is **destroyed**.

Android: Broadcast Receiver

- **Registration** of the Broadcast Receiver to the event … **XML** Code: → modify the **AndroidManifest**.xml

```
<application>
    <receiver class="SMSReceiver">
        <intent-filter>
            <action  android:value="android.provider.Telephony.SMS_RECEIVED" />
        </intent-filter>
    </receiver>
</application>
```

Android: Broadcast Receiver

- **Registration** of the Broadcast Receiver to the event …
  In **Java** → **registerReceiver**(BroadcastReceiver, IntentFilter)

```
receiver=new BroadcastReceiver() { … }

protected void onResume() {
    registerReceiver(receiver, new IntentFilter(Intent.ACTION_TIME_TICK));
}

protected void onPause() {
    unregisterReceiver(receiver);
}
```

Android: Broadcast Receiver

How to send the **Intents** handled by **Broadcast Receivers**?

- void **sendBroadcast**(Intent intent)

 … No order of reception is specified

- void **sendOrderedBroadcast**(Intent intent, String permit)

 … reception order given by the android:priority field

sendBroadcast() and startActivity() work on different contexts!