Platform-Based Development: Background Processing

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Dr Veljko Pejović
Veljko.Pejovic@fri.uni-lj.si

University of Ljubljana
Faculty of Computer and Information Science

Broadcast

- Messages sent from other components of your app, other apps or from the Android system
- Messages are wrapped in Intents

```
Intent intent = new Intent();
intent.setAction(ACTION);
intent.putExtra(STOP_SERVICE_BROADCAST_KEY, RQS_STOP_SERVICE);
sendBroadcast(intent);
```

- Send broadcasts
  - System sends certain broadcasts when an event happens, e.g. ACTION_BOOT_COMPLETED
  - Send custom broadcasts via sendBroadcast()

Broadcast

- Broadcasts are captured in an app/component if a BroadcastReceiver is dynamically registered in the code:
  - Create a BroadcastReceiver and impl. onReceive()

```
public class NotifyServiceReceiver extends BroadcastReceiver{

    @Override
    public void onReceive(Context arg0, Intent arg1) {
                …
    }
}
```

  - Register for receiving certain kinds of Intents

```
IntentFilter intentFilter = new IntentFilter();
intentFilter.addAction(ACTION);
registerReceiver(notifyServiceReceiver, intentFilter);
```

Broadcast

- Broadcasts are captured in an app if a BroadcastReceiver is statically registered in AndroidManifest.XML and onReceive() is implemented in the code:

Not available for all system bcasts

```
<receiver android:name=".MyBroadcastReceiver” android:exported="true">
 <intent-filter>
   <action android:name="android.intent.action.BOOT_COMPLETED"/>
   <action android:name="android.intent.action.INPUT_METHOD_CHANGED”/>
 </intent-filter>
</receiver>
```

```
      public class MyBroadcastReceiver extends BroadcastReceiver {
           @Override
           public void onReceive(Context context, Intent intent) {
      ….
```

IntentService

- A Service that
  - Runs on a separate thread
  - Queues up requests and processes them one by one
- Suitable for long running one-off tasks when we don't want to affect the UI responsiveness
- IntentService survives Activity lifecycle changes
- Called using explicit Intent
- Starts on demand, stops when it runs out of work

IntentService

- Define in AndroidManifest.XML

```
<service
    android:name=".FetchAddressIntentService"
    android:exported="false"/>
```

- Extend the class in your Java code

```
public class FetchAddressIntentService extends
IntentService {
```

Invoking IntentService

- Create an explicit Intent for your IntentService
- Use startService() to start the IntentService
- Add additional data if needed with the extra field

Handling Results – from IntentService to Activity (1)

- BroadcastReceiver in your Activity
  - Subclass BroadcastReceiver, implement onReceive
  - Register the receiver for a particular action for times when you would like to handle IntentService results (usually when your Activity is in the foreground)
- Broadcast from your IntentService
  - sendBroadcast() from your IS using the same Intent action as the above

Handling Results – from IntentService to Activity (2)

- ResultReceiver in your Activity
  - Subclass ResultReceiver, implement onReceiveResult

```
class AddressResultReceiver extends ResultReceiver {
    public AddressResultReceiver(Handler handler) {
        super(handler);
    }

    @Override
    protected void onReceiveResult(int resultCode,
                                                     Bundle resultData) {…}
```

  - Pass ResultReceiver through Intent when starting IS

```
Intent intent = new Intent(this, FetchAddressIntentService.class);
intent.putExtra(Constants.RECEIVER, mResultReceiver);
intent.putExtra(Constants.LOCATION_DATA_EXTRA, mLastLocation);
startService(intent);
```

Handling Results – from IntentService to Activity (2)

- Set ResultReceiver result
  - IntentService sends results to ResultReceiver in a Bundle with send() method

```
Bundle bundle = new Bundle();
bundle.putString(Constants.RESULT_DATA_KEY, message);
mReceiver.send(resultCode, bundle);
```

- Example
  - Display location address

http://developer.android.com/training/location/display-address.html

IntentService Example

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Based on:
https://www.vogella.com/tutorials/AndroidServices/article.html

AsyncTask

DEPRECATED

- For short, more interactive tasks
- Runs on a separate worker thread, but keeps a link with the main UI thread via:
  - onPreExecute
  - onProgressUpdate
  - onPostExecute

AsyncTask <?, ?, ?>
“?” param types for input, progress, output

- Define what we want to do in the background in:
  - doInBackground
- Start with YourTask().execute()

https://github.com/googlesamples/android-play-location/tree/master/ActivityRecognition

AsyncTask Example

```
private class PostTask extends AsyncTask<String, Integer, String> {
    @Override
    protected void onPreExecute() {
        super.onPreExecute();
        ProgressBar bar=(ProgressBar)findViewById(R.id.progressBar);
        bar.setVisibility(View.VISIBLE);
        bar.setProgress(0);
    }

 @Override
 protected String doInBackground(String... params) {
     String url=params[0];
     for (int i = 0; i <= 10; i += 1) {
         try {
             Thread.sleep(1000);
         } catch (InterruptedException e) {
             e.printStackTrace();
         }
         publishProgress(i);
     }
     return "All Done!";
 }
```

Just before the task starts

This is done in the background, and the status is communicated via publishProgress()

AsyncTask Example

```
@Override
protected void onProgressUpdate(Integer... values) {
    super.onProgressUpdate(values);
    ProgressBar bar=(ProgressBar)findViewById(R.id.progressBar);
    bar.setVisibility(View.VISIBLE);
    bar.setProgress(values[0]);
}
```

Connects with the UI thread

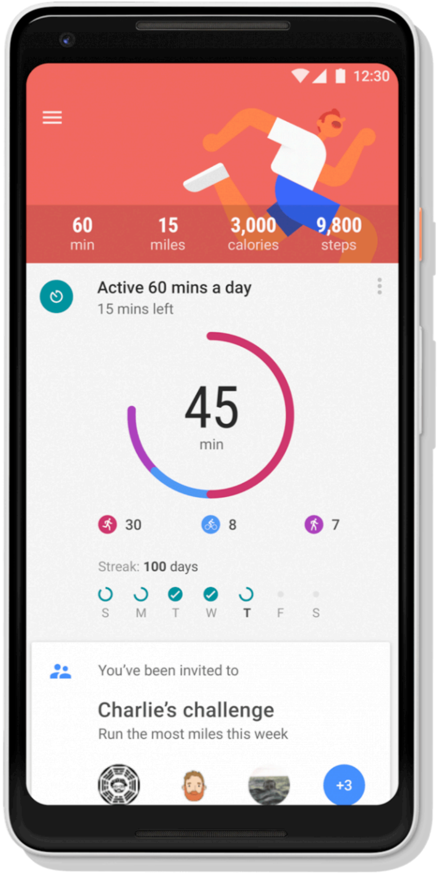
```
@Override
protected void onPostExecute(String result) {
    super.onPostExecute(result);
    ProgressBar bar=(ProgressBar)findViewById(R.id.progressBar);
    bar.setVisibility(View.GONE);
    TextView text = (TextView) findViewById(R.id.status);
    text.setText(R.string.after);
}
```

Immediately after the task is finished

AsyncTask Example

Periodic/Occasional Task Scheduling

- Numerous situations in which we require occasional processing:
  - Tracking physical activity throughout a day – e.g. Google Fit
    - Sampling sensors periodically
  - Synchronizing data with the server
    - Send data periodically, when there is WiFi connectivity
  - Reminding a user when in a particular location
    - Geofenced reminder



Periodic/Occasional Task Scheduling

- Limited battery capacity is the main issue in mobile computing
- Long and frequent background processing is the main reason for inefficient energy use:
  - Users are often unaware of background processes and their intentions, cannot easily shut them down
  - Processes consume computational and memory resources
  - Processes prevent a device from going to a low-power mode

Periodic/Occasional Task Scheduling

- Android's general direction is towards limited and controlled background processing
- In the old days (API<19):
  - schedule a periodic job to be executed every 15 mins
- Today:
  - schedule a job and Android will aggregate jobs of all apps, schedule them for a particular time slot (that you have no control off), if the app is used only rarely it might have to wait for 24 hours, and forget about getting location updates more than a few times per hour (if in background), getting notified when there is connectivity, etc.

Tools for Periodic/Occasional Task Scheduling

- Wake lock
- Foreground Service
- AlarmManager
- WorkManager (JobScheduler++)
- DownloadManager
- SyncAdapter

Wake Lock

- App prevents the phone from going to a low-power sleep mode
- Needs a special permission

```
<uses-permission android:name="android.permission.WAKE_LOCK" />
```

- Acquire a wake lock

```
PowerManager powerManager = (PowerManager)
                            getSystemService(POWER_SERVICE);
WakeLock wakeLock = powerManager
                   .newWakeLock(PowerManager.PARTIAL_WAKE_LOCK,
                                "MyApp::MyWakelockTag");
wakeLock.acquire();
```

- Release: `wakelock.release()`

This does not prevent the screen from going dark!

(use FLAG_KEEP_SCREEN_ON)

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AlarmManager

- Running periodic operations at specified times or with a specified time interval
- Use when you need your tasks done at (almost) exact times between them
- Do not use for:
  - Periodic backups to the server
  - Checking for new notifications/ messages from the server

Use SyncAdapter

Use Firebase messaging if possible

AlarmManager

- Alarm types (exactness):
  - Inexact – Android will decide how to group alarms coming from multiple apps in order to optimize energy use
  - Exact – Your alarm will be executed at the prescribed time, unless the device is “sleeping”
  - Exact while idle - Your alarm will be executed at the prescribed time (+/- 9 minutes), even if the device is “sleeping”
- Alarm types (clock):
  - RTC – real time clock
  - ELAPSED_REALTIME – time since booted

AlarmManager

- Using AlarmManager
  - Create a BroadcastReceiver that manages the task you wish to perform when the alarm is ready
  - Set alarm
    - Define the type (exact/inexact, one off/repeating, RTC/ELAPSED)
    - Define the starting time
    - Define the repeating interval (optionally)
    - Supply Intent that starts the above BroadcastReceiver
  - Alarms can be cancelled

AlarmManager

- Restoring alarms when the device is rebooted
  - Acquire the necessary permission

```
<uses-permission
android:name="android.permission.RECEIVE_BOOT_COMPLETED"/>
```

  - Create a receiver

```
public class SampleBootReceiver extends BroadcastReceiver {
    @Override
    public void onReceive(Context context, Intent intent) {
        if (intent.getAction()
            .equals("android.intent.action.BOOT_COMPLETED")) {
            // Set the alarm here.
         }
```

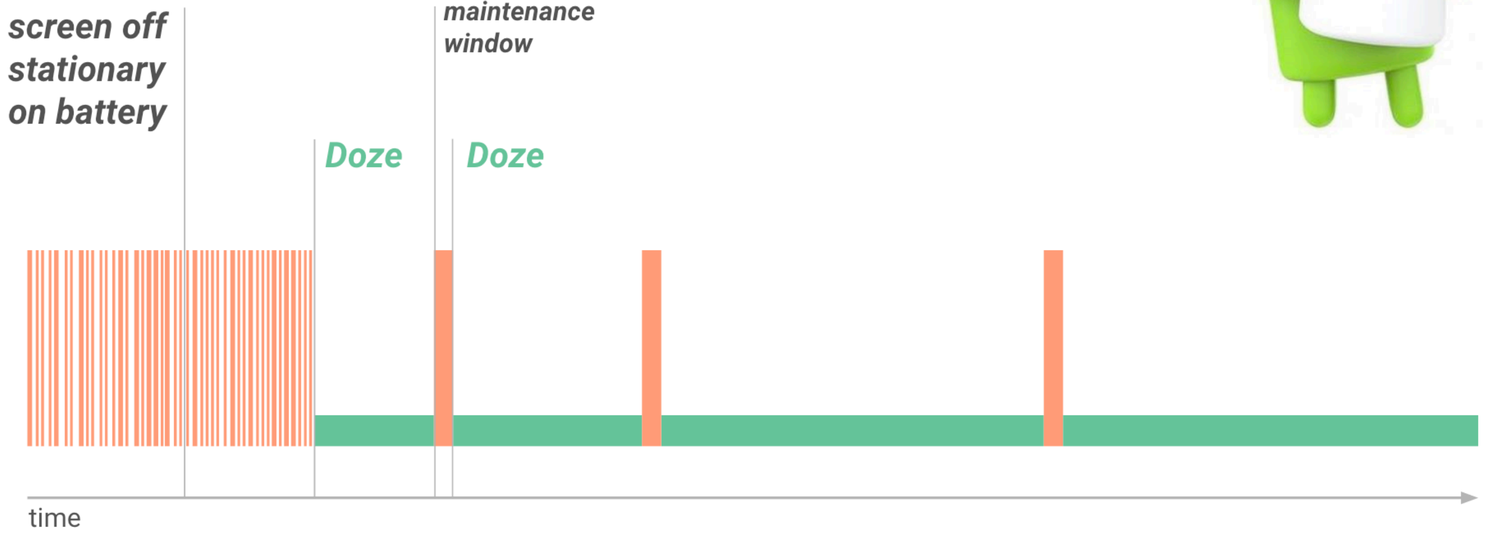
  - Register in the manifest

```
<receiver android:name=".SampleBootReceiver”>
 <intent-filter>
    <action android:name="android.intent.action.BOOT_COMPLETED"></action>
 </intent-filter>
</receiver>
```

AlarmManager Example

Doze Mode

- If a device is not charging nor actively used, it enters Doze Mode



Doze Mode

- The system sleeps most of the time
- Periodic maintenance periods when it wakes up and performs tasks from the backlog
- During the sleep time:
  - Wake locks ignored
  - Network access suspended
  - AlarmManager deferred to later times
  - No WiFi scanning
  - Jobs not scheduled (see WorkManager)
  - Sync adapters don't run

unless setAndAllowWhileIdle() or setExactAndAllowWhileIdle()

Doze Mode

- To program with Doze Mode in mind, use
  - Firebase cloud messaging (FCM) for communication apps – a single connection is established
    - High priority messages can wake the device up
  - Use WorkManager for scheduling jobs
  - Request to be exempt from Doze
    - Can acquire partial wake lock
    - Requires a special permission

```
REQUEST_IGNORE_BATTERY_OPTIMIZATIONS
```

Use for very specific apps only!

- To test your apps in Doze Mode:
  - Force a device/emulator to idle mode

```
adb shell dumpsys deviceidle force-idle
```

WorkManager

- Idea:
  - Guaranteed deferrable execution
  - Constraint-aware execution (e.g. run when on WiFi)
  - Respect system restrictions
- Implementation:
  - Part of Android Jetpack (introduced in 2018)
    - Add as a dependency to your app
  - Backwards compatible
    - Uses JobScheduler for newer APIs
    - Uses AlarmManager for older APIs

WorkManager

- Worker – a unit of work

```
public class UploadWorker extends Worker {

    public UploadWorker(
        @NonNull Context context,
        @NonNull WorkerParameters params) {
        super(context, params);
    }

    @Override
    public Result doWork() {
      // Do the work here, e.g. uploa
      uploadImages()

      // Indicate whether the task finished successfully
      return Result.success()
    }
}
```

By default runs on a background thread

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WorkManager

- WorkRequest – set constraints, types of execution for your work, e.g.

```
Constraints constraints = new Constraints.Builder()
    .setRequiresDeviceIdle(true)
    .setRequiresCharging(true)
     .build();

// ...then create a OneTimeWorkRequest that uses those constraints
OneTimeWorkRequest compressionWork =
                new OneTimeWorkRequest.Builder(CompressWorker.class)
     .setConstraints(constraints)
     .build();
```

WorkManager

- Running tasks

```
WorkManager.getInstance().enqueue(uploadWorkRequest);
```

WorkManager Example

When to Use What?

- Best effort execution
  - E.g. updating an ImageView based on an API call
  - Need to update UI, which may or may not be available (a user can navigate back from your app)

HandlerThread or IntentService, perhaps AsyncTask (but be careful)

- Guaranteed execution at the current moment
  - E.g. the user hits a "Pay" button, the transaction is processed, and the user is notified
  - We must ensure that the payment goes through and the user informed

ForegroundService is the most reliable

When to Use What?

- Guaranteed eventual execution
  - E.g. reminding a user to exercise
  - Should be executed every once a while

Work Manager

- Guaranteed execution at exact (periodic) times
  - E.g. control an oven through an Android app
  - Extremely difficult, if not impossible on certain devices

Make your app exempt from battery optimization; use foreground service; use AlarmManager exact alarms (9 min granularity), use Firebase Cloud Messaging

When to Use What?

- Specialised solutions for particular use cases
  - E.g. synchronise data with a server
  - E.g download large content in the background
  - E.g. remind a user to buy milk when at a grocery store

Sync Adapter

Download Manager

Geofencing from GooglePlayServices