Location-based services in Android

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Outline

Motivation

Quarter of all Android apps ask for users' GPS location data

https://thehill.com/policy/technology/259655-quarter-of-all-android-apps-ask-for-gps-data

Motivation

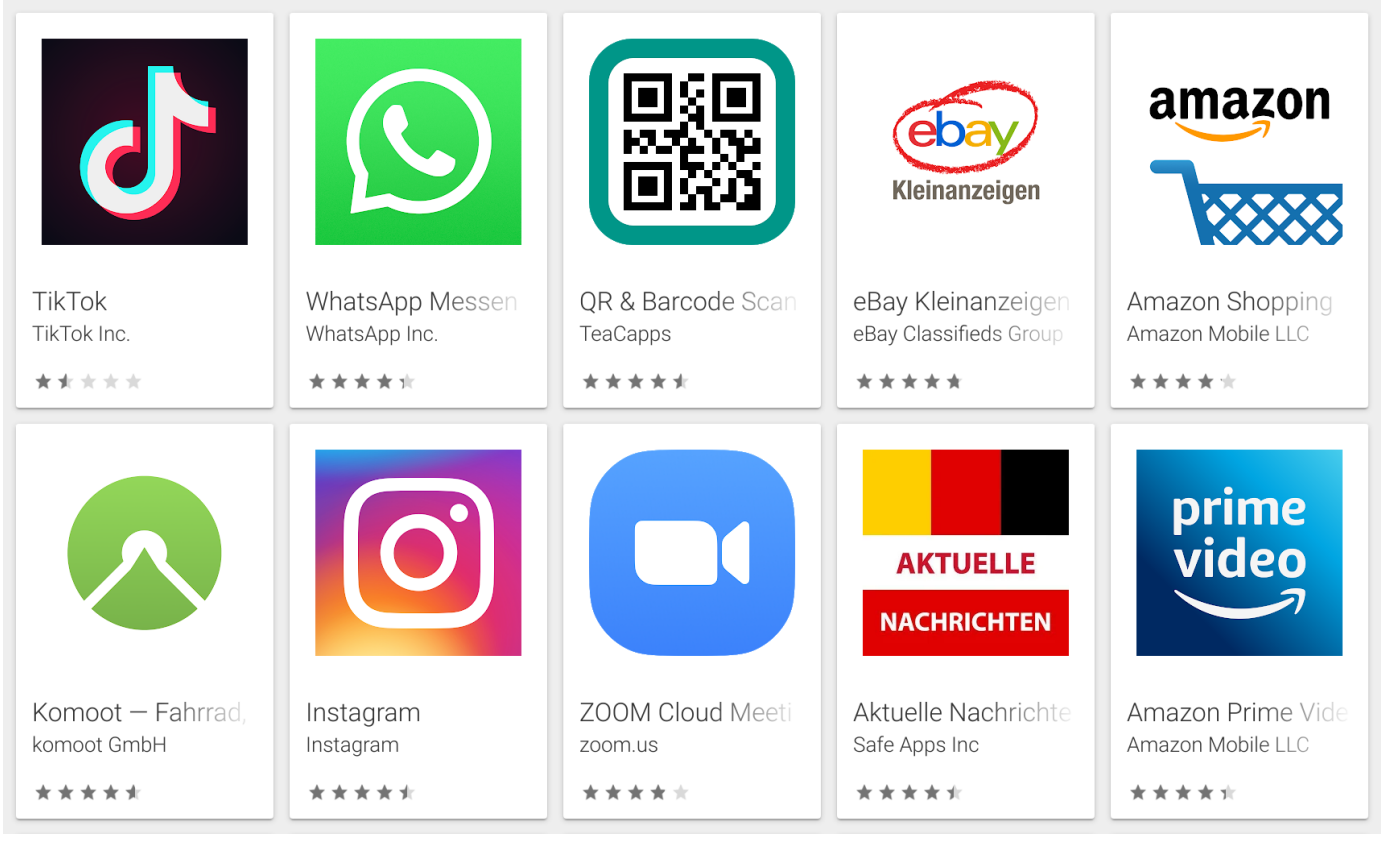


Figure: 9/10 apps from the ‘TopCharts‘ access the device’s location

Introduction

- Provides information based on the geographical location
- Initially driven by emergency assistance applications
- Android comes with location APIs to faciliate adding location awareness

Android Location APIs

- Location Manager
- Fused Location API (Play Services)
- Geofencing (Play Services)

Location Manager

Included in the Android API since version 1

- Request location updates (periodically)
- Get last known location of this provider
- Use different providers
- Retrieve information about GPS chipset

Providers:

- `LocationManager.GPS_PROVIDER`
- `LocationManager.NETWORK_PROVIDER`
- `LocationManager.PASSIVE_PROVIDER`

Location Manager

Get system service

```
val locationManager =
      getSystemService(Context.LOCATION_SERVICE)
           as LocationManager
```

Initialize GPS provider

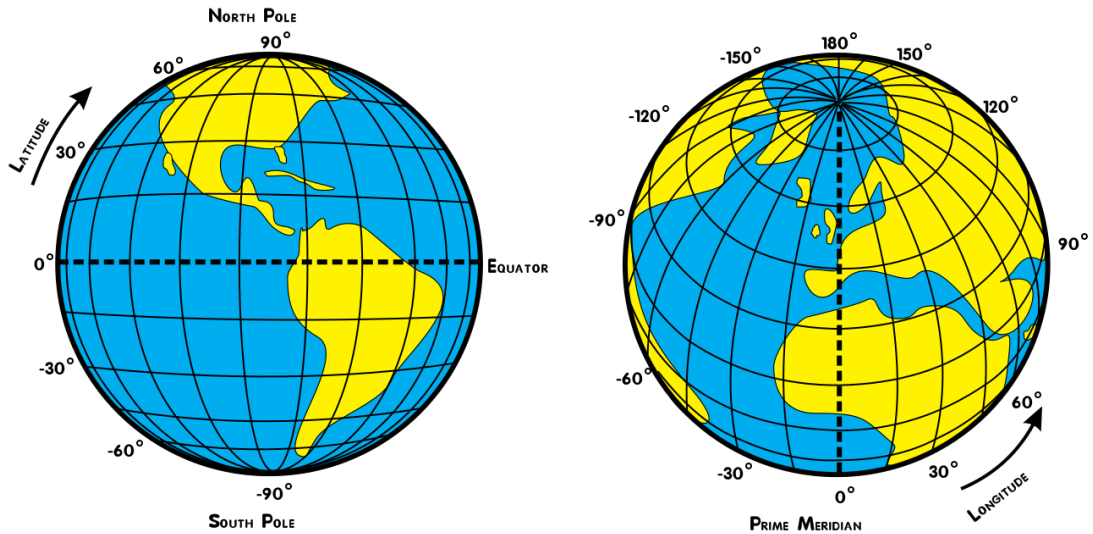
```
val gpsProvider =
     locationManager.getProvider(
          LocationManager.GPS_PROVIDER)
```

Request location update

```
gpsProvider?.let {
     locationManager.requestSingleUpdate(
          it.name, this, null)
}
```

Location Manager

```
override fun onLocationChanged(location:Location?)
{
    println(location?.latitude)
    println(location?.longitude)
    println(location?.accuracy)
}
```



(https://en.wikipedia.org/wiki/File:Latitude_and_Longitude_of_the_Earth.svg)

Fused Location API

Part of Google Play Services

- Simple and battery-efficient
- Request location updates
- Get last known location (system-wide)
- Automaticly changes to the appropiate location source
- Can deliver updates to a callback at specific intervals
  $\Rightarrow$ Provide additional information like direction

Fused Location API

- Location is queried with a *LocationRequest*
  - Interval settings
  - Priorities
  - Displacements
  - ...
- Initialized via *GoogleApiClient.Builder*

Priorities:

- `PRIORITY_BALANCED_POWER_ACCURACY`
- `PRIORITY_HIGH_ACCURACY`
- `PRIORITY_LOW_POWER`
- `PRIORITY_NO_POWER`

Fused Location API

Initialize API client

```
val client = LocationServices
     .getFusedLocationProviderClient(this)
```

Build LocationRequest

```
val locationRequest = LocationRequest()

locationRequest.apply {
     interval = 2_000
     fastestInterval = 1_000
     priority =
          LocationRequest.PRIORITY_LOW_POWER
}
```

Fused Location API

Build LocationCallback

```
val callback = object :LocationCallback(){
override fun onLocationResult(l:
LocationResult?)
     {
          super.onLocationResult(l)
     }
}
```

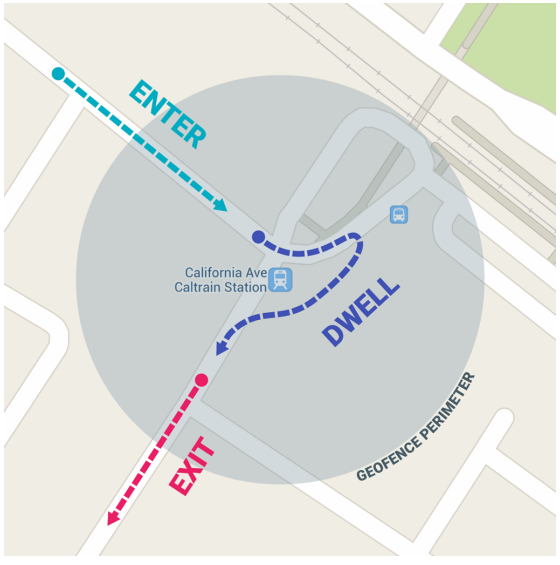
Request location updates

```
client.requestLocationUpdates(
     locationRequest,
     callback,
     null)
```

Geofencing API

Part of Google Play Services

- Recognize when user enters/leaves a predefined circular region
- Simple but limited API
- Very power efficient
- Up to 100 geofences per app, per device



(https://developer.android.com/training/location/geofencing)

Geofencing API

Initialize geofencing client

```
val client = LocationServices
      .getGeofencingClient(this)
```

Build list of geofences

```
val geofences = mutableListOf<Geofence>()

geofences.add(Geofence.Builder()
      .setRequestId("gf-id")
      .setCircularRegion(48.1887, 11.5842, 50f)
      .setExpirationDuration(
            Geofence.NEVER_EXPIRE)
      .setTransitionTypes(
            Geofence.GEOFENCE_TRANSITION_ENTER)
      .build())
```

Geofencing API

Build geofencing request

```
val request = GeofencingRequest.Builder()
      .addGeofences(geofences)
      .setInitialTrigger(
            GeofencingRequest.INITIAL_TRIGGER_ENTER)
      .build()
```

Geofencing API

Build Intent

```
val intent = Intent(this,
     BroadcastReceiver::class.java)

val pendingIntent = PendingIntent.getBroadcast(
     this, 0, intent,
          PendingIntent.FLAG_UPDATE_CURRENT)
```

Add geofences

```
client.addGeofences(request, pendingIntent)
```

Battery Usage

Location based services can cause a huge battery drain when done wrong.
The location is related to the battery drain in the following aspects:

- Higher accuracy $\rightarrow$ higher battery drain
- Higher frequency $\rightarrow$ higher battery drain
- Less latency $\rightarrow$ higher battery drain

Battery Usage

The developer can reduce the battery drain of his application by...

- ...using geofencing whenever possible
- ...using getLastLocation() instead of requesting a new location
- ...tweaking the frequency and accuracy

Best practices:

- Remove location updates if no longer needed
- Set timeouts for location updates
- Batch requests together
- Use passive location updates

Permissions

- `ACCESS_FINE_LOCATION`
- `ACCESS_COARSE_LOCATION`
- `ACCESS_BACKGROUND_LOCATION`
- The permissions should be requested by using *requestPermission*

App Idea

- Track the behavior of our user in the city center of Munich
- Do not collect any location data anywhere else

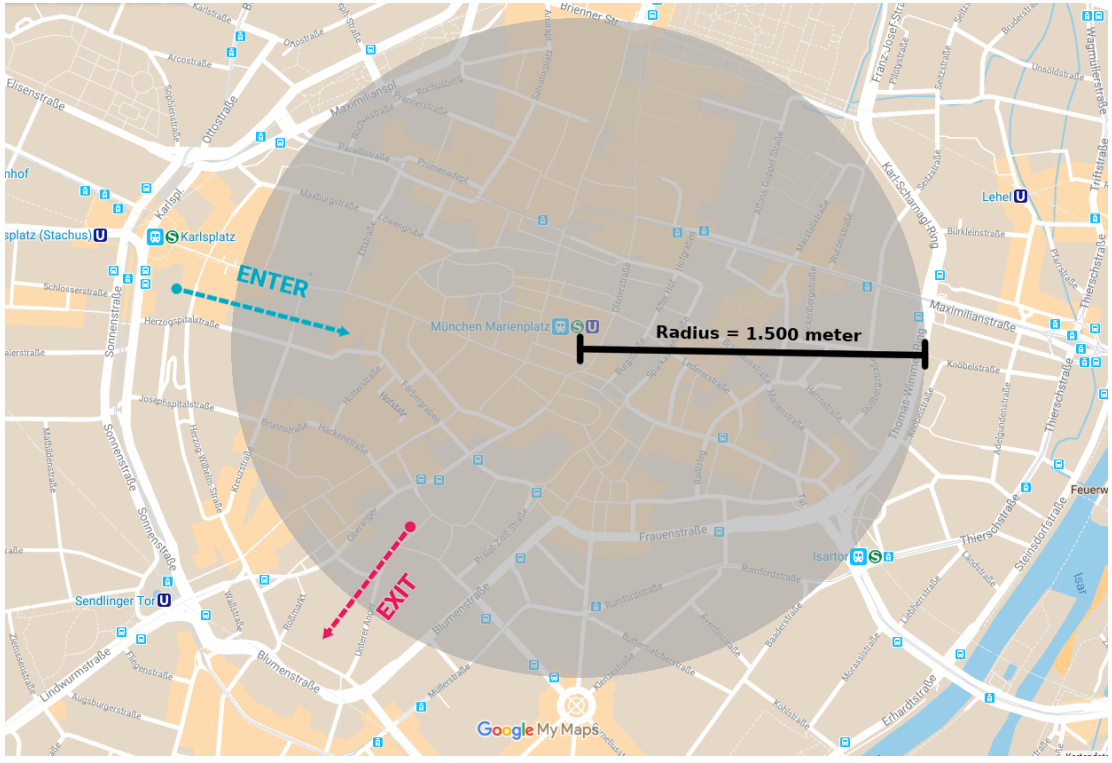
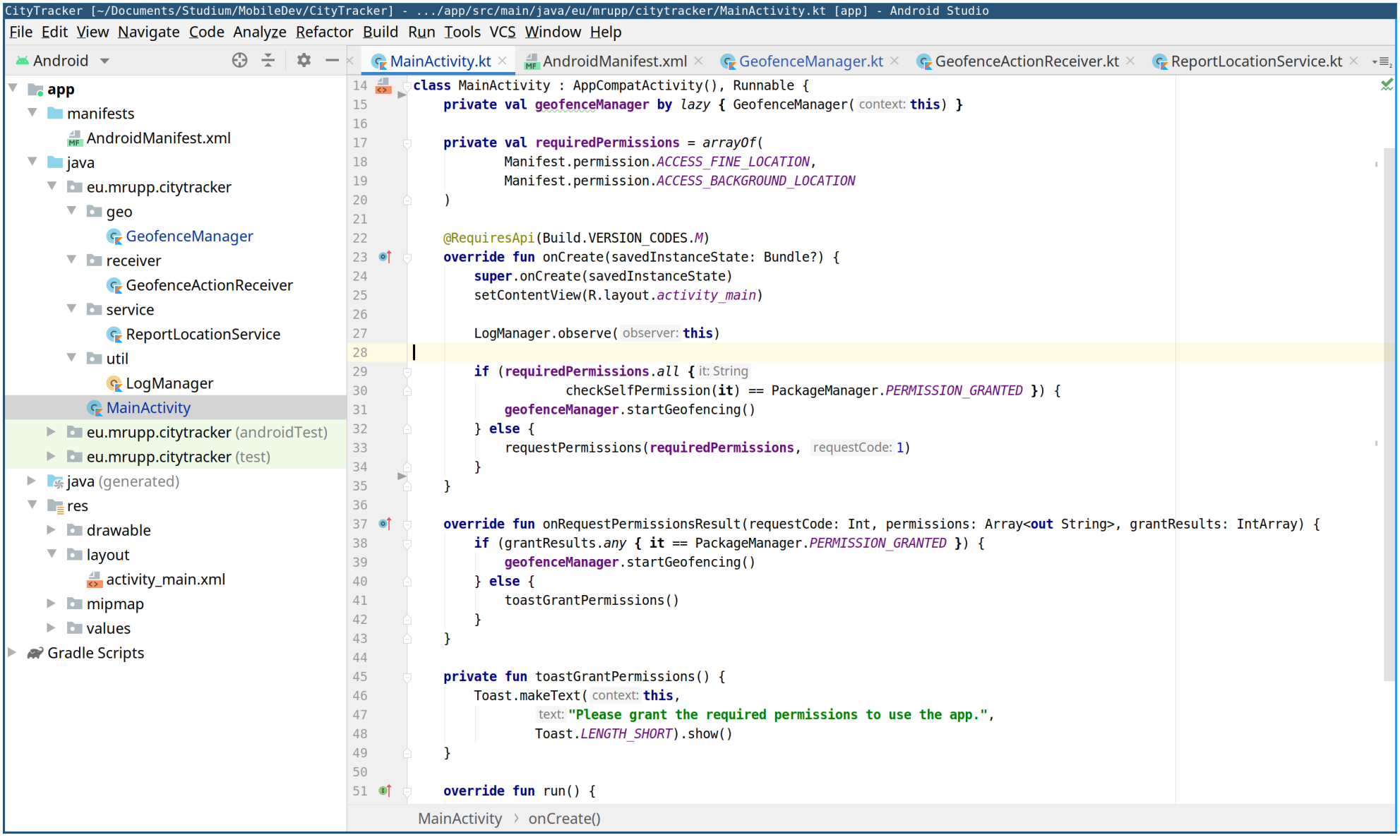


Figure: Our Geofence


CityTracker [~/Documents/Studium/MobileDev/CityTracker] - .../app/src/main/java/eu/mrupp/citytracker/MainActivity.kt [app] - Android Studio
File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help
Android
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manifests
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java
eu.mrupp.citytracker
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GeofenceActionReceiver
service
ReportLocationService
util
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MainActivity
eu.mrupp.citytracker (androidTest)
eu.mrupp.citytracker (test)
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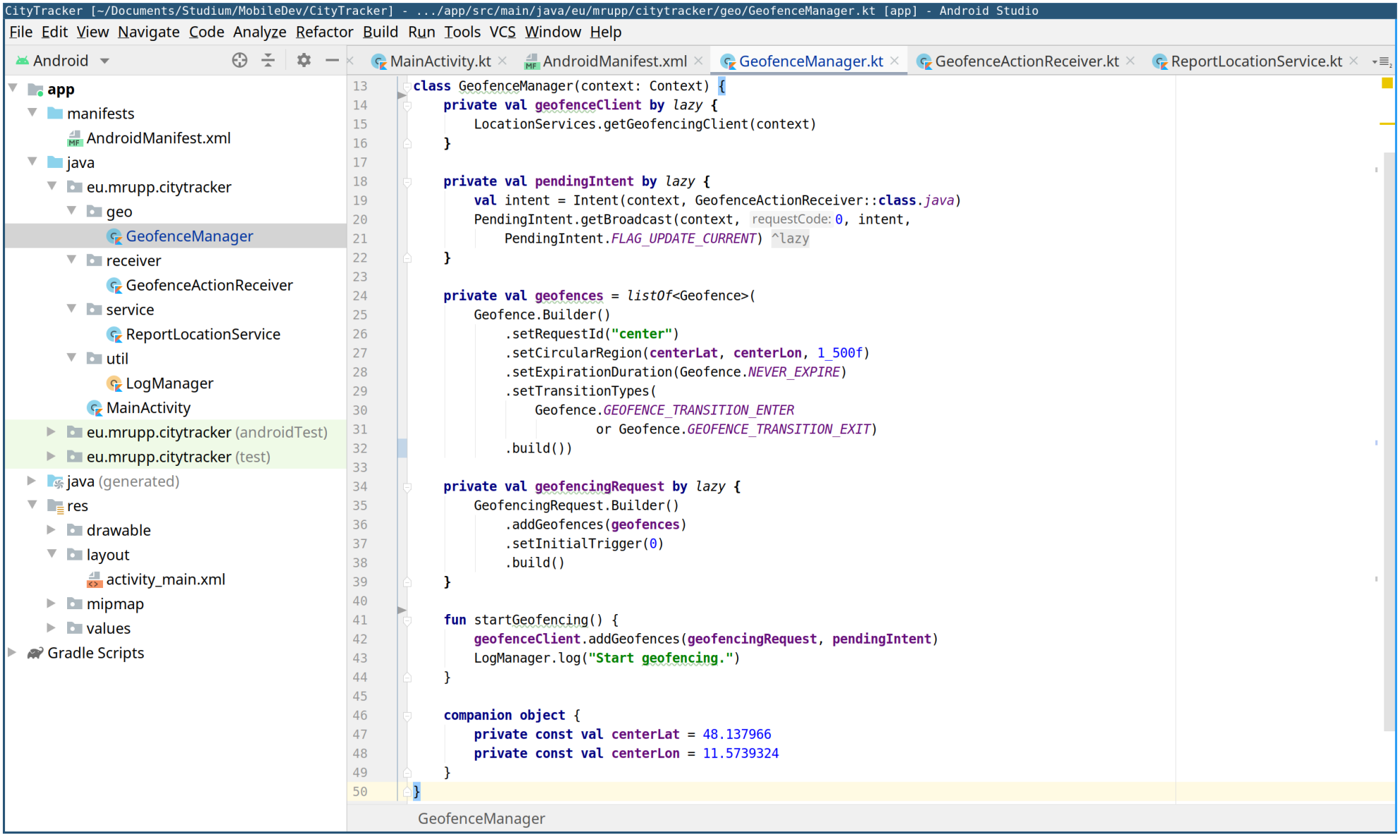
res
drawable
layout
activity_main.xml
mipmap
values
Gradle Scripts
MainActivity.kt
AndroidManifest.xml
GeofenceManager.kt
GeofenceActionReceiver.kt
ReportLocationService.kt
class MainActivity : AppCompatActivity(), Runnable {
private val geofenceManager by lazy { GeofenceManager(context: this) }
private val requiredPermissions = arrayOf(
Manifest.permission.ACCESS_FINE_LOCATION,
Manifest.permission.ACCESS_BACKGROUND_LOCATION
)
@RequiresApi(Build.VERSION_CODES.M)
override fun onCreate(savedInstanceState: Bundle?) {
super.onCreate(savedInstanceState)
setContentView(R.layout.activity_main)
LogManager.observe(observer: this)
if (requiredPermissions.all { it: String
checkSelfPermission(it) == PackageManager.PERMISSION_GRANTED }) {
geofenceManager.startGeofencing()
} else {
requestPermissions(requiredPermissions, requestCode: 1)
}
}
override fun onRequestPermissionsResult(requestCode: Int, permissions: Array<out String>, grantResults: IntArray) {
if (grantResults.any { it == PackageManager.PERMISSION_GRANTED }) {
geofenceManager.startGeofencing()
} else {
toastGrantPermissions()
}
}
private fun toastGrantPermissions() {
Toast.makeText(context: this,
text: "Please grant the required permissions to use the app.",
Toast.LENGTH_SHORT).show()
}
override fun run() {
MainActivity › onCreate()


CityTracker [~/Documents/Studium/MobileDev/CityTracker] - .../app/src/main/java/eu/mrupp/citytracker/geo/GeofenceManager.kt [app] - Android Studio
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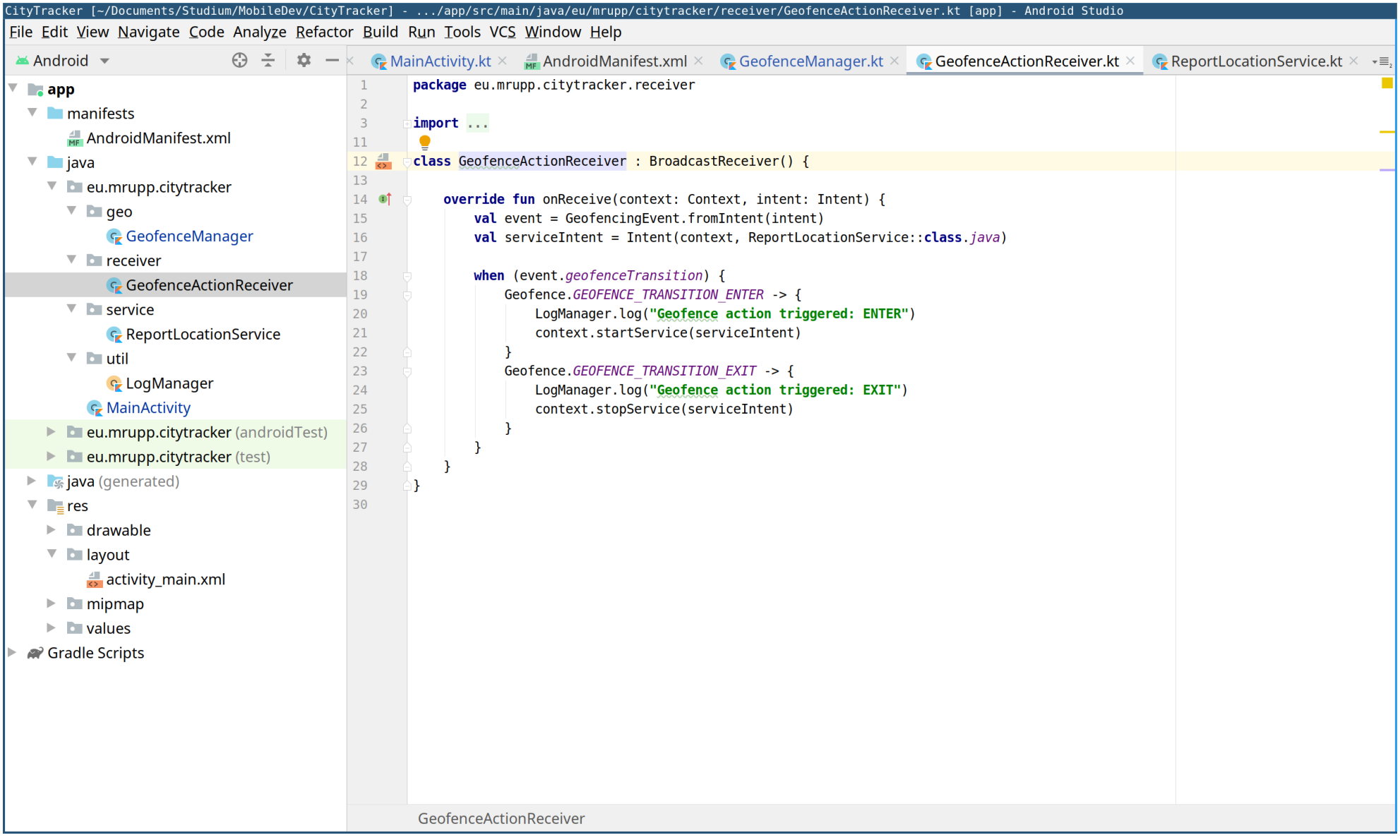
GeofenceActionReceiver.kt
ReportLocationService.kt
class GeofenceManager(context: Context) {
private val geofenceClient by lazy {
LocationServices.getGeofencingClient(context)
}
private val pendingIntent by lazy {
val intent = Intent(context, GeofenceActionReceiver::class.java)
PendingIntent.getBroadcast(context, requestCode: 0, intent,
PendingIntent.FLAG_UPDATE_CURRENT) ^lazy
}
private val geofences = listOf<Geofence>(
Geofence.Builder()
.setRequestId("center")
.setCircularRegion(centerLat, centerLon, 1_500f)
.setExpirationDuration(Geofence.NEVER_EXPIRE)
.setTransitionTypes(
Geofence.GEOFENCE_TRANSITION_ENTER
or Geofence.GEOFENCE_TRANSITION_EXIT)
.build())
private val geofencingRequest by lazy {
GeofencingRequest.Builder()
.addGeofences(geofences)
.setInitialTrigger(0)
.build()
}
fun startGeofencing() {
geofenceClient.addGeofences(geofencingRequest, pendingIntent)
LogManager.log("Start geofencing.")
}
companion object {
private const val centerLat = 48.137966
private const val centerLon = 11.5739324
}
}
GeofenceManager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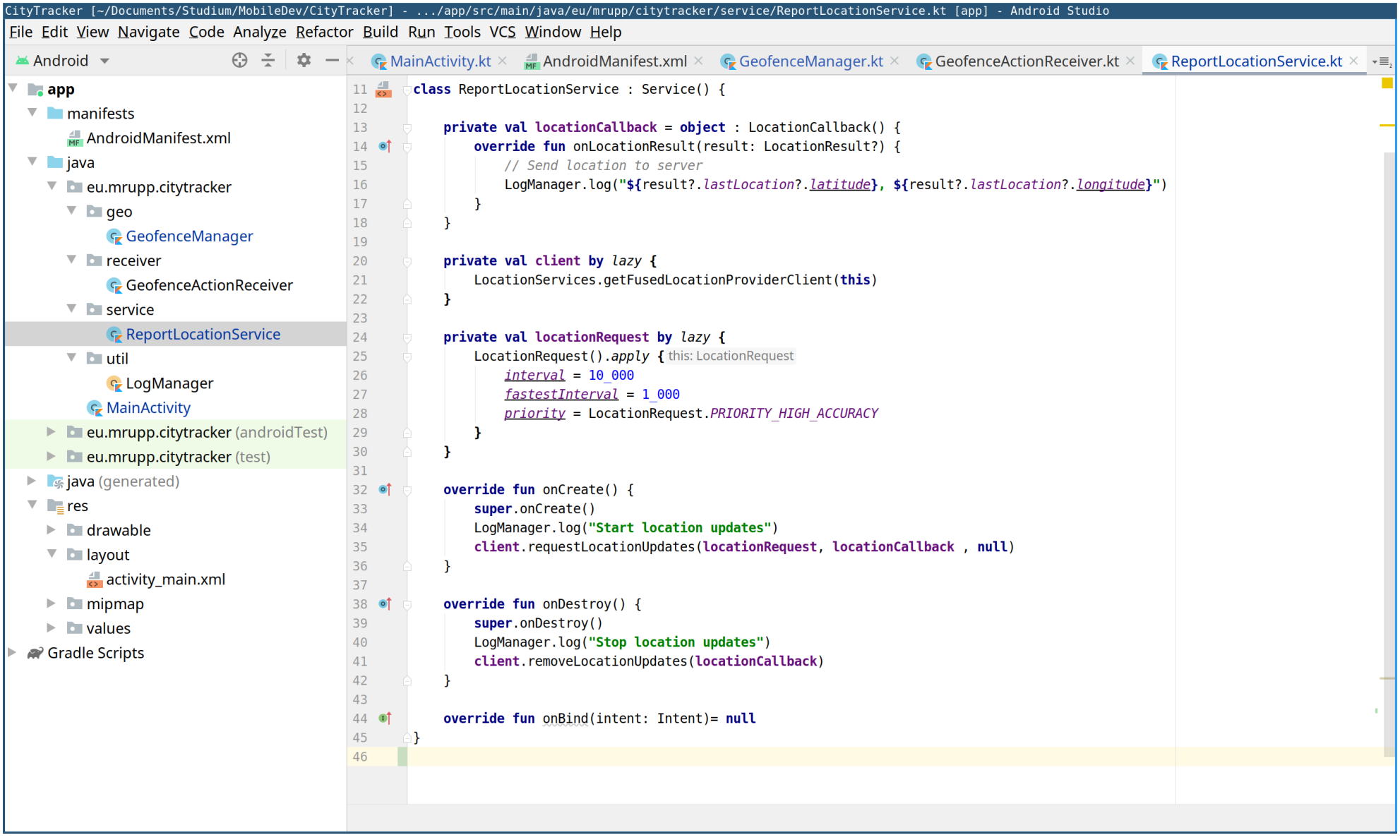
GeofenceActionReceiver.kt
ReportLocationService.kt
1 package eu.mrupp.citytracker.receiver
2
3 import ...
11
12 class GeofenceActionReceiver : BroadcastReceiver() {
13
14 override fun onReceive(context: Context, intent: Intent) {
15 val event = GeofencingEvent.fromIntent(intent)
16 val serviceIntent = Intent(context, ReportLocationService::class.java)
17
18 when (event.geofenceTransition) {
19 Geofence.GEOFENCE_TRANSITION_ENTER -> {
20 LogManager.log("Geofence action triggered: ENTER")
21 context.startService(serviceIntent)
22 }
23 Geofence.GEOFENCE_TRANSITION_EXIT -> {
24 LogManager.log("Geofence action triggered: EXIT")
25 context.stopService(serviceIntent)
26 }
27 }
28 }
29 }
30
GeofenceActionReceiver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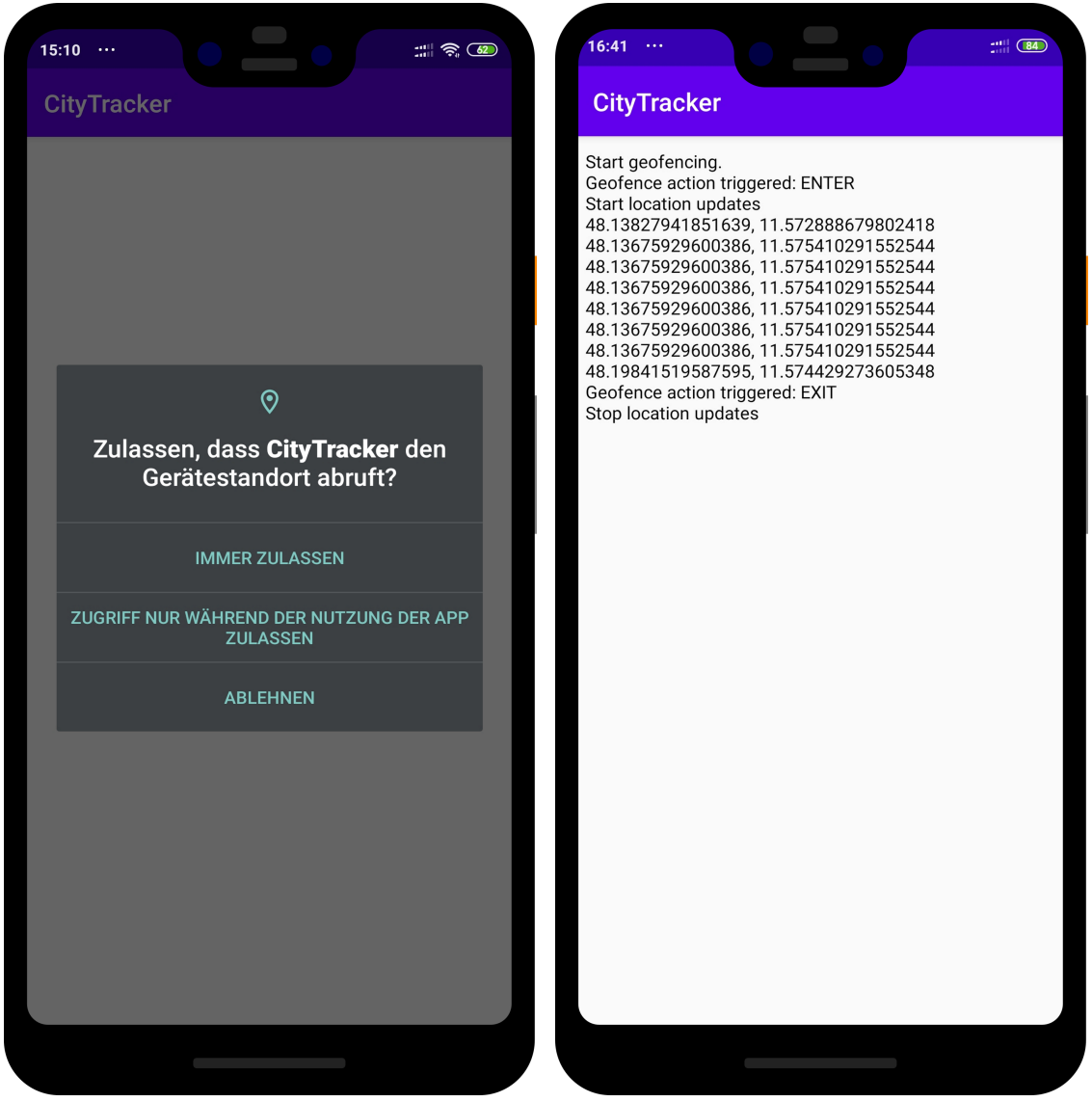
ReportLocationService.kt
class ReportLocationService : Service() {
private val locationCallback = object : LocationCallback() {
override fun onLocationResult(result: LocationResult?) {
// Send location to server
LogManager.log("${result?.lastLocation?.latitude}, ${result?.lastLocation?.longitude}")
}
}
private val client by lazy {
LocationServices.getFusedLocationProviderClient(this)
}
private val locationRequest by lazy {
LocationRequest().apply { this: LocationRequest
interval = 10_000
fastestInterval = 1_000
priority = LocationRequest.PRIORITY_HIGH_ACCURACY
}
}
override fun onCreate() {
super.onCreate()
LogManager.log("Start location updates")
client.requestLocationUpdates(locationRequest, locationCallback , null)
}
override fun onDestroy() {
super.onDestroy()
LogManager.log("Stop location updates")
client.removeLocationUpdates(locationCallback)
}
override fun onBind(intent: Intent)= null
}

App Example



(a) (b)

App

https://github.com/mobileappdevhm20/CityTracker

Summary

- Important feature for android development
- Android provides many different possibilities to implement location awareness
- Keep the battery usage in mind and use the best practices
- Pay attention to the access guidelines

References

- https://developer.android.com/training/location
- https://developers.google.com/location-context/fused-location-provider
- https://thehill.com/policy/technology/259655-quarter-of-all-android-apps-ask-for-gps-data
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