

Asynchrónnosť corutiny

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MS-Teams: [2sf3ph4](#), [List](#), [github](#)
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Kap. ... ~~A Basic Overview of Threads and AsyncTasks~~

Kap. 61. An Introduction to Kotlin Coroutines

Kap. 62. An Android Kotlin Coroutines Tutorial



Asynchrónnosť corutiny

nabudúce

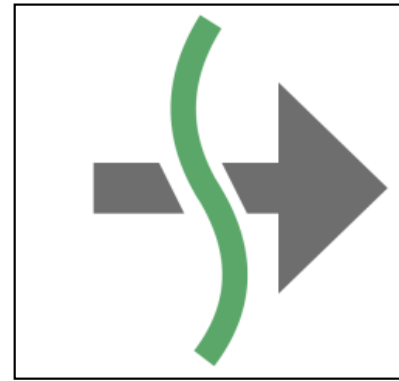
AsyncTask
Retrofit
RoomDB

Coroutines

- channel
- flow
- Shared state
 - Atomická premenná
 - prepínanie kontextov
 - mutex

na Cvičení

Asynchronnosť



- je vážny problém

- ako vykonávať niečo, čo môže dlho trvať, napr. výpočet, simuláciu ... **thread/vlákn**o, a eventuálne...
- čo ak potrebujeme výsledok tohoto procesu pre ďalší svoj výpočet ... **čakanie na výsledok**

- v rôznych jazykoch sa rieši rôzne

- Javascript: **callback** vedie k tzv. callback hell
- Java: **Thread**, FutureTask, RxJava
- GO: **go rutiny**, kanály, ...
- Android: **AsyncTask** (donedávna, ale dnes už je AsyncTask Deprecated)

! This class was deprecated in API level 30.
! Use the standard `java.util.concurrent` or [Kotlin concurrency utilities](#) instead.

- v Kotline od verzie 1.3 existuje koncept **corutiny** (nie go-rutiny :)

- nie je to len knižnica/package
- ale je to súčasť jazyka, Kotlin obsahuje kľúčové slová (napr. **suspend**, **async**)
- podpora IDE

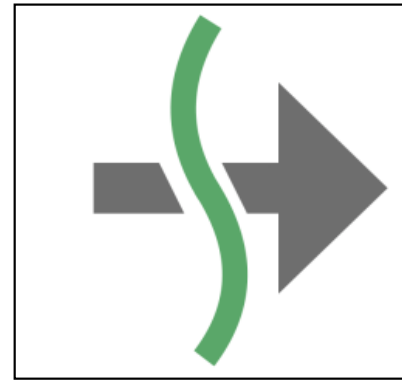


- lepšie môžeme pochopiť koncept corutín bez Android prostredia

- IntelliJ – projekt Coroutines1 obsahuje ~30 malých gradujúcich Kotlin-corutín príkladov

Asynchronnosť

(obsah cvičenia)



- súvisiace problémy - ako **zdieľať dáta** medzi konkurentne bežiacimi kódmi
 - posilať **agresívne** – zodpovedá koncept kanálu (trieda **Channel<T>**)
 - do značnej miery zodpovedá kanálu v jazyku GO (asi aj tam sa inšpirovali...)
 - je dravý/eager/**hot** – to čo do neho napíšete, to sa dá prečítať...
 - posilať **lenivo** – zodpovedá koncept toku (trieda **Flow<T>**)
 - do značnej miery zodpovedá **generátorom z jazyka Python**, resp. **lazy listom** z Haskellu
 - je lenivý/lazy/**cold** – začne sa do neho písať, len až sa niekto zaujíma o hodnoty, a niekto ich chce čítať
- môj “vážny” terminologický problém
 - píše sa to coroutine (EN)
 - ale v SK coroutina, corutina, korutina ???

Callback je cesta do pekla 😊

čo je callback ?

```
fun getValueAsync(onCompletion: (R) -> Unit) {  
    val result = getValue() // toto trvá dlho ...  
    onCompletion(result)  
}
```

Callback je pointer na inú procedúru, ktorá sa má vykonať, keď sa dopočíta dlho trvajúci výpočet

```
getValueAsync() {  
    result -> print(result)  
}
```

čo je callback hell (pojem známy z Javascript) ?

```
1 // Callback Hell  
2  
3  
4 a(function (resultsFromA) {  
5     b(resultsFromA, function (resultsFromB) {  
6         c(resultsFromB, function (resultsFromC) {  
7             d(resultsFromC, function (resultsFromD) {  
8                 e(resultsFromD, function (resultsFromE) {  
9                     f(resultsFromE, function (resultsFromF) {  
10                         console.log(resultsFromF);  
11                     })  
12                 })  
13             })  
14         })  
15     })  
16 });  
17
```

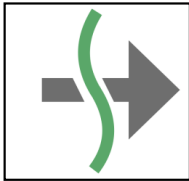
callback hell
pri sekvenčnom volaní
viacerých dlho-trvajúcich
procedúr dôjde ku
kaskádovému vnoreniu kódu

Callback vs Promises vs Async Await

<https://www.loginradius.com/blog/async/callback-vs-promises-vs-async-await/>

Kotlin suspend function

podpora v jazyku



```
suspend fun getValue(): R { // procedúra trvá dlho ...  
    val result = getValue()    // toto trvá dlho ...  
    return result              // vráti hodnotu  
}
```

corutina - funkcia označená **suspend** - jej výpočet môže trvať dlho

```
launch { // coroutine scope  
    val res = getValue()  
    print(res)  
}
```

v coroutine scope (oblasť corutiny) môžeme volať iné **suspend** funkcie

coroutine scope

```
launch {  
    val res = getValue()    // trvá..  
    val nextRes = getNextValue(res)  
    val nextNextRes = getNextNextValue(nextRes)  
    print(nextNextRes)  
}
```

Corutiny umožňujú písať

- elegantne,
- asynchrónny kód,
- bez vnárania kódu
- bez javu *callback hell*

aj sekvenciu takých funkcií, nevzniká callback-hell



Corutina

suspend fun – alias corutina je funkcia, ktorej výpočet môže dlho trvať z akýchkoľvek dôvodov. Takáto funkcia NESMIE byť vykonávaná v hlavnom GUI vlákne aplikácie, inak task manager zavrie aplikáciu, ak nereaguje na UI eventy

Taká **suspend fun** funkcia/výpočet sa púšťa v tzv. coroutine scope.

Výpočet corutiny v coroutine scope

- môže trvať (I/O, DB, NETWORK, scientific computation, simulácia čohosi)
- môže byť pozastavený bez toho, aby sa to dotklo hlavného vlákna
- viaceré corutiny môžu bežať konkurentne v rôznych vláknach

```
launch {  
    val res = getValue()  
    val nextRes = getNextValue(res)  
    print(nextRes)  
}
```

```
launch {  
    val res = getValue()  
    val nextRes = getNextValue(res)  
    print(nextRes)  
}
```



Corutina

- je odľahčené vlákno <https://kotlinlang.org/docs/reference/coroutines/basics.html#coroutines-are-light-weight>
- non-preemptive multitasking
- 1958 zaviedli ich Donald Knuth a Melvin Conway, *trochu* predbehli dobu...
- vyskytujú sa v iných jazykoch, C#, javascript, continuation-passing style
- ale nemajú podporu jazyka (len ako knižnice)

suspend je modifikátor funkcie, ktorá sa vykonávaná v coroutine scope, a preto môže byť pozdržaná

await() je čaká na hodnotu výpočtu bez blokovania coroutiney.

```
fun main() = runBlocking {  
    repeat(100_000) { // launch 10^5 coroutines  
        launch {  
            delay(5000L) // wait 5s.  
            print(".")  
        }  
    }  
}
```


Kotlin Academy

<https://kt.academy/workshop/coroutines>

Kotlin Coroutines

Register

This is a 2-day workshop for experienced developers, that covers asynchronous programming in Kotlin using coroutines. It covers both build-in support for coroutines and dives deep into `kotlinx.coroutines` library.

At the workshop you will



Learn from lecture supported by slides



Solve coding challenges



Complete practical exercises



Solve puzzles

- Styles of concurrence
- Understanding how suspension works
- Coroutine Context
- Coroutine builders
- Coroutine Scope
- Dispatchers
- Structured concurrency
- Understanding Job
- Cancellation
- Exception handling
- Coroutine Scope Functions
- Constructing Coroutine Scope
- Shared mutable state and concurrency
- Testing Kotlin Coroutines
- Channels
- Actors
- Flow
- Flow processing
- Select expression
- UI programming with coroutines
- Reactive streams with coroutines

Marcin Moskala

Kotlin Coroutines

DEEP DIVE



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Async/Await in Python

Mali by ste poznať z Python 3.7 +

```
import asyncio
```

```
async def coroutine1():  
    task = asyncio.create_task(coroutine2())  
    await task  
    print(1)
```

```
async def coroutine2():  
    print(2)  
    await asyncio.sleep(1)
```


```
asyncio.run(coroutine1())  
print("finito")
```

??? Čo mám s tým kódom urobiť, aby som dostal
požadovaný výstup ??

```
=====
1
2
finito
>>>
=====
2
1
finito
>>>
```

Hádanka 1

neobsahuje corutinu ale stream (Java StreamAPI)

```
fun main() {  
    println("Start")  
    val list = listOf(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)  
    val newList = list.stream()  
  
    .map {    
        Thread.sleep(1000)  
        it*it // return it * it  
    }  
    println("End")  
    newList.forEach { // výpis kolekcie  
        println(it)  
    }  
}
```

`Stream.of(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)`

```
08:59:32.832 Start  
08:59:32.834 End   Start+0sec.  
08:59:33.839 1      +1sec.  
08:59:34.841 4      +2sec.  
08:59:35.842 9  
08:59:36.844 16  
08:59:37.846 25  
08:59:38.849 36  
08:59:39.851 49  
08:59:40.854 64  
08:59:41.856 81  
08:59:42.858 100
```

stream bez .collect() je *lenivá* kolekcia

Hádanka 2

neobsahuje corutinu ale stream (Java StreamAPI)

```
fun main() {  
    println("Start")  
    val newList = Stream.of(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)  
        .map {  
            Thread.sleep(1000)  
            it*it  
        }.collect(Collectors.toList())  
    println("End")  
    newList.forEach { // výpis kolekcie  
        println(it)  
    }  
}
```

```
09:02:23.363 Start  
09:02:33.389 End   Start+10sec.  
09:02:33.389 1      +0sec.  
09:02:33.389 4      +0sec.  
09:02:33.389 9  
09:02:33.389 16  
09:02:33.389 25  
09:02:33.389 36  
09:02:33.390 49  
09:02:33.390 64  
09:02:33.390 81  
09:02:33.390 100
```

Hádanka 3

neobsahuje corutinu ale stream (Java StreamAPI)

```
fun main() {  
    println("Start")  
    val newList = (1..10).toList()  
        .parallelStream() ←  
        .map {  
            Thread.sleep(1000)  
            it*it  
        }  
        .collect(Collectors.toList())  
    println("End")  
    newList.forEach { // výpis kolekcie  
        println(it)  
    }  
}  
  
parallelStream používá  
toľko paralelizmu, koľko je #cores  
Runtime.getRuntime()  
.availableProcessors() == 8
```

? (1..100) ?

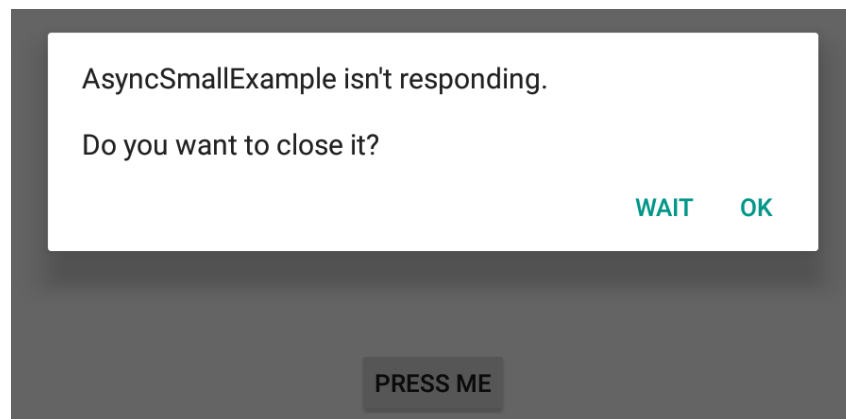
```
8  
09:04:06.410 Start  
09:04:09.420 End   Start+3sec.  
09:04:09.420 1      +0sec.  
09:04:09.420 4      +0sec.  
09:04:09.420 9  
09:04:09.420 16  
09:04:09.420 25  
09:04:09.420 36  
09:04:09.421 49  
09:04:09.421 64  
09:04:09.421 81  
09:04:09.422 100
```

Asynchrónne operácie

trochu androidu

- nie je možné robiť časovo náročné operácie v hlavnom vlákne aplikácie
 - extra komplikovaný (matematický) výpočet
 - simuláciu procesu spomaľovanú napr. `Thread.sleep(...)`
 - dlho trvajúce požiadavky (napr. IO/http/sql-request)
- takýto kód zablokuje hlavné vlákno, a ak vyvoláte GUI eventy (napr. pohnutím klikaním v priebehu 20s), správca aplikácií usúdi, že aplikácia je mŕtva zavrie ju

```
fun buttonClick(view: View) {  
    for (i in 0..20) {  
        try {  
            Thread.sleep(1000) // zabije  
                               // hlavné vlákno  
        }  
        catch (e: Exception) {  
            e.printStackTrace()  
        }  
    }  
}
```





Async Task

(doInBackground)

Parametrizovaná trieda AsyncTask je thread-wrapper a rieši problém, existuje od API-3

typ parametrov, type progresu, typ výsledku

```
private inner class MyTask : AsyncTask<String, Int, String>() {
```

pred {
 override fun onPreExecute() {...} // vykoná sa pred doInBackground
 // celé jadro toho, čo sa má vykonávať v extra vlákne

vo vlákne →
 override fun doInBackground(vararg params: String): String {
 while (i in 0..10) {
 try {
 Thread.sleep(1000)
 publishProgress(i) // Counter = \$i
 } catch (e: Exception) { ... }
 return "Button Pressed"
 }
 }

počas {
 override fun onProgressUpdate(vararg values: Int?) { ... }

po
 override fun onPostExecute(result: String) {...} // po doInBackground.
}



Async Task

(onPre/PostExecute)

```
private inner class MyTask : AsyncTask<String, Int, String>() {  
    var color : Int = Color.BLACK  
    override fun onPreExecute() {  
        color = ... Random Color ...  
    }  
  
    override fun doInBackground(vararg params:String):String {  
        // varargs je variabilný počet argumentov, ako ... v Java  
  
        override fun onProgressUpdate(vararg values: Int?) {  
            myTextView.setTextColor(color) // beží v main thread  
            val counter = values.get(0)  
            myTextView.text = "Counter = $counter"  
        }  
  
        override fun onPostExecute(result:String) { "Button Pressed"  
            myTextView.setTextColor(color)  
            myTextView.text = result  
        }  
    }  
}
```



```
AsyncTask<String, Int, String>() {
```

Async Task

(spustenie)

'constructor AsyncTask<Params : Any!, Progress : Any!, Result : Any!>()' is deprecated. Deprecated in Java

kotlin kotlin.kotlin_builtins

public final class String : Comparable<String>, CharSequence

The String class represents character strings. All string literals in Kotlin programs, such as "abc", are implemented as instances of this class.

Gradle: org.jetbrains.kotlin:kotlin-stdlib:1.3.31

Štandardne sa rôzne inštancie AsyncTask spúšťajú sériovo, kým nedobehne jedna, ostatné čakajú vo fronte, blokujú sa...

```
val task1 = MyTask().execute() // serial run of AsyncTask
...vyskúšaj...
```

Ak ich chceme spustiť viaceru a paralelne, tak cez POOL_EXECUTOR

```
task = MyTask().executeOnExecutor(AsyncTask.THREAD_POOL_EXECUTOR)
...vyskúšaj...
```

Ale počet paralelne bežiacich AsyncTaskov je limitovaný, v závislosti od počtu jadier CPU

```
val cpu_cores = Runtime.getRuntime().availableProcessors()
```

Reálne väčším problémom, že napriek popularite a jednoduchosti používania AsyncTask je od Android 11 AsyncTask zastaralý (*deprecated*)

https://www.xda-developers.com/asynctask-deprecate-android-11/amp/?_twitter_impression=true

Z toho zatiaľ nie je jasné, či ho Google odstráni, ale ...

! This class was deprecated in API level 30.

! Use the standard java.util.concurrent or Kotlin concurrency utilities instead.

AsyncSmallExample.zip



Alternatívy

Kotlin - corutiny

Čo je alternatíva:

- RxJava-library (Reactive Externsion) observable.subscribe(...
- Java's Concurrency framework - ForkJoinPool
- Kotlin coroutines od verzie Kotlin 1.3

build.gradle:

- `implementation`

`"org.jetbrains.kotlinx:kotlinx-coroutines-core:1.4.1"`

import

- `import kotlinx.coroutines.*`

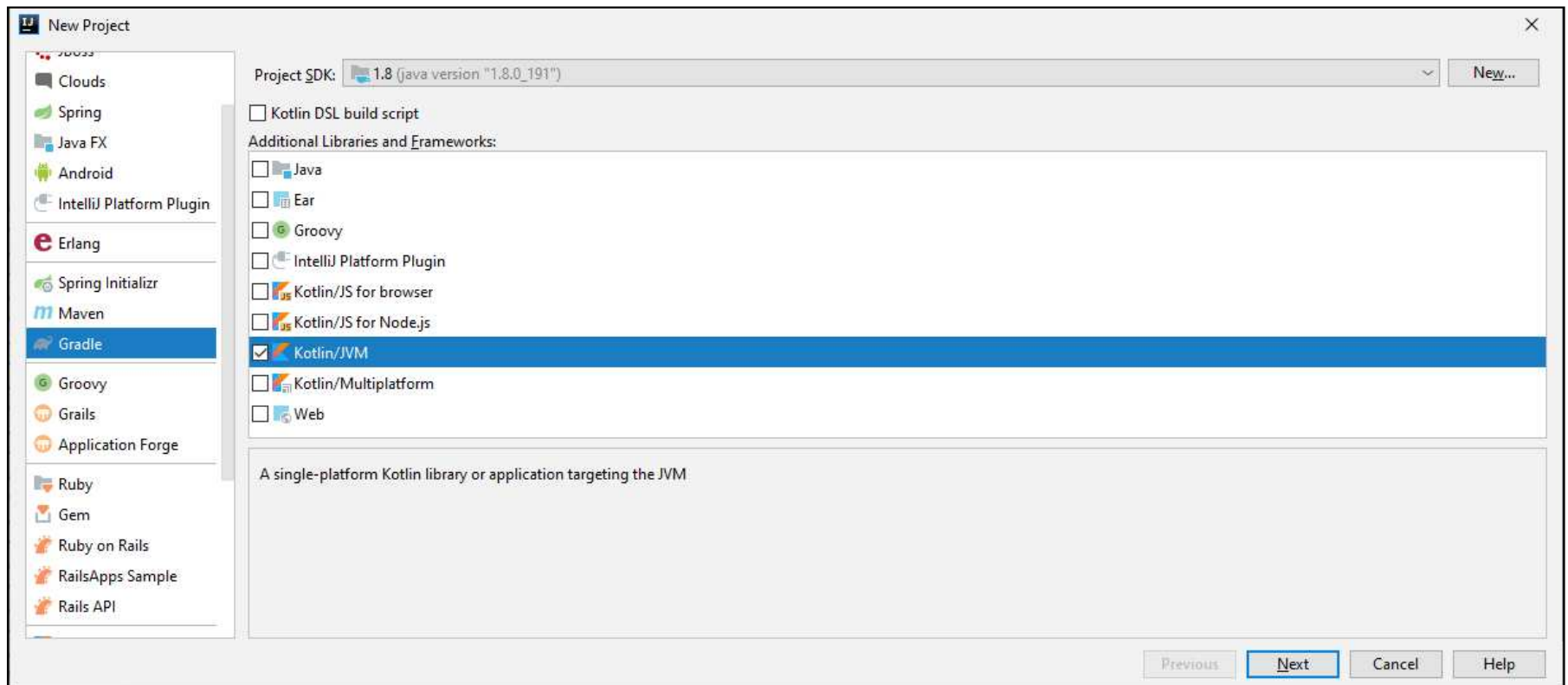
first-touch tutorial:

- <https://kotlinlang.org/docs/coroutines-basics.html>

IntelliJ/Gradle/KotlinJVM1.8

IntelliJ

- koncept corutiny je zložitý dosť na to ho študovať separátne, bez androidového okolia,
- ale ukážeme aj použitie corutín v reálnych Android aplikáciach, časom...
- V IntelliJ si vytvorte Gradle project/KotlinJVM



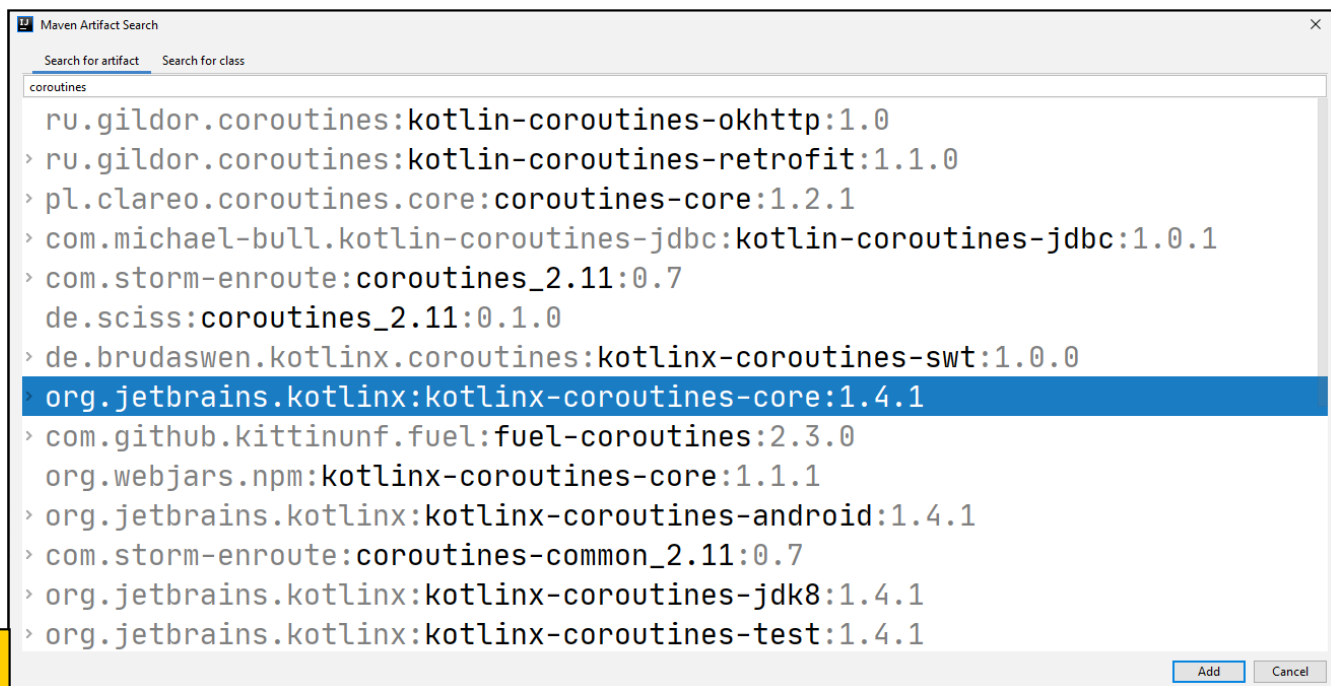
Pridanie Coroutine dependencies do build.gradle

- na súbore build.gradle (app), right click/Generate/Add Maven Artifact dependencies/Search for artifacts:"coroutines", vyber
- org.jetbrains.kotlinx-coroutines-core:1.*.1

```
dependencies {  
    implementation "org.jetbrains.kotlin:kotlin-stdlib-jdk8"  
    compile 'org.jetbrains.kotlinx:kotlinx-coroutines-core:1.4.1'  
}
```

nechajte syncovať
gradle, ~60sec.

Alebo si importujte
projekt Coroutines1





Corutina

(Spustenie – blokujúce, neblokujúce)

- .launch** spustí novú corutinu a neblokuje hlavné vlákno
- .corutina delay(ms)** pozastaví výpočet corutiny na ms..
- .runBlocking** spustí novú corutinu a blokuje hlavné vlákno

```
suspend fun delay(timeMillis: Long)
```

```
Log.d(TAG, "Start")
GlobalScope.launch { // Start a coroutine, non-blocking
    delay(1000)        // wait 1s.
    Log.d(TAG, "Hello")
}
Thread.sleep(3000)    // wait for 3s.
Log.d(TAG, "Stop")
runBlocking {         // Start a coroutine, blocking
    delay(4000)
}
Log.d(TAG, "Finish")
```

```
21:22:18.220 Start
21:22:19.225 Hello   Start+1sec.
21:22:21.222 Stop    Start+3sec.
21:22:25.225 Finish  Start+7sec.
```



Corutina

(Spustenie – blokujúce, neblokujúce)

.join počká na dokončenie spustenej corutiny/jobu

```
println("Start")
→ val job:Job = GlobalScope.launch { // Start a non-blocking
    delay(1000)                        // wait 1s.
    println("Hello")
}
Thread.sleep(3000)                    // wait for 3s.
println("Stop")
runBlocking {                          // Start a blocking
→   job.join()                        // waiting until job finishes
}
println("Finish")
```

```
interface Job
suspend fun join()
```

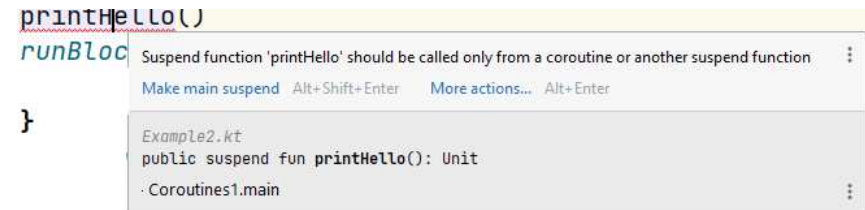
16:29:18.408	Start	
16:29:19.498	Hello	Start+1sec.
16:29:21.484	Stop	Start+3sec.
16:29:21.496	Finish	Start+3sec.

Corutina

(suspend)

- corutina/suspend fun môže byť volaná len z coroutine scope
- corutina/suspend fun môže volať inú corutinu/suspend fun (napr. delay)

```
Log.d(TAG, "Start")
printHello()
runBlocking {
    printHello()
}
Log.d(TAG, "Finish")
```



→ suspend fun printHello() {
 delay(1000L)
 Log.d(TAG, "Hello")
}

21:27:34.083	Start	
21:27:35.089	Hello	Start+1sec.
21:27:35.089	Finish	Start+1sec.



GlobalScope/launch/delay

```
import kotlinx.coroutines.GlobalScope
import kotlinx.coroutines.delay
import kotlinx.coroutines.launch
```

```
fun main() {
    GlobalScope.launch {
        "world!".forEach {
            delay(200)
            print(it)
        }
    }
    print("Hello, ")
    Thread.sleep(2000)
}
```

// Start a non-blocking

```
12:46:15.811 Start
12:46:15.878 Hello,
12:46:16.106 w
12:46:16.318 o
12:46:16.519 r
12:46:16.721 l
12:46:16.924 d
12:46:17.130 !
12:46:17.882 Stop
```




Corutina

(suspend)

```
Log.d(TAG, "Start main")
```

```
→ GlobalScope.launch {  
    Log.d(TAG, "Start background")  
    delay(1000L)  
    Log.d(TAG, "Finish background")  
}  
Log.d(TAG, "Continue main")
```

```
→ runBlocking {  
    delay(2000L)  
    Log.d(TAG, "Stop main")  
}
```

```
12:54:03.422 Start main  
12:54:03.491 Continue main  
12:54:03.495 Start background  
12:54:04.501 Finish background  
12:54:05.513 Stop main
```



Corutina

(async/await)

```
12:59:07.099 Start main
12:59:07.175 Awaiting computations...
12:59:08.192 Computation1 finished
12:59:09.188 Computation2 finished
12:59:09.188 The result is 3
12:59:09.189 Stop main
```

.async spustí novú corutinu, ktorá počíta nejaký výsledok
.await čaká na tento výsledok

```
runBlocking { // deferred=odložený/oneskorený výsledok
    val result1:Deferred<Int> = async { computation1() }
    val result2:Deferred<Int> = async { computation2() }
    Log.d(TAG, "Awaiting computations...")
    val result = result1.await() + result2.await()
    Log.d(TAG, "The result is $result")
} }

suspend fun computation1(): Int {
    delay(1000L) // simulated computation
    Log.d(TAG, "Computation1 finished")
    return 1 }

suspend fun computation2(): Int {
    delay(2000L)
    Log.d(TAG, "Computation2 finished")
    return 2 }
```

```
16:32:10 Start main
16:32:10 Awaiting computations...
16:32:11 Computation1 finished
16:32:12 Computation2 finished
16:32:12 The result is 3
16:32:12 Stop main
```

Corutina

(cancel)

```
14:23:50.411 Start main
14:23:50.488 Processing 0 ...
14:23:51.499 Processing 1 ...
14:23:52.513 Processing 2 ...
14:23:53.520 Processing 3 ...
14:23:54.534 Processing 4 ...
14:23:55.546 Processing 5 ...
14:23:56.554 Processing 6 ...
14:23:57.568 Processing 7 ...
14:23:58.582 Processing 8 ...
14:23:59.597 Processing 9 ...
14:24:00.490 main: The user requests the cancellation
14:24:00.505 main: The batch is cancelled
```

```
runBlocking {
    → val job = launch { // Emulate some batch processing
        repeat(30) { i ->
            Log.d(TAG, "Processing $i ...")
            delay(1000L)
        }
    }
    delay(10000L)
    Log.d(TAG, "main: The user requests the cancellation")
    → job.cancelAndJoin()
        // cancel the job and wait for it's completion
    Log.d(TAG, "main: The batch is cancelled")
}
```



Corutina

(withTimeout)

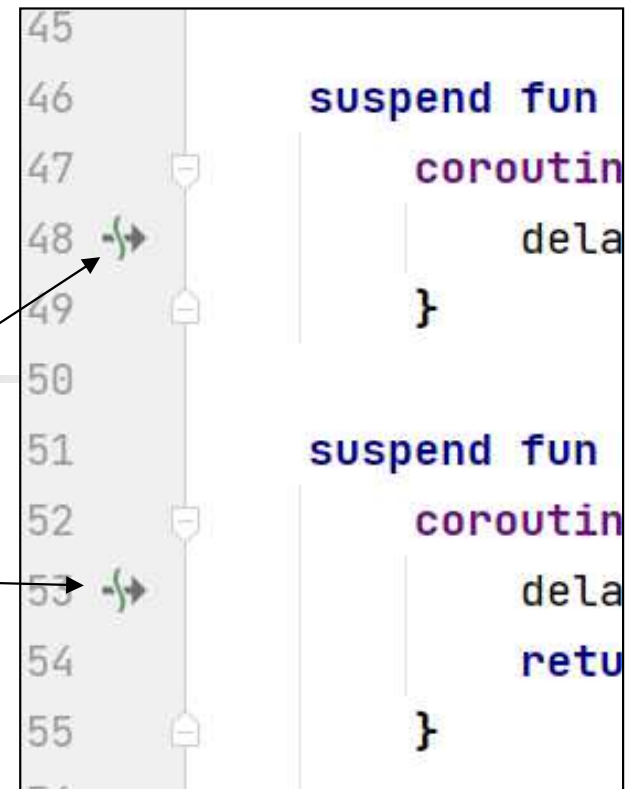
```
14:28:58.109 Start main
14:28:58.192 Processing 0 ...
14:28:59.205 Processing 1 ...
14:29:00.214 Processing 2 ...
14:29:01.227 Processing 3 ...
14:29:02.239 Processing 4 ...
14:29:03.249 Processing 5 ...
14:29:04.262 Processing 6 ...
14:29:05.267 Processing 7 ...
14:29:06.280 Processing 8 ...
14:29:07.293 Processing 9 ...
14:29:08.194 The processing return status is: null
```

```
runBlocking {
    → val status = withTimeoutOrNull(10000L) {
        repeat(30) { i ->
            Log.d(TAG, "Processing $i ...")
            delay(1000L)
        }
        "Finished"
    }
    Log.d(TAG, "The processing return status is: $status")
}
```

Kotlin Coroutines

praktické použitie

- Coroutines:
 - už tušíme základy
 - majú podporu v AS aj IntelliJ IDE
- MVVM
 - download image
 - processing image, image filter, ...
- Retrofit
 - download json
 - upload json
- Coroutines ďalšie koncepty – asi na cviku, na pidi príkladoch...
triedy
 - Flow
 - Channel
- Room database – na budúce
 - lokálna SQL databáza
 - DAO – data access object



```
45
46 suspend fun
47     coroutine
48     dela
49 }
50
51 suspend fun
52     coroutine
53     dela
54     retu
55 }
```



Dispatchers

vlákna, v ktorých môžu bežať corutiny, tzv. **CoroutineDispatcher**

- **Dispatchers.Main** - hlavné Android vlákno, interaguje s UI, pre ľahšie operácie
- **Dispatchers.IO** - vlákno optimalizované na sieťové IO mimo hlavného vlákna

hlavné použitie:

- databázové operácie
- I/O, čítanie/písanie do súborov
- sieťové veci (http requests, ...)

- **Dispatchers.Default** – vlákno optimalizované pre CPU intenzívne operácie mimo hlavného vlákna

hlavné použitie:

- ťažké výpočty, matematické výpočty, simulácie, triedenie zoznamov, ...
- spracovanie väčších dát

Corutiny

v Android projekte

build.gradle

```
dependencies {
    implementation 'org.jetbrains.kotlinx:kotlinx-coroutines-core:1.5.0'
    implementation 'org.jetbrains.kotlinx:kotlinx-coroutines-android:1.5.0'
}

import do *.kt
import kotlinx.coroutines.*

val cCount = 10 // počet corutín
fun launchCoroutines(view: View) { // onClickListerner pre Button
    (1..cCount).forEach {
        Log.d(TAG, "$it")
        begins.append("<$it")
        CoroutineScope(Dispatchers.Main).launch {
            val result: Deferred<String> = async { perform2(it) }
            ends.append(result.await()) ←
        }
    }
}

suspend fun perform2(corIndex: Int): String {
    delay(Random.nextLong(5_000))
    return "$corIndex>"
}
```

CorutineSmallExample

11 coroutines

<1<2<3<4<5<6<7<8<9<10<11

1>6>10>7>11>8>3>9>2>5>4>

LAUNCH COROUTINES

CorutineSmallExample.zip

async/await

```
fun launchCoroutines(view: View) {  
    (1..cCount).forEach {  
        Log.d(TAG, "$it")  
        begins.append("<$it")  
        CoroutineScope(Dispatchers.Main).launch(Dispatchers.Main) {  
            ends.append(perform3(it).await())  
        }  
    }  
}
```



```
suspend fun perform3(corIndex: Int): Deferred<String> =  
    CoroutineScope(Dispatchers.Main).async {  
        delay(Random.nextLong(5_000))  
        return@async ">$corIndex"  
    }
```

CoroutineSmallExample

11 coroutines

<1<2<3<4<5<6<7<8<9<10<11

>11>8>7>4>9>5>2>6>10>1>3

LAUNCH COROUTINES

async/await

```
fun launchCoroutines(view: View) {
    (1..cCount).forEach {                // spustí cCount corutín
        Log.d(TAG, "$it")
        begins.append("<$it")
        CoroutineScope(Dispatchers.Main).launch {
            perform1(it)
            ends.append("$it>")
        }
    }
}

suspend fun perform1(corIndex: Int) {
    delay(1_000)
    val x = CoroutineScope(Dispatchers.Main).async {
        val duration = Random.nextLong(2_000)
        delay(duration)
        duration                // vráti hodnotu, koľko spala
    }.await()                  ← // prečíta hodnotu z corutiny
    Log.d(TAG, "$corIndex has duration $x")
    delay(Random.nextLong(3_000))
}
```

```
10:28:06.613 : 1
10:28:06.680 : 2
10:28:06.681 : 3
10:28:06.682 : 4
10:28:06.683 : 5
10:28:06.684 : 6
10:28:07.809 : 2 has duration 70
10:28:07.987 : 1 has duration 251
10:28:08.014 : 6 has duration 276
10:28:08.760 : 4 has duration 1023
10:28:09.575 : 3 has duration 1838
10:28:09.676 : 5 has duration 1938
```

Image download

from url

- download image from URL, image processing
- <http://dai.fmph.uniba.sk/courses/VMA/ISLAND2.JPG>, 5.5 MB
- <http://dai.fmph.uniba.sk/courses/VMA/NikonRaw.NEF>, 20 MB
- <https://dai.fmph.uniba.sk/courses/VMA/Quebec.tif>, 50MB

```
CoroutineScope(Dispatchers.Main).launch { ← Main
    val originalImage = async(Dispatchers.IO) { ← IO
        URL(IMAGE_URL).openStream().use { // download image from URL
            BitmapFactory.decodeStream(it)
        }
    }
    // wait for complete download of an image
    val originalBitmap = originalImage.await()
    imageView.setImageBitmap(originalBitmap) // show original image
    val filteredImage = async(Dispatchers.Default) { ← Default
        toBlackAndWhite(originalBitmap)
    }
    // wait for processing image
    val filteredBitmap = filteredImage.await()
    progressBar.visibility = View.GONE
    imageView.setImageBitmap(filteredBitmap)
    imageView.visibility = View.VISIBLE
}
```



Process Image

spracovanie Bitmap – nepodstatné z pohľadu corutín ...

- image processing – hodí sa do cvičenia...

```
fun toBlackAndWhite(source: Bitmap): Bitmap {  
    val w = source.width  
    val h = source.height  
    val bitmapArray = IntArray(w*h)  
    source.getPixels(bitmapArray, 0, w, 0, 0, w, h) // array from source  
    (0 until h).forEach { y->  
        (0 until w).forEach { x->  
            val index = x+y*w // index in 2D-matrix  
            val R = Color.red(bitmapArray[index])  
            val G = Color.green(bitmapArray[index])  
            val B = Color.blue(bitmapArray[index])  
            val grey = (R + G + B)/3  
            bitmapArray[index] = Color.rgb(grey, grey, grey)  
        }  
    }  
    val bitmapOut = Bitmap.createBitmap(w, h, Bitmap.Config.RGB_565)  
    bitmapOut.setPixels(bitmapArray, 0, w, 0, 0, w, h) // bitmap  
    bitmapOut // return bitmap  
}
```

ClearText HTTP Problem

no longer in Android9+ – nepodstatné z pohľadu corutín

- `java.io.IOException: Cleartext HTTP traffic to dai.fmph.uniba.sk not permitted`

Starting with Android 9 (API level 28), cleartext support is disabled by default...

- **Option 1:** URL with "https://" instead of "http://"

```
private val IMAGE_URL = https://dai.fmph.uniba.sk/courses/VMA/ISLAND2.JPG
```

- **Option 2:** Pridaj `network_security_config` link do AndroidManifest.xml:

```
<manifest>
    <uses-permission android:name="android.permission.INTERNET" />
    <application
        android:networkSecurityConfig="@xml/network_security_config,"
```

vytvor súbor `res/xml/network_security_config.xml` obsahujúci:

- ```
<?xml version="1.0" encoding="utf-8"?>
<network-security-config>
 <base-config cleartextTrafficPermitted="true">
 <trust-anchors>
 <certificates src="system" />
 </trust-anchors>
 </base-config>
</network-security-config>
```

- **Option 3:** Pridaj do AndroidManifest.xml:

```
<application
 android:usesCleartextTraffic="true"
```



# Kotlin Coroutines

praktické použitie

---

- Coroutines:
  - už tušíme základy
- Download big image
  - download image
  - processing image, image filter, ...
- Retrofit + MVVM
  - download json
  - upload json
- Room database
  - lokálna SQL databáza
  - DAO – data access object

# Retrofit



- Retrofit je REST klient pre Android
- zjednodušuje download & upload JSON (cez HTTP GET/POST)
- používa napr. Gson converter
- build.gradle treba doplniť o

```
implementation 'com.squareup.retrofit2:retrofit:2.6.2'
implementation 'com.squareup.retrofit2:converter-gson:2.6.2'
```

- data class zodpovedajúci JSONu (mapovanie na json tagy):

```
data class Stat (
 @SerializedName("name") /* -> */ val countryName: String?,
 @SerializedName("capital") /* -> */ val capital: String?,
 @SerializedName("flagPNG") /* -> */ val flag: String?,
 @SerializedName("latlng") /* -> */ val latlng: Array<Float>?,
 @SerializedName("borders") /* -> */ val borders: List<String>?,
 @SerializedName("alpha3Code") /* -> */ val code: String?
)
```

- REST API pre Retrofit

```
interface StatInterface {
 @GET("vlajky/staty.json")
 suspend fun get(): Response<List<Stat>>
}
```

<https://dai.fmph.uniba.sk/courses/VMA/vlajky/staty.json>

# Coroutines+MVVM+Retrofit

(model)

<https://dai.fmph.uniba.sk/courses/VMA/vlajky/staty.json>

```
data class Stat(
 @SerializedName("name") /* -> */ val countryName: String?,
 @SerializedName("capital") /* -> */ val capital: String?,
 @SerializedName("flagPNG") /* -> */ val flag: String?,
 @SerializedName("latlng") /* -> */ val latlng: Array<Float>?,
 @SerializedName("borders") /* -> */ val borders: List<String>?,
 @SerializedName("alpha3Code") /* -> */ val code: String?
)
```

```
/*
{
 "alpha2Code": "SK",
 "alpha3Code": "SVK",
 "altSpellings": [
 "SK",
 "Slovak Republic",
 "Slovensk\u00e1 republika"
],
 "area": 49037,
 "borders": [
 "AUT",
 "CZE",
 "HUN",
 "POL",
 "UKR"
],
 "callingCodes": [
 "421"
],
 "capital": "Bratislava",
 "currencies": [
 {
 "code": "EUR",
 "name": "Euro",
 "symbol": "\u20ac"
 }
],
 "demonym": "Slovak",
 "flagPNG":
 "https://dai.fmph.uniba.sk/courses/VMA/vlajky/svk.png",
 "gini": 26.0,
 "languages": [
 {
 "iso639_1": "sk",
 "iso639_2": "slk",
 "name": "Slovak",
 "nativeName": "sloven\u010dina"
 }
],
 "latlng": [
 48.6666666666,
 19.5
],
 "name": "Slovakia",
 "nativeName": "Slovensko",
 "numericCode": "703",
 "population": 5426252,
 "region": "Europe",
 "regionalBlocs": [
 {
 "acronym": "EU",
 "name": "European Union"
 }
],
 "subregion": "Eastern Europe",
 "timezones": [
 "UTC+01:00"
],
}
```

# Coroutines+MVVM+Retrofit

(REST API - model)

```
interface StatInterface {
 @GET("vlajky/staty.json")
 suspend fun get(): Response<List<Stat>>
}

object StatService {
 private val BASE_URL = "https://dai.fmph.uniba.sk/courses/VMA/"

 fun get(): StatInterface =
 Retrofit.Builder()
 .baseUrl(BASE_URL)
 .addConverterFactory(GsonConverterFactory.create())
 .build()
 .create(RetroInterface::class.java)
 }
}
```



# Coroutines+MVVM+Retrofit

(viewmodel)

```
class ListViewModel: ViewModel() {
 val service = StatService.get()
 lateinit var job: Job
 val staty = MutableLiveData<List<Stat>>()

 fun fetch() {
 job = CoroutineScope(Dispatchers.IO)
 .launch {
 val response = service.get() // : Response<List<Stat>>
 withContext(Dispatchers.Main) {
 if (response.isSuccessful)
 staty.value = response.body()
 else
 Log.d("MODEL", "Error: ${response.message()}")
 }
 }
 }
 override fun onCleared() {
 super.onCleared()
 job.cancel()
 }
}
```

# Coroutines+MVVM+Retrofit

(view)

```
class MainActivity : AppCompatActivity() {
 lateinit var viewModel: ListViewModel
 private val listAdapter = ListAdapter(arrayListOf())
 override fun onCreate(savedInstanceState: Bundle?) {
 super.onCreate(savedInstanceState)
 setContentView(R.layout.activity_main)
 viewModel = ViewModelProviders.of(this).get(ListViewModel::class.java)
 viewModel.fetch()
 listView.apply {
 layoutManager = LinearLayoutManager(context)
 adapter = listAdapter
 }
 observeViewModel()
 }
 fun observeViewModel() {
 viewModel.staty.observe(this, Observer { staty ->
 staty?.let { // if staty != null ...
 countriesList.visibility = View.VISIBLE
 listAdapter.updateCountries(it)
 }
 })
 }
}
```



# Glide

- List adaptér používa Glide na čítanie obrázkov z URL
- <https://medium.com/@vlonjatgashi/using-glide-with-kotlin-5e345b557547>
- build.gradle:

```
apply plugin: 'kotlin-kapt' // kotlin anotation processing tool

dependencies {
 implementation 'com.github.bumptech.glide:glide:4.4.0'
 kapt 'com.github.bumptech.glide:compiler:4.4.0'
}
```

- kód:

```
import com.bumptech.glide.Glide

val options=RequestOptions().error(R.mipmap.ic_launcher_round)
Glide.with(imageView)
 .setDefaultRequestOptions(options)
 .load(country.flag)
 .into(imageView)
```



# Glide

jednoduché demo

```
Glide.with(this)
 .load(IMAGE_URL)
 .into(imageView)
```

```
CoroutineScope(Dispatchers.Main).launch {
 Glide.with(this@MainActivity)
 .asBitmap()
 .error(R.mipmap.ic_launcher_round)
 .load(IMAGE_URL)
 .into(object : CustomTarget<Bitmap>() {
 override fun onResourceReady(
 resource: Bitmap,
 transition: Transition<in Bitmap>?) {
 val filteredBitmap = toBlackAndWhite(resource)
 progressBar.visibility = View.GONE
 imageView.setImageBitmap(filteredBitmap)
 imageView.visibility = View.VISIBLE
 }
 override fun onLoadCleared(placeholder: Drawable?) { }
 })
}
```



# GSM-Retrofit

<https://eu1.unwiredlabs.com/v2/process.php>

```
{
 "token": "95b2941777892d",
 "mcc": 231,
 "mnc": 2,
 "cells": [{
 "lac": 1,
 "cid": 31441
 }],
 "address": 1
}
```

```
{
 "status": "ok",
 "balance": 97,
 "lat": 48.14875,
 "lon": 17.06679,
 "accuracy": 837,
 "address": "Botanická, Švédske
domky, Bratislava, Karlova Ves,
Bratislava, Region of Bratislava, 841
04, Slovakia"
}
```

V prednáške o polohe sme narazili  
na problém, že GSM súradnice prekladá do lat-long servis

- potrebujeme mu poslať a prečítať json-dáta, cez HTTP-POST
  - ak zavrhneme riešenie, že "lepíme reťazce" do JSON a vyhladávame v ňom podstringy, ...
  - riešenie založené na json knižnici `android.util.JsonReader/JsonWriter` (ukážeme)
  - riešenie založené na Gson knižnici (konvertuje json do objektu cez Java reflection model)
- nesmieme to robiť v hlavnom vlákne, lebo to môže trvať...
  - riešenie pomocou AsyncTask (old-school)
  - corutinovské riešenie (new-wave)

ako zo vzorky JSON to vyrobiť Kotlin Class ?

- build.gradle

# Výměna dát so serverom

Výměna dát klient-server

- cez parametre GET/POST requestu,
- cez obsah POST requestu,
- cez cookies - nebude



uvidíme:

- cez JSON objekt
  - `pomocou org.json.*`
  - `pomocou com.google.gson.*`
- cez xml formát
  - `pomocou org.xml.sax.*;`
  - <http://dai.fmph.uniba.sk/courses/java2/sl/xml.pdf>





# LocationAPI.org

```
D/MyGSMLocation(19361): gsm cid: 396517
D/MyGSMLocation(19361): gsm lac: 1001
D/MyGSMLocation(19361): operator:23102
D/MyGSMLocation(19361): network: 23102
D/MyGSMLocation(19361): mcc: 231
D/MyGSMLocation(19361): mnc: 2
```

- zaregistrujete sa napr. na 7-dňový trial, max. 50 requests/day
- dostanete kľúč (token), 95b2941777892d (keď toto čítate, asi už neplatí ☹)
- skúste 95b2941777892d (7.dec 2017).

<http://locationapi.org/site/page?view=apiv2>

Request: **1 cell** | 3 cells | 7 cells

```
1 {
2 "token": "1445573628",
3 "mcc": 231,
4 "mnc": 2,
5 "cells": [{
6 "cid": 396517,
7 "lac": 1001,
8 "signal": -60,
9 "tA": 13
10 }]
11 }
```

Response:

```
1 {
2 "status": "ok",
3 "balance": 45,
4 "lat": 48.16802,
5 "lon": 17.11049,
6 "accuracy": 1063,
7 "message": "Accuracy is in BETA!"
8 }
```

## API v2 Documentation

1. [Usage](#)
2. [Test it out](#)
3. [Request body](#)
4. [Response body](#)
5. [Example Script - PHP](#)
6. [Example Script - Python](#)

### Usage

Requests are sent using POST to the following url:

<http://locationapi.org/v2/process.php>

# LocationAPI z aplikácie

- potrebujeme urobiť http-POST request na <http://locationapi.org/v2/process.php>
- keďže to niečo trvá, nesmieme to robiť v hlavnom vlákne – AsyncTask
- do tela dotazu (requestu) potrebujeme zakódovať (cellID, lac, mcc, mnc + môj token) hoc jednoduchý, ale predsa-len JSON objekt
- z tela odpovede (responzu) potrebujeme dekodovať hoc jednoduchý, ale JSON objekt, t.j. prečítať latitude-longitude

Request: 1 cell | 3 cells | 7 cells

```
1 {
2 "token": "1445573628",
3 "mcc": 231,
4 "mnc": 2,
5 "cells": [{
6 "cid": 396517,
7 "lac": 1001,
8 "signal": -60,
9 "tA": 13
10 }]
11 }
```

Response:

```
1 {
2 "status": "ok",
3 "balance": 45,
4 "lat": 48.16802,
5 "lon": 17.11049,
6 "accuracy": 1063,
7 "message": "Accuracy is in BETA!"
8 }
```



# Vytvorenie (malého) JSON objektu

(pre GET LocationAPI)

```
val sw = StringWriter()
```

```
val jw = JsonWriter(sw)
```

```
try {
```

```
 jw.beginObject() -- {
```

```
 jw.name("token").value(token_locationAPIORG)
```

```
 jw.name("mcc").value(mcc)
```

```
 jw.name("mnc").value(mnc)
```

```
 jw.name("cells")
```

```
 jw.beginArray() -- [
```

```
 .beginObject() -- {
```

```
 jw.name("cid").value(cid)
```

```
 jw.name("lac").value(lac)
```

```
 jw.name("signal").value(-60)
```

```
 jw.name("tA").value(13)
```

```
 jw.endObject().endArray().endObject().close() -- }] }
```

```
import android.util.JsonWriter
```

Request: 1 cell | 3 cells | 7 cells

```
1 {
2 "token": "1445573628",
3 "mcc": 231,
4 "mnc": 2,
5 "cells": [{
6 "cid": 396517,
7 "lac": 1001,
8 "signal": -60,
9 "tA": 13
10 }]
11 }
```

Project:MyGSMLocation.zip

# Dekódovanie (malého) JSON

```
import android.util.JsonReader

val sr = StringReader(result)
val jr = JsonReader(sr)
jr.beginObject() -- {
 jr.nextName() -- skip: "status"
 jr.nextString() -- skip: "ok"
 jr.nextName() -- skip: "balance"
 jr.nextInt() -- skip: 45

 jr.nextName() -- skip: "lat"
 lat = jr.nextDouble()
 jr.nextName() -- skip: "lon"
 lng = jr.nextDouble()
 jr.nextName() -- skip: "accuracy"
 accur = jr.nextInt()
```

Response:

```
1 {
2 "status": "ok",
3 "balance": 45,
4 "lat": 48.16802,
5 "lon": 17.11049,
6 "accuracy": 1063,
7 "message": "Accuracy is in BETA!"
8 }
```

# GSON

(fromJson)

```
{
 "id": "1547257485",
 "name": "Peter Borovansky",
 "first_name": "Peter",
 "last_name": "Borovansky",
 "link": "http://www.facebook.com/
 peter.borovansky",
 "username": "peter.borovansky",
 "gender": "male",
 "locale": "cs_CZ"
}
```

Idea: k JSON objektu definujeme zodpovedajúcu (1:1) java triedu

Obmedzenia (viac <https://github.com/google/gson/blob/master/UserGuide.md>):

- mená JSON tagov sa musia zhodovať s java menami polí v triede

```
class FBHeader {
 public String id = "";
 public String name = "";
 public String first_name = "";
 public String last_name = "";
 public String link = "";
 public String username = "";
 public String gender = "";
 public String locale = "";
}
```

```
import com.google.gson
```

```
Gson gson = new GsonBuilder().create();
```

```
FBHeader header = gson.fromJson(jsonstring, FBHeader.class);
```



# FB Friends

(fromJson)

```
{ "data":
 [{ "name": "Zuzka B...", "id": "582749468" },
 { "name": "Lubica K...", "id": "583024903" },
 { "name": "Barbora F...", "id": "632007063" },
],
 "paging": { "next": "https://graph.facebook.com/15..." }
```

```
class FBFriends { // dvojica
 public FBPairs[] data = null;
 public FBPagination paging = null; }
class FBPairs { // dvojica
 public String name = "";
 public String id = ""; }
class FBPagination { // singleton
 public String next = ""; }
```

```
import com.google.gson
```

```
Gson gson = new GsonBuilder().create();
FBFriends friends = gson.fromJson(result, FBFriends.class);
if (friends != null) {
 if (friends.data != null)
 for (int i = 0; i < friends.data.length; i++)
 if (friends.data[i] != null)
 tv.append(friends.data[i].name + ",");
}
```

# GSON – ako to funguje ?

## Reflexivita

Ukázali sme

- `fromJson` (do Javy)
- ale analogicky funguje
- `toJson` (z Javy)

`org.json`

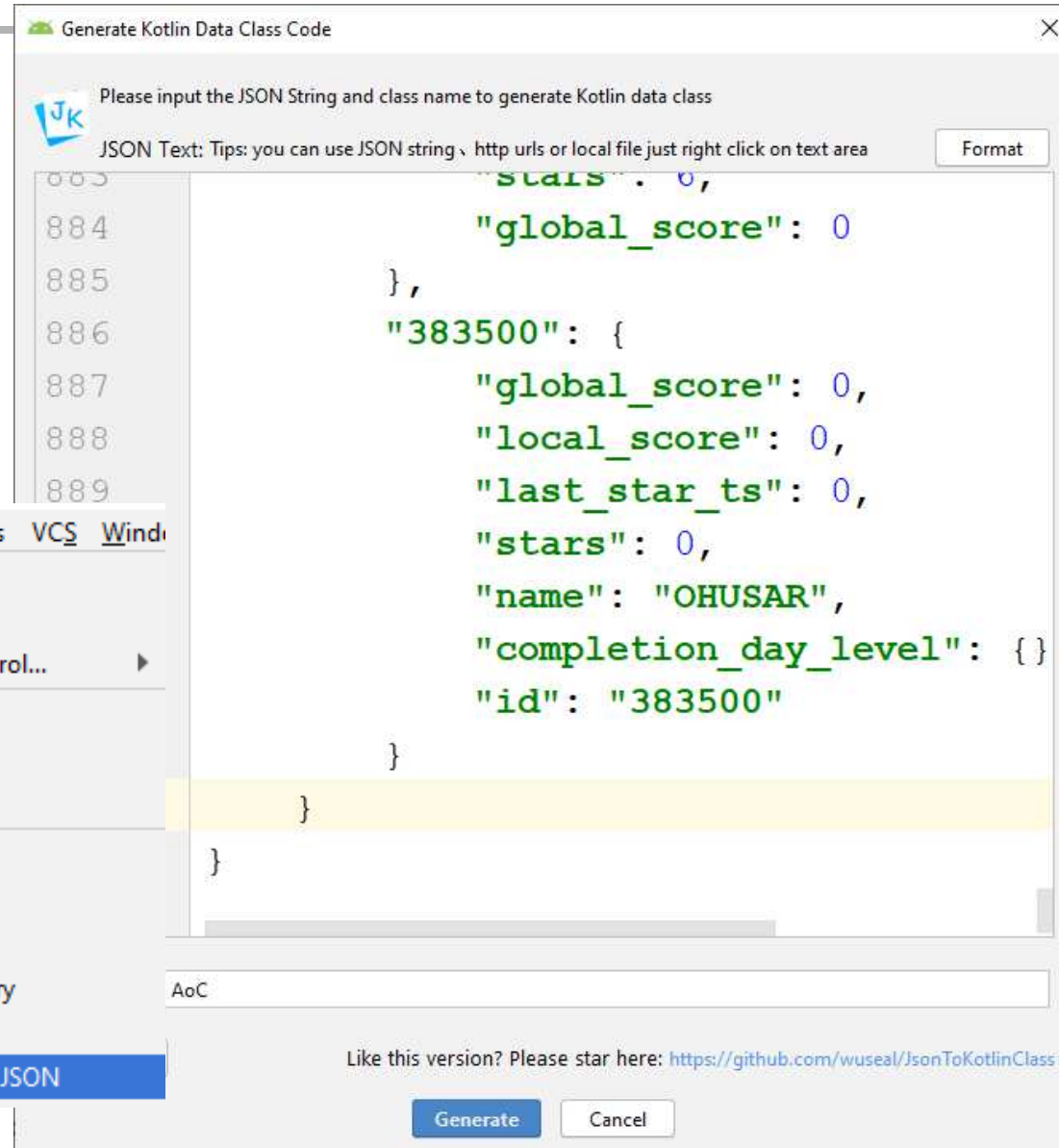
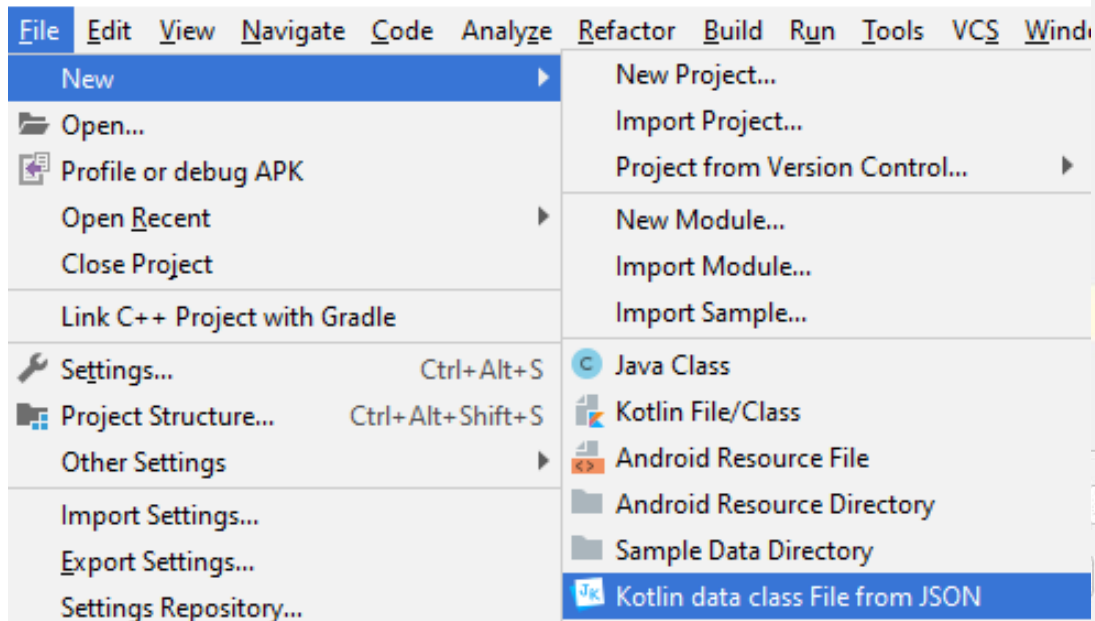
vs.

`com.google.gson`



# Plugin JSON to Kotlin Class

- z daného JSON vytvorí definíciu Kotlin tried
- potom stačí zavolať fromJson prekonvertuje vám json-string do dátovej štruktúry



# GSM-Retrofit

- JSON to Kotlin Class
- build.gradle

```
implementation 'com.google.code.gson:gson:2.8.5'
implementation 'com.squareup.retrofit2:retrofit:2.6.2'
implementation 'com.squareup.retrofit2:converter-gson:2.6.2'
```

- toto si dáme vygenerovať pluginom JSON to Kotlin Class

```
data class Cell(
 val cid: Int,
 val lac: Int
)
```

```
data class GSMRequest(
 val address: Int,
 val cells: List<Cell>,
 val mcc: Int,
 val mnc: Int,
 val token: String
)
```

ak interné mená zodpovedajú JSON tagom,  
tak neriešime `@SerializedName`

<https://eu1.unwiredlabs.com/v2/process.php>

```
{
 "token": "95b2941777892d",
 "mcc": 231,
 "mnc": 2,
 "cells": [{
 "lac": 1,
 "cid": 31441
 }],
 "address": 1
}
```

GSMRequest

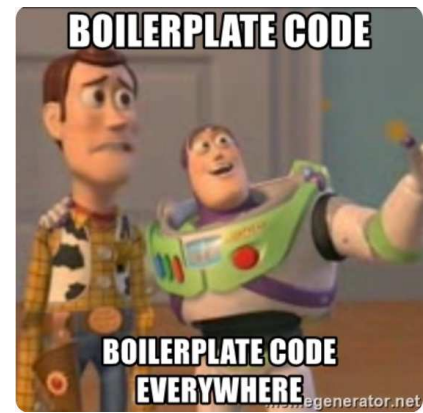
```
{
 "status": "ok",
 "balance": 97,
 "lat": 48.14875,
 "lon": 17.06679,
 "accuracy": 837,
 "address": "Botanická,
 Švédske domky, Bratislava,
 Karlova Ves, Bratislava,
 Region of Bratislava, 841 04,
 Slovakia"
}
```

GSMResponse

```
data class GSMResponse(
 val accuracy: Int,
 val address: String,
 val balance: Int,
 val lat: Double,
 val lon: Double,
 val status: String
)
```

GSMRetrofit





# Rest API

```
interface RestApiInterface {
 @Headers("Content-Type: application/json")
 @POST("process.php")
 fun gsm2latlong(@Body gsmRequest: GSMRequest): Call<GSMResponse>
}
```

```
class RestApiService {
 suspend
 fun gsm2latlong(gsmRequest: GSMRequest, onResult: (GSMResponse?) -> Unit){
 val retrofit = ServiceBuilder.get()
 retrofit.gsm2latlong(gsmRequest).enqueue(
 object : Callback<GSMResponse> {
 override fun onFailure(call: Call<GSMResponse>, t: Throwable) {
 onResult(null) ← null
 }
 override fun onResponse(call: Call<GSMResponse>,
 response: Response<GSMResponse>) {
 val resp = response.body() ← !=null
 onResult(resp)
 }
 }) } } }
```



# Service Builder



```
object ServiceBuilder {
 private val client = OkHttpClient.Builder().build()

 suspend
 fun get(): RestApiInterface =
 Retrofit.Builder()
 .baseUrl("https://eu1.unwiredlabs.com/v2/")
 .addConverterFactory(GsonConverterFactory.create())
 .client(client)
 .build()
 .create(RestApiInterface::class.java)
}
```

# Volanie - bez corutiny



```
val request = GSMRequest(
 token = "95b2941777892d",
 mcc = mcc,
 mnc = mnc,
 cells = listOf(Cell(lac = lac, cid = cid)),
 address = 1
)

val apiService = RestApiService()
val response = apiService.gsm2latlong(request) {
 response -> // toto je onResult
 if (response != null) {
 Log.d(TAG, "${response.lat}, ${response.lon}")
 latTV.text = response.lat.toString()
 longTV.text = response.lon.toString()
 } else
 Log.d(TAG, "response is null")
}
```

```
class RestApiService {
 suspend
 fun gsm2latlong(gsmRequest: GSMRequest,
 onResult: (GSMResponse?) -> Unit)
```

# Volanie – s corutinou

```
val request = GSMRequest(
 token = "95b2941777892d",
 mcc = mcc,
 mnc = mnc,
 cells = listOf(Cell(lac = lac, cid = cid)),
 address = 1
)
CoroutineScope(Dispatchers.IO).Launch {
 val apiService = RestApiService()
 val response = apiService.gsm2latlong(request) {
 response -> // toto je onResult
 if (response != null) {
 Log.d(TAG, "${response.lat}, ${response.lon}")
 latTV.text = response.lat.toString()
 longTV.text = response.lon.toString()
 } else
 Log.d(TAG, "response is null")
 }
}
```

```
class RestApiService {
 suspend
 fun gsm2latlong(gsmRequest: GSMRequest,
 onResult: (GSMResponse?) -> Unit)
```



# GUI len ako Dispatchers.Main

```
val request = GSMRequest(
 token = "95b2941777892d",
 mcc = mcc,
 mnc = mnc,
 cells = listOf(Cell(lac = lac, cid = cid)),
 address = 1
)
CoroutineScope(Dispatchers.IO).Launch {
 val apiService = RestApiService()
 val response = apiService.gsm2latlong(request) {
 response -> // toto je onResult
 if (response != null) {
 Log.d(TAG, "${response.lat}, ${response.lon}")
 CoroutineScope(Dispatchers.Main).Launch {
 latTV.text = response.lat.toString()
 longTV.text = response.lon.toString()
 }
 } else
 Log.d(TAG, "response is null")
 }
}
```