

# Mobile Computing

## Storing Data on Android

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Slides: [tmb.gr/mc-dat](http://tmb.gr/mc-dat)



# Overview

These slides show how to store app data on Android.

How to persist preferences and write to shared files.

How to use the *Room* database abstraction library.

How to get a *Flow* of changes to update the UI.

# Prerequisites

Have some basic knowledge of [writing Kotlin code](#).

Finish the lesson on [managing state on Android](#).

Bring your Android device or use the emulator.

# Data and file storage

[.html](#)

Android uses a file system offering these options:

App-specific storage, private data in internal files.

Shared preferences, small data in key-value pairs.

Shared storage, for documents that can be shared.

Databases, for private, relational application data.

# App-specific files

[.html](#)

Files that other apps don't need to or shouldn't access, stored in internal & encrypted or external directories, which are (both) removed when uninstalling the app.

```
context.openFileOutput(filename,  
    Context.MODE_PRIVATE  
) .use { it.write(fileContents.toByteArray()) }  
  
context.openFileInput(filename).bufferedReader(  
    ) .useLines { lines -> Log.v(lines) }
```

# Shared preferences

[.kt](#) | [.html](#)

*SharedPreferences* store key/value pairs in a file.\*

```
var score = 0 // a value to be persisted

val prefs = context.getSharedPreferences(
    "prefs", Context.MODE_PRIVATE)

prefs.edit().putInt("score", score).apply()

score = prefs.getInt("score")
```

\*A recent alternative is [DataStore](#).

# Shared storage

[.html](#)

Shared storage saves user data that can or should be accessible to other apps and saved even if the app is uninstalled, e.g. sensor data exported to a CSV file.

To create and use files, apps interact with document providers, including external and cloud storage, via the storage access framework, by launching intents.

# Creating a shared document [.kt](#) | [.html](#)

Use an *Intent* to ask the user to pick a file location.

```
val exportToCsvIntent = Intent(  
    Intent.ACTION_CREATE_DOCUMENT  
)  
.apply {  
    addCategory(Intent.CATEGORY_OPENABLE)  
    type = "text/csv" // mime type  
    putExtra(Intent.EXTRA_TITLE, "export.csv")  
}
```



# Writing a shared document

[.kt](#) | [.html](#)

```
var l = rememberLauncherForActivityResult(  
    contract = ...StartActivityResult() {  
        result -> val uri = result.data?.data; ... }  
  
l.launch(Intent(Intent.ACTION_PICK)) ... // user picks uri  
  
app.contentResolver.openOutputStream(uri).use {  
    out -> out.bufferedWriter(charset =  
        Charsets.US_ASCII).use { w ->  
        w.write("ID, Name, Surname\n"); ... } }  
}
```

# Hands-on, 10': CSV export to file

Extend the code, *commit* and *push* changes.

- Update your private repository (see [these slides](#)).
- Open the *MyCSVExportApp* in your repository /03 which writes a shared document as sketched before.
- Add *Space*, ' ' as an option for separator characters.
- Change the *Toast* to also show exception messages.

Open files in a [CSV app](#) or use a tool like [OpenMTP](#).

# App architecture

[.png](#) | [.html](#)

An app architecture defines the boundaries between parts and the responsibilities each part should have.

Separation of concerns is the guiding principle, e.g. when an app is split into a UI layer and a data layer.

Data should drive UI, from a single source of truth, e.g. in an "offline-first" app, from a local database.

# Data layer

[.png](#) | [.kt](#) | [.html](#)

The data layer contains app data and business logic, i.e. rules on how data is created, stored, and changed.

Separating it from the UI allows the data to be shared among screens and enables testing of business logic.

# Room database

[.png](#) | [.html](#)

*Room* provides an abstraction layer over SQLite DBs, including compile-time verified SQL, annotations to generate code and streamlined database migration.

```
val dao = db.getPersonDao() // get data access
val p = dao.getPerson(id) // get person entity
dao.update(person =          // update their name
    p.copy(name = "Adele")) // copy other fields
```

# Room uses KSP

[.toml](#) | [.kts](#) | [.html](#)

Add the KSP\* *plugin* to the project's *build.gradle.kts*

```
id("com.google.devtools.ksp") version  
"2.0.21-1.0.28" apply false
```

Make sure the first part matches the Kotlin version,  
which is included in the project's *libs.versions.toml*

```
kotlin = "2.0.21"
```

\*Kotlin Symbol Processing, used to generate code. 14

# Room dependencies

[.kts](#) | [.html](#)

Add these *dependencies* to the app's *build.gradle.kts*

```
val v = "2.8.1" // room_version, see releases  
implementation("androidx.room:room-runtime:$v")  
implementation("androidx.room:room-ktx:$v")  
ksp("androidx.room:room-compiler:$v")
```

# Database entities

[.kt](#) | [.html](#)

Define a class per table, create an instance per row.

```
@Entity(tableName = "person") // *
Data class PersonEntity(
    @PrimaryKey(autoGenerate = true)
    val id: Int, // or Long
    @ColumnInfo(name = "name")
    val name: String?)
```

\*For table names, consider using **singular** nouns.



# Data access object

[.kt](#) | [.html](#)

Define an interface to access a table / the database.

@Dao

```
interface PersonDao { // _Impl.kt is generated
    @Query("SELECT * from person WHERE id = :id")
    fun getPerson(id: Int): Flow<PersonEntity>
    @Insert suspend fun insert(p: PersonEntity)
    @Update suspend fun update(p: PersonEntity)
    @Delete suspend fun delete(p: PersonEntity)
}
```

# Database instance

[.kt](#) | [.html](#)

Extend *RoomDatabase* to provide a (generated) DB.

```
@Database(entities = [PersonEntity::class], ...)
abstract class PersonDb : RoomDatabase(
) { // _Impl.kt is generated
    abstract fun personDao(): PersonDao
    ... { fun getInstance(c: Context): PersonDb {
        Room.databaseBuilder(context = c,
            PersonDb::class.java, "person_db") ...
    } } }
```

# Repository pattern

[.kt](#) | [.html](#)

Decouple client code from how the data is accessed.

```
interface PersonRepo { ... } // is a pattern

class LocalPersonRepo(private val dao:
PersonDao) : PersonRepo {
    override fun getPersonFlow(id: Int):
        Flow<PersonEntity?> = dao.getPerson(id)
    override suspend fun insertPerson(person:
        PersonEntity) = dao.insert(person) ... }
```

# App container

[.kt](#) | [.html](#)

Combine a specific repo, database and DAO instance.

```
interface AppContainer { val personRepo: ... }

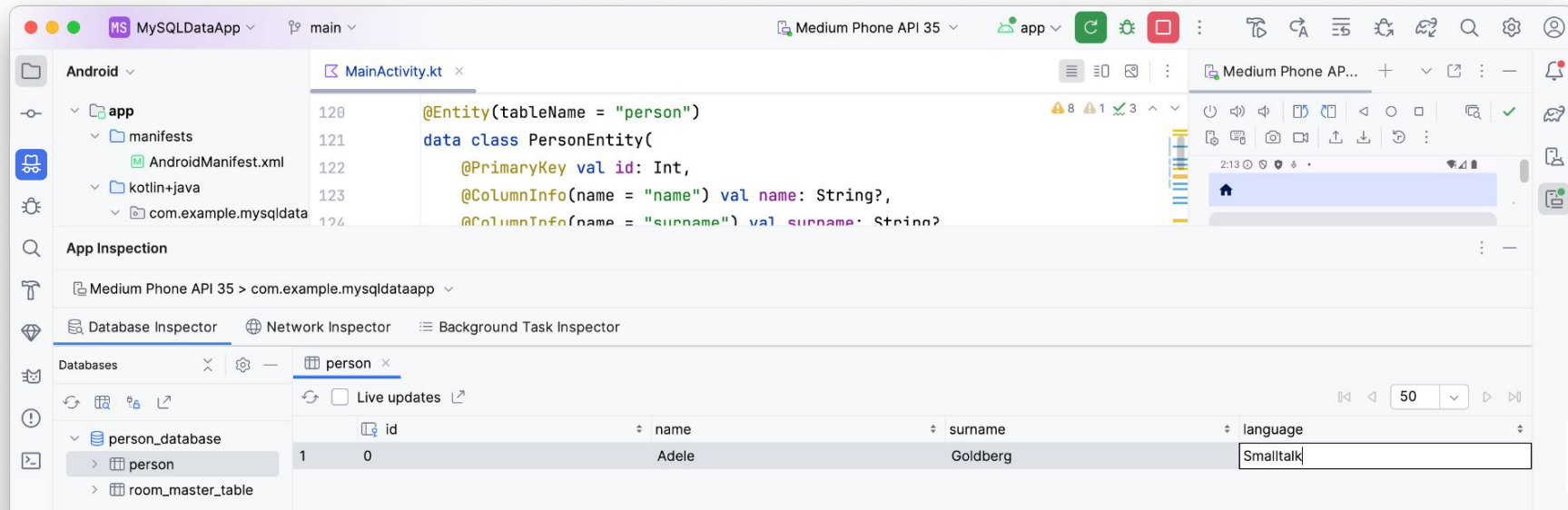
class DbAppContainer(private val c: Context
) : AppContainer {
    override val personRepo: PersonRepo by lazy {
        LocalPersonRepo(PersonDb.getInstance(
            context = c).personDao())
    }
}
```

# Database inspector

.html

Inspect, query and modify an app's MySQL database.

View > Tool Windows > App Inspection



# Hands-on, 10': Data layer with Room

Extend the code, *commit* and *push* changes.

- Open the *MySQLDataApp* in your repository /03 which implements a *PersonDao* as sketched before.
- Add a property *language* to the *PersonEntity* class.
- Make sure the field is added to the database table.\*
- Use the database inspector to add some new rows.

\*Ignore the ViewModel and UI client code for now.

# UI layer

[.png](#) | [.kt](#) | [.html](#)

The user interface displays application data on screen and serves as the primary point of user interaction.

When data changes, due to user interaction or external input like a network response, the UI should update.

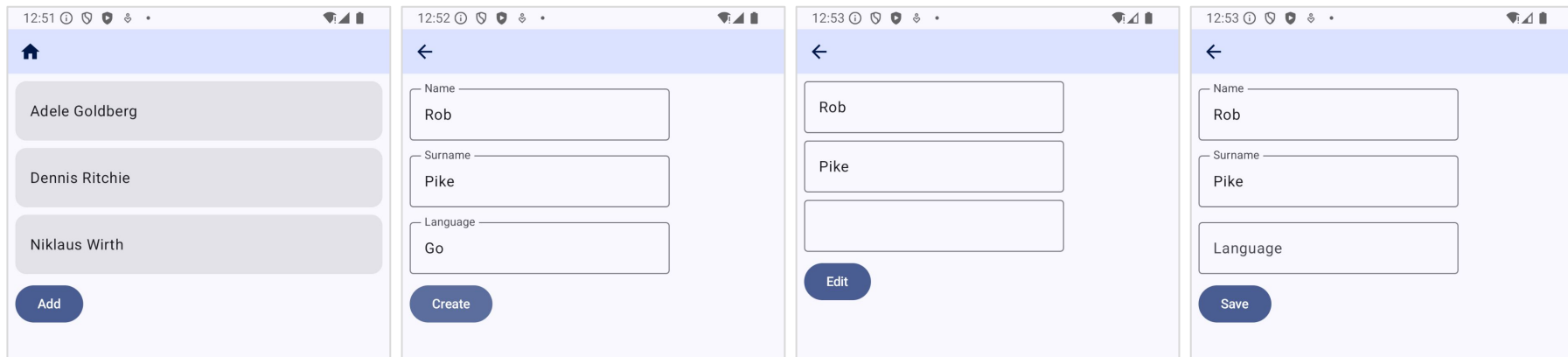
The UI layer converts application data changes to a form that the UI can present and then displays it.

# Screens

.kt | .html

A typical UI for a database app offers these screens.\*

```
enum class Screen { LIST, ENTRY, DETAIL, EDIT }
```



\*Depending on the use case, list items show details.



# Navigation

[.kt](#) | [.html](#)

Use *when* for prototypes, *NavController* for products.

```
when (screen) {  
    Screen.LIST -> ListScreen(  
        onAdd = { screen = Screen.ENTRY },  
        onOpen = { id -> personId = id  
            screen = Screen.DETAIL },  
        modifier)  
    Screen.ENTRY -> EntryScreen(personId, ...) ...  
}
```

ViewModels hold UI state [.kt|.html](#)

*ViewModels* hold what users should see, the UI state.

Any change to the state leads to an update of the UI.

This principle is called unidirectional data flow.

See also [managing state on Android](#).

# Coroutines

[.kt](#) | [.html](#)

A coroutine is a concurrency design pattern that helps to simplify asynchronous code with *suspend/launch*.

On Android, coroutines help to manage long-running tasks that would block the main thread, slow the app.

```
class ...ViewModel { suspend fun createPerson() }  
scope.launch { viewModel.createPerson() }
```

# Flows

[.kt](#) | [.html](#)

In coroutines, a *Flow* is a type that can emit multiple values sequentially, as opposed to suspend functions that return only a single value. For example, you can receive live updates from a database or a Web API.

```
val latestNews: Flow<List<ArticleHeadline>> =  
flow {  
    while(true) { emit(newsApi.fetchNews()) }  
}
```

# Hands-on, 10': UI layer with Flows

Extend the code, *commit* and *push* changes.

- Open the *MySQLDataApp* in your repository /03 which implements a *Flow<List...>* as sketched.
- Add a *Delete* button to the *PersonDetailScreen*.
- Make sure the row is removed from the database.
- Make sure the *ListScreen* shows an up to date list.\*

\*Without restarting the app.

# Summary

These are the basics of storing app data on Android.

Storing key/value entries using *SharedPreferences*.

Creating a shared document and writing data to it.

Storing local data using the *Room* database library.

Propagating a single source of truth with a *Flow*.

# Challenge: Inventory app with Room

Work through the [Persist data with Room](#) codelab.

- Start from [Inventory app project](#), *starter* branch.
- Add the *project files* to your private repository.
- Make sure *not* to add the 3rd-party *repository*.
- Git *commit* and *push* your code to your repo.

Done? There are more [codelabs](#).

# Feedback or questions?

Write me on Teams or email

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Thanks for your time.