



Data Management

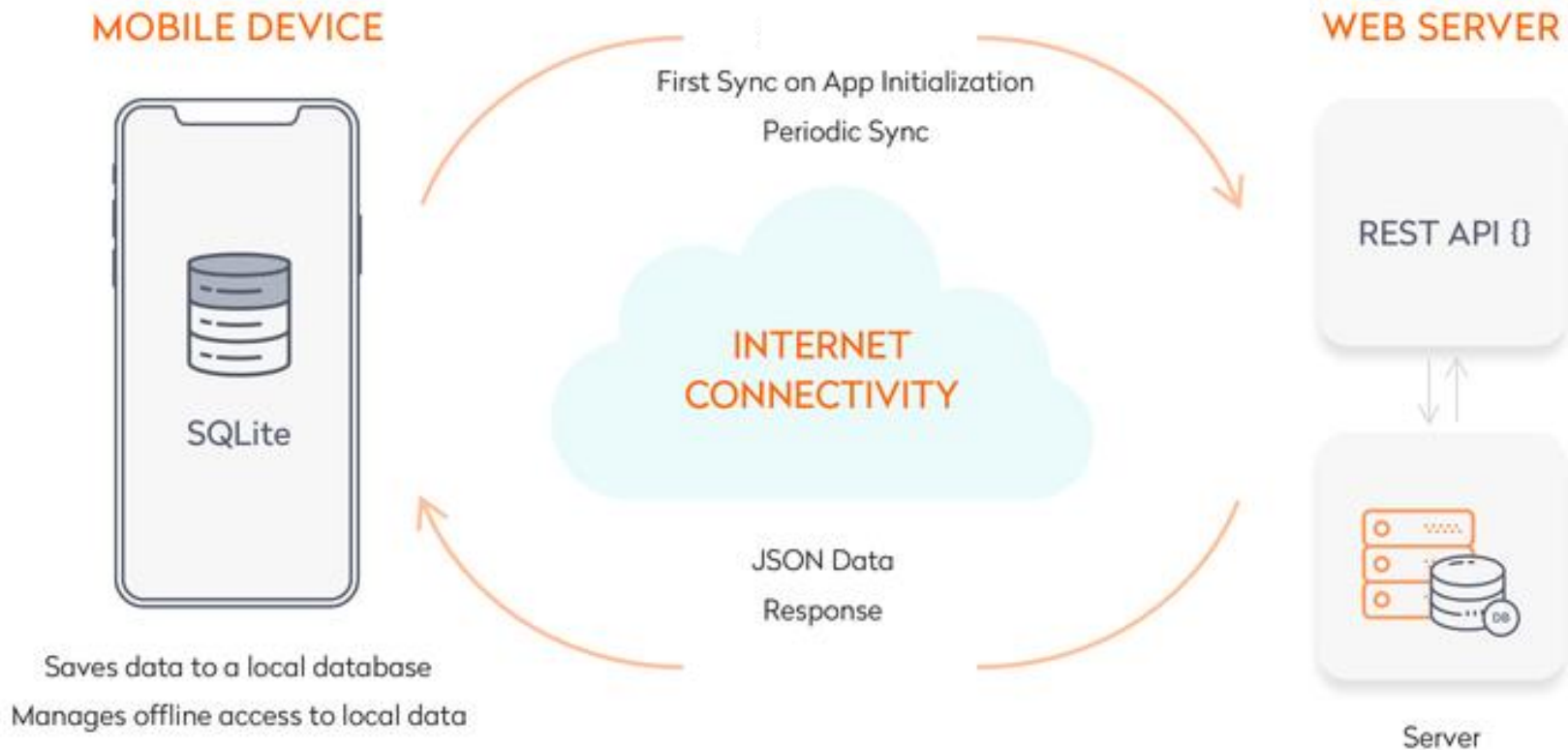


Dr. Abdelkarim Erradi
CSE@QU

Outline

1. Data persistence options on Android
2. Room programming model
3. Relationships

Offline app with Sync



- **Cache** relevant pieces of data on the device. App continues to work offline when a network connection is not available.
- When the network connection is back, the app's repository **syncs** the data with the server.



Data Storage Options on Android

- **Preferences DataStore**

- Lightweight mechanism to store and retrieve key--value pairs
- Typically used to store application settings (e.g., app theme, language), store user details after login

- **Files**

- Store unstructured data such as text, photos or videos, on the device (Current application folder only) or removable storage

- **SQLite database**

- Store structured data (e.g., posts, events) in tables

- **Cloud Data Stores**

- e.g., Cloud Firestore

Relational Database

- Database allows **persisting structured data**
- A **relational** database organizes data into **tables**
 - A table has rows and columns
 - Tables can have relationships between them
- Tables could be queries and altered using SQL

The diagram illustrates a table with three columns: CustomerID, CustomerName, and Status. The first column, CustomerID, is highlighted in yellow and labeled as the 'Primary Key' with a green line. The second and third columns are labeled as 'Column' with green lines. The first two rows of the table are highlighted in yellow and labeled as 'Row' with a blue line. The third row is not highlighted. The table contains the following data:

CustomerID	CustomerName	Status
1	Google	Active
2	Amazon	Active
3	Apple	Inactive

SQL Statements

- Structured Query Language (**SQL**)
 - Language used to define, query and alter database tables
 - SQL is a language for interacting with a relational database

- Creating data:

```
INSERT into person (first_name, last_name)  
VALUES ("Ahmed", "Sayed")
```

- Reading data:

```
SELECT * FROM person WHERE last_name = "Sayed"
```

- Updating data:

```
UPDATE person SET first_name = "Ali" where  
last_name = "Sayed"
```

- Deleting data:

```
DELETE from person where last_name = "Sayed"
```

Room Library

- The Room persistence library provides an abstraction layer over SQLite to ease data management
 - Define the database, its tables and data operations using **annotations**
 - Room automatically translates these annotations into SQLite instructions/queries to be executed by the DB engine
- **Dependencies:**

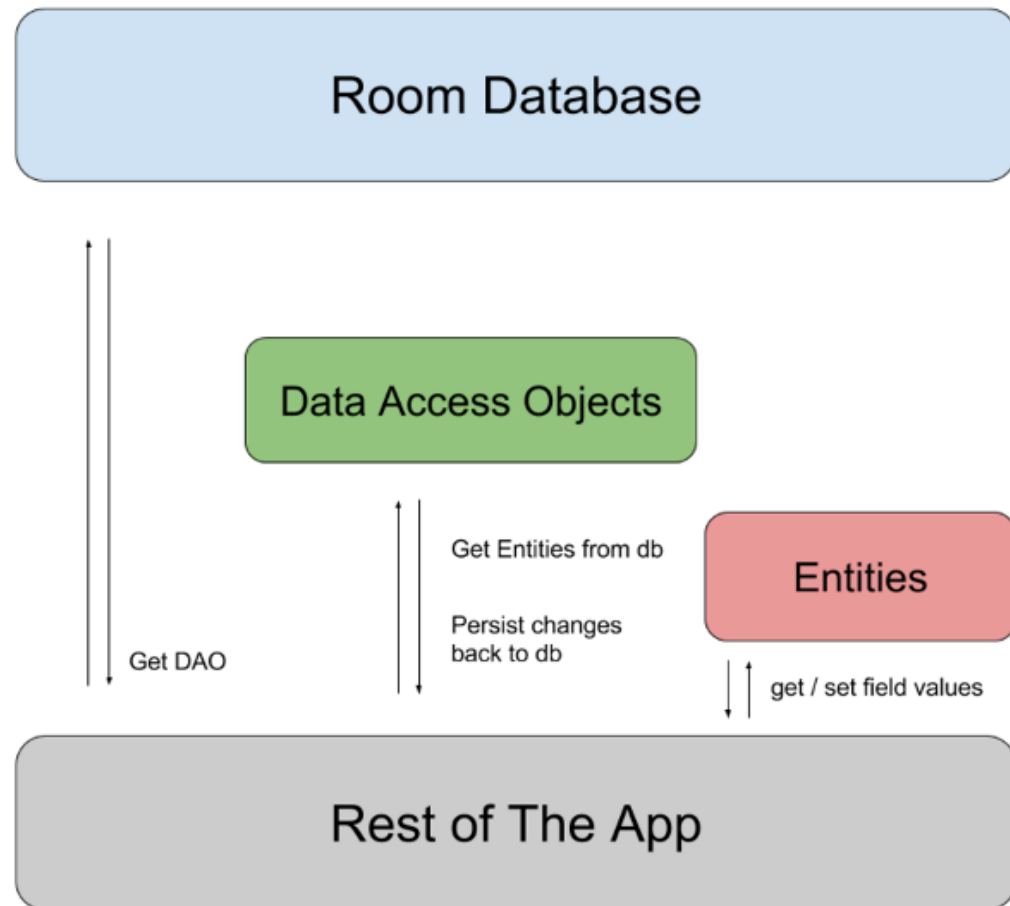
```
def room_version = "2.2.5"
implementation "androidx.room:room-runtime:$room_version"
kapt "androidx.room:room-compiler:$room_version"
// Kotlin Extensions and Coroutines support for Room
implementation "androidx.room:room-ktx:$room_version"
```

Room architecture diagram

Working with Room

- Model DB Tables as regular **entity classes**
- Define queries for Insert, Update and Delete and associate them with methods in **DAO interface**.
Implementation is auto-generated by the compiler
- Interact with the database using DAOs
- **RoomDatabase** → holds a connection to the SQLite DB and all the operations are executed through it

3 major components in Room



Room main components





- **Entity** → app class maps to a table within the database
 - Kotlin class annotated with **@Entity** to map it to a DB table
 - Must specify one of the entity properties as a **primary key**
 - Table representation (e.g., name and column names) is controlled by annotations
- **Data Access Object (DAO)** → how to persist and retrieve entities
 - Contains CRUD methods defining operations to be done on data
 - Interface or abstract class marked as **@Dao**
 - One or many DAOs per database
- **Database** → where data is persisted
 - abstract class that extends **RoomDatabase** and annotated with **@Database**

Entity

- **Entity** represents a database **table**, and each **entity instance** corresponds to a **row** in that table
 - Class properties are mapped to table columns
 - Each entity object has a Primary Key that **Uniquely identifies** the entity object in memory and in the DB
 - The primary key values can be assigned by the database by specifying **autoGenerate = true**

@Entity

```
data class Item(  
    @PrimaryKey(autoGenerate = true)  
    val id: Long = 0  
    val productId: Long,  
    var quantity: Int) {  
}
```

▼		Item
		id : INTEGER, NOT NULL
		productId : INTEGER, NOT NULL
		quantity : INTEGER, NOT NULL

Customizing Entity Annotation

- In most cases, the defaults are sufficient
- By default the table name corresponds to the name of the class

OPTIONAL Use **@Entity** (tableName = "...") to set the name of the table

OPTIONAL The columns can be customized using **@ColumnInfo**(name = "column_name") annotation

- If an entity has fields that you don't want to persist, you can annotate them using **@Ignore**
- If multiple constructors are available, add the **@Ignore** annotation to tell Room which should be used and which not

DAO @Query

- **@Query** used to annotate query methods
- Room ensures **compile time verification** of SQL queries

@Dao

```
interface UserDao {  
    @Query("select * from User limit 1")  
    suspend fun getFirstUser(): User  
    @Query("select * from User")  
    fun getAll(): List<User>  
    @Query("select firstName from User")  
    fun getFirstNames(): List<String>  
    @Query("select * from User where firstName = :fn")  
    fun getUsers(fn: String): List<User>  
    @Query("delete from User where lastName = :ln")  
    fun deleteUsers(ln: String): Int  
}
```

DAO @Insert, @Update, @Delete

- Used to annotate insert, update and delete methods
- Suspend ensure that DB operations are not done on the main UI thread

@Dao

```
interface UserDao {  
    @Insert  
    suspend fun insert(user: User): Long  
    @Insert  
    suspend fun insertList(users: List<User>): List<Long>  
  
    @Delete  
    suspend fun delete(user: User)  
    @Delete  
    suspend fun deleteList(users: List<User>)  
  
    @Update  
    suspend fun update(user: User)  
    @Update  
    suspend fun updateList(users: List<User>)  
}
```

Room database object

- Provides a singleton dbInstance created using **Room.databaseBuilder()** to open (or create) the database
 - abstract class that extends RoomDatabase
 - Annotated with **@Database**
- Serves as the **main access point** to get DAOs to interact with DB

```
@Database(entities = [Item::class], version = 1)
abstract class ShoppingDB : RoomDatabase() {
    abstract fun getShoppingDao(): ShoppingDao
    companion object { // Create a singleton dbInstance
        private var dbInstance: ShoppingDB? = null
        fun getInstance(context: Context): ShoppingDB {
            if (dbInstance == null) {
                dbInstance = Room.databaseBuilder(
                    context,
                    ShoppingDB::class.java, "shopping.db"
                ).build()
            }
            return dbInstance as ShoppingDB
        }
    }
}
```



Observable queries

- Observable queries allow automatic notifications when data changes
 - Notifies the app with of any data updates
- We can accomplish this using **LiveData**, a lifecycle-aware observable value holder
 - We simply **wrap** the return type of our DAO methods with LiveData.

*// App will be notified of any changes of the Item table data
// Whenever Room detects Item table data change our LiveData
observer will be called with the new list of items
// No need for suspend function as LiveData is already asynchronous*

```
fun getAll() : LiveData<List<Item>>
```

TypeConverter

- SQLite only support basic data types, no support for data types such as Date, enum, BigDecimal etc. Need to add a **TypeConverter** for such data types
- Convert an entity property datatype to a type that can be written to the associated table column and vice versa

```
class DateConverter {  
    // Convert from Date to a value that can be stored in SQLite Database  
    @TypeConverter  
    fun fromDate(date: Date) = date.time  
  
    // Convert from date Long value read from SQLite DB to a Date value  
    // that can be assigned to an entity property  
    @TypeConverter  
    fun toDate(dateLong: Long) = Date(dateLong)  
}  
  
@TypeConverters(DateConverter::class)  
abstract class ShoppingDB : RoomDatabase() { ... }
```


Nested @Embedded object

- Nested object annotated with @Embedded -> Room **flattens out** the embedded object and maps its properties to columns in the DB table
 - User table will have a houseNumber, street and city columns

```
data class Address(val houseNumber: String,  
                  val street: String,  
                  val city: String)
```

@Entity

```
data class User (  
    @PrimaryKey(autoGenerate = true)  
    var id: Long,  
    val firstName: String,  
    val lastName: String,  
    @Embedded val address: Address  
)
```

▼ User

🔑	id	: INTEGER, NOT NULL
📄	firstName	: TEXT, NOT NULL
📄	lastName	: TEXT, NOT NULL
📄	houseNumber	: TEXT, NOT NULL
📄	street	: TEXT, NOT NULL
📄	city	: TEXT, NOT NULL

Enforce integrity checks with foreign keys

- Foreign key allows **integrity checks** (e.g., can insert pet only for a valid owner) & **cascading** deletes
 - `onDelete = ForeignKey.CASCADE` when owner is deleted then auto-delete associated pets

```
@Entity(foreignKeys = [  
    ForeignKey(entity = Owner::class,  
        parentColumns = ["id"],  
        childColumns = ["ownerId"],  
        onDelete = ForeignKey.CASCADE)  
    ] ,  
    // Create an index on the ownerId column to speed-up query execution  
    indices = [Index(value = ["ownerId"])] )  
data class Pet(@PrimaryKey val catId: Long,  
    val name: String, val ownerId: Long)  
  
@Entity  
data class Owner(@PrimaryKey val id: Long, val name: String)
```

Summary

Major Components

- **@Entity** - Defines table structure
- **@DAO** - An interface with functions define how to access the database
- **@Database** - Connects all the pieces of Room together



Resources

- Save data in a local database using Room
 - <https://developer.android.com/training/data-storage/room>
- Room pro tips
 - <https://medium.com/androiddevelopers/7-pro-tips-for-room-fbadea4bfbd1>
- Room codelab
 - <https://codelabs.developers.google.com/codelabs/android-room-with-a-view-kotlin/>
 - <https://developer.android.com/codelabs/kotlin-android-training-room-database>