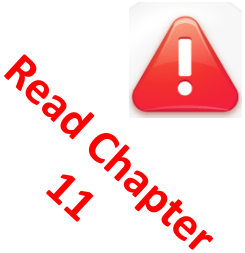
CMPS 312



Data Management

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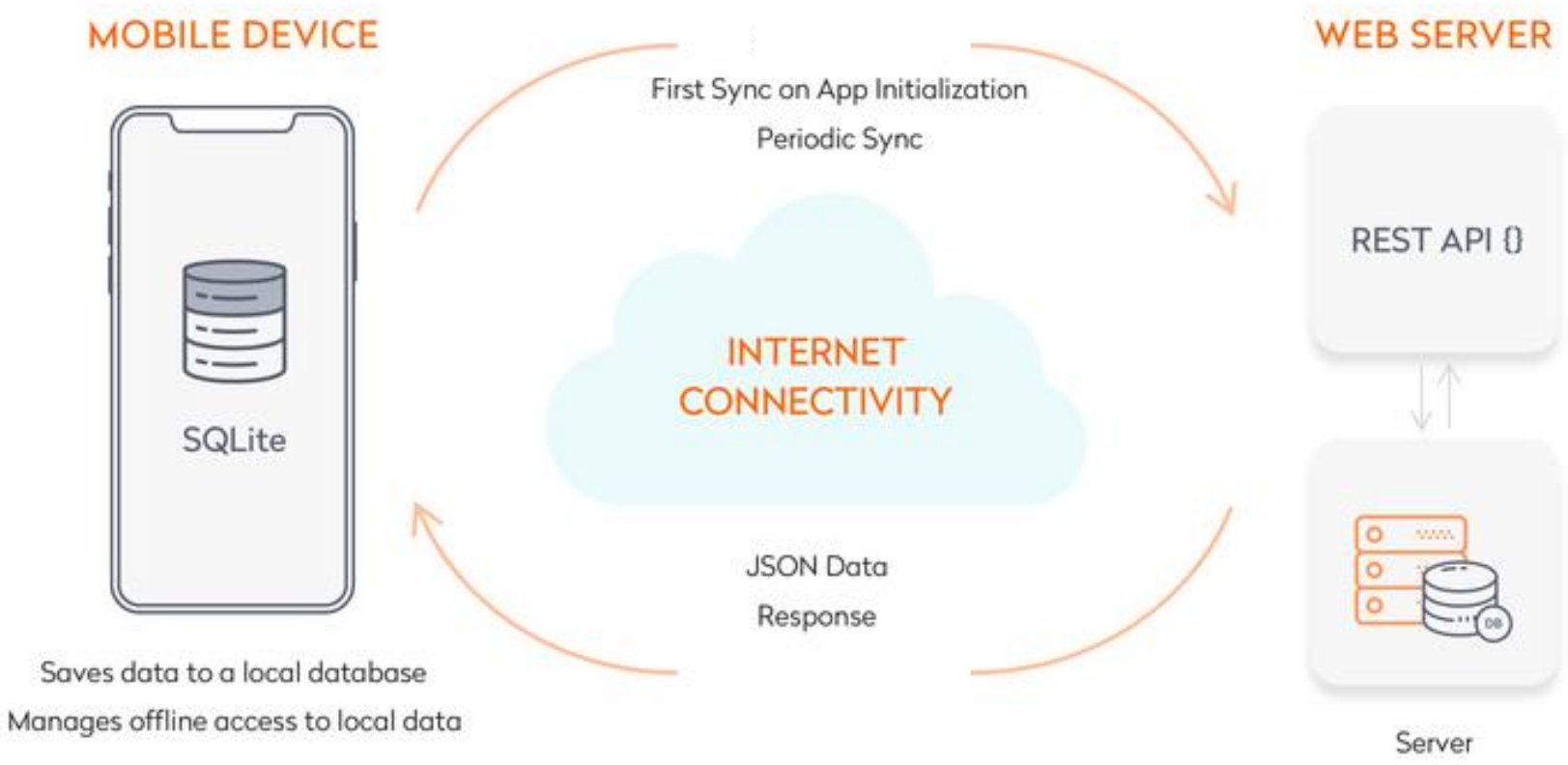
CSE@QU

Outline

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

Offline app with Sync



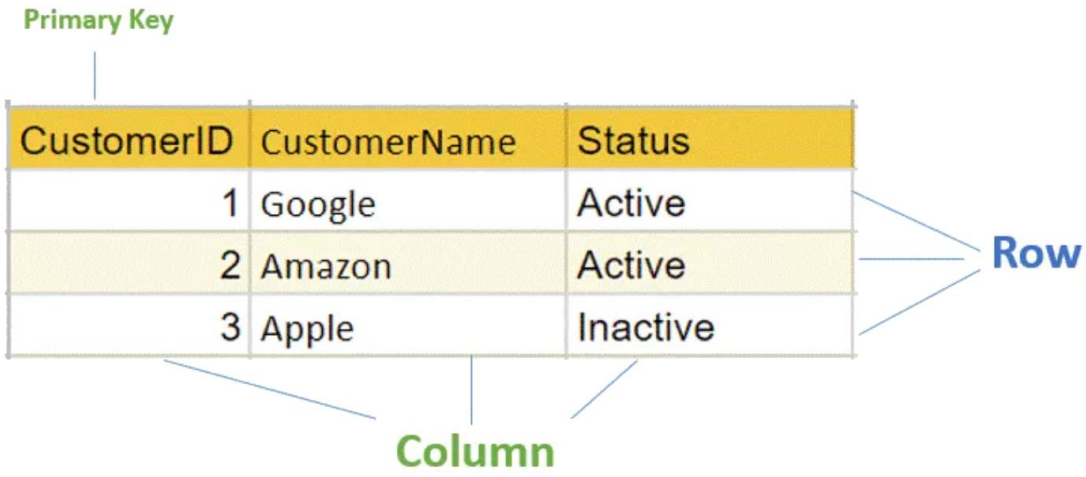
- **Cache** relevant pieces of data on the device. App continues to work offline when a network connection is not available.
- When the network connection is back, the app's repository **syncs** the data with the server.

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



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
- **C**reating data:

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

- **R**eading data:

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

- **U**pdating data:

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

- **D**eleting 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:**

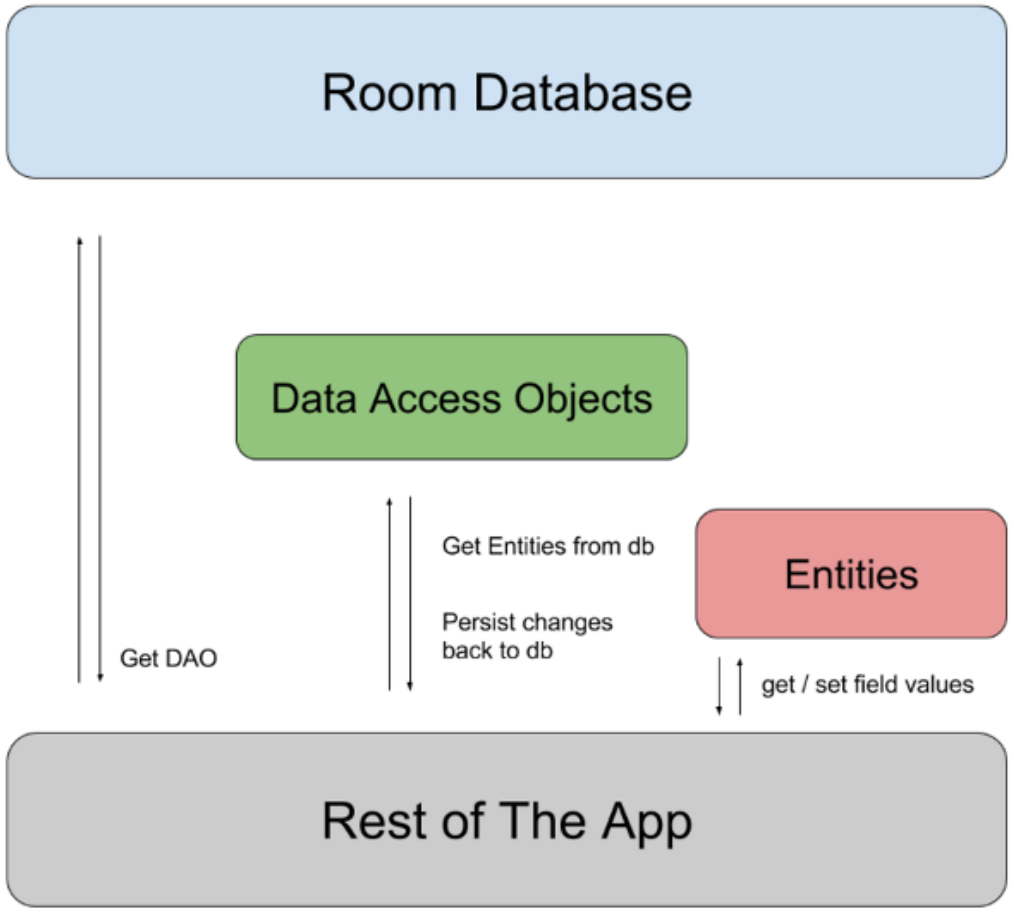
```
def room_version = "2.2.5"
implementation "androidx.room:room-runtime:$room_version"
kapt "androidx.room:room-compiler:$room_version"
// Kotlin Extensions and Coroutines support for Room
implementation "androidx.room:room-ktx:$room_version"
```

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 complier
- 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 //(tableName = "shopping_items")
data class Item(
    @PrimaryKey(autoGenerate = true)
    //@ColumnInfo(name="item_id")
    var id: Long = 0
    val name: String,
    var quantity: Int) {
}
```

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 = 0
    val firstName: String,
    val lastName: String,
    @Embedded val address: Address
)
```

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