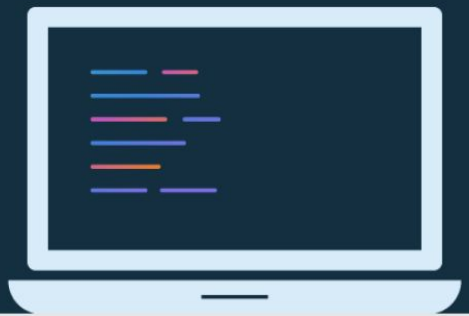
Lesson 9: App architecture (persistence)



About this lesson

Lesson 9: App architecture (persistence)

- Storing data
- Room persistence library
- Asynchronous programming
- Coroutines
- Testing databases
- Summary

Storing data

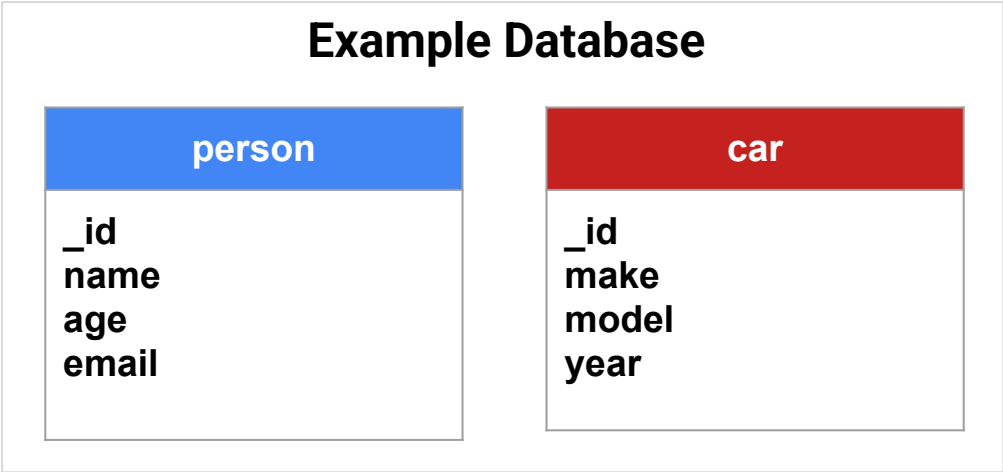
Ways to store data in an Android app

- App-specific storage
- Shared storage (files to be shared with other apps)
- Preferences
- Databases

What is a database?

Collection of structured data that can be easily accessed, searched, and organized, consisting of:

- Tables
- Rows
- Columns

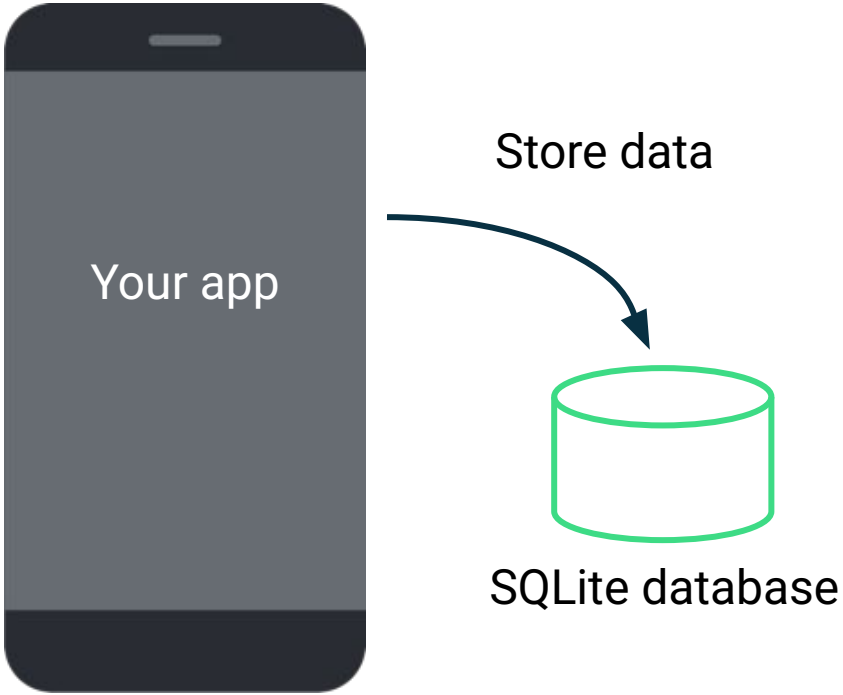


Structured Query Language (SQL)

Use SQL to access and modify a relational database.

- Create new tables
- Query for data
- Insert new data
- Update data
- Delete data

SQLite in Android



Example SQLite commands

Create

```
INSERT INTO colors VALUES ("red", "#FF0000");
```

Read

```
SELECT * from colors;
```

Update

```
UPDATE colors SET hex="#DD0000" WHERE name="red";
```

Delete

```
DELETE FROM colors WHERE name = "red";
```

Interacting directly with a database

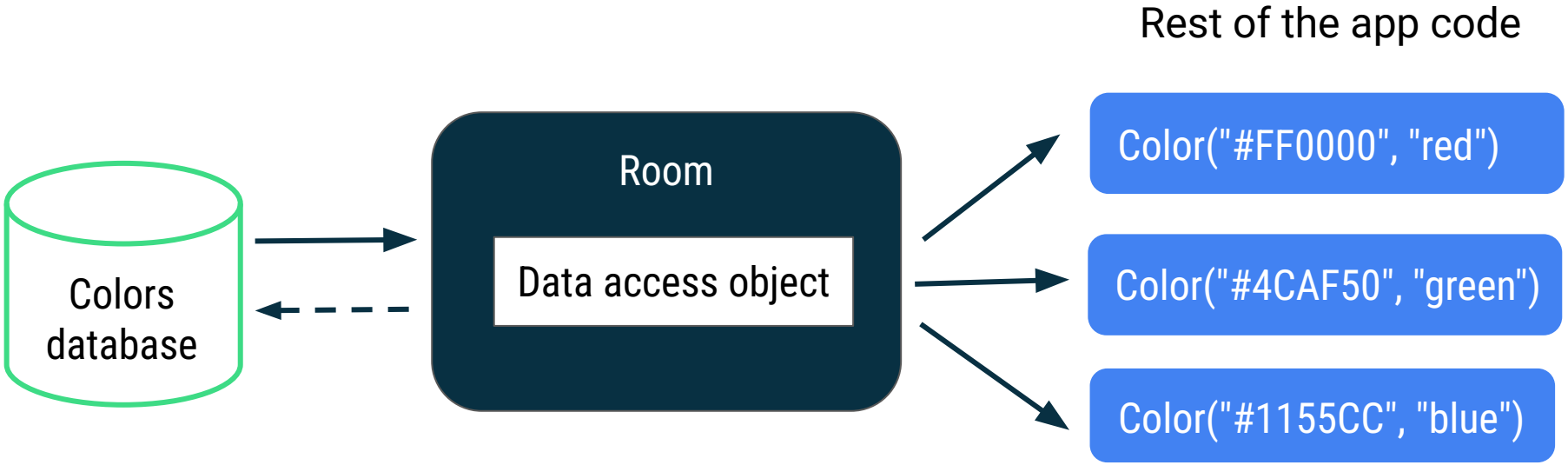
- No compile-time verification of raw SQL queries
- Need lots of boilerplate code to convert between SQL queries ⟷ data objects

Room persistence library

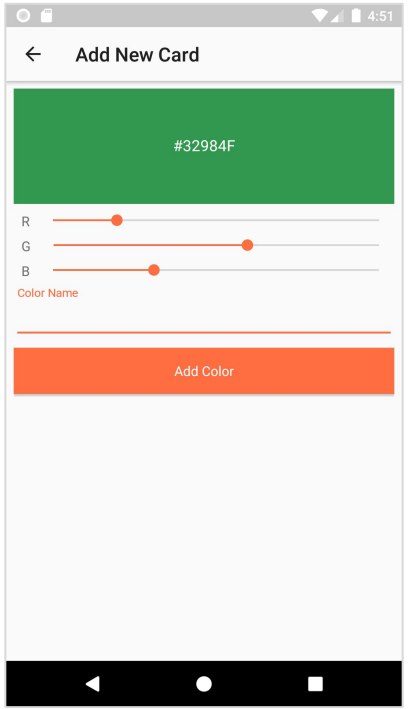
Add Gradle dependencies

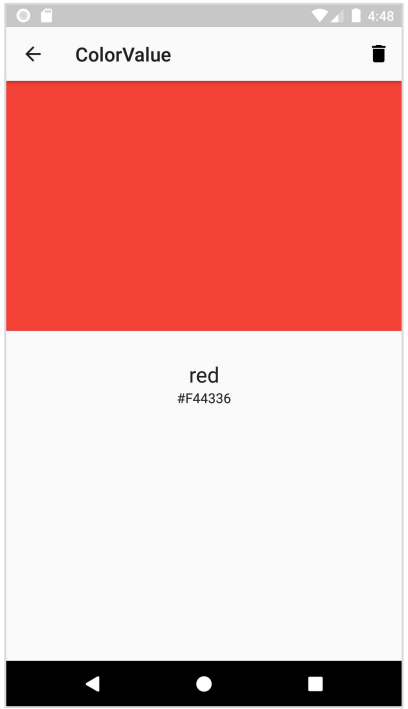
```
dependencies {
    implementation "androidx.room:room-runtime:$room_version"
    kapt "androidx.room:room-compiler:$room_version"

    // Kotlin Extensions and Coroutines support for Room
    implementation "androidx.room:room-ktx:$room_version"

    // Test helpers
    testImplementation "androidx.room:room-testing:$room_version"
}
```

Room



ColorValue app





Room

- Entity `Color`
- DAO `ColorDao`
- Database `ColorDatabase`

Color class

```
data class Color {
    val hex: String,
    val name: String
}
```

Annotations

- Provide extra information to the compiler

  `@Entity` marks entity class, `@Dao` for DAO, `@Database` for database

- Can take parameters

```
@Entity(tableName = "colors")
```

- Can autogenerate code for you

Entity

Class that maps to a SQLite database table

- `@Entity`
- `@PrimaryKey`
- `@ColumnInfo`

Example entity

```
@Entity(tableName = "colors")
data class Color {
    @PrimaryKey(autoGenerate = true) val _id: Int,
    @ColumnInfo(name = "hex_color") val hex: String,
    val name: String
}
```

Data access object (DAO)

Work with DAO classes instead of accessing database directly:

- Define database interactions in the DAO.
- Declare DAO as an interface or abstract class.
- Room creates DAO implementation at compile time.
- Room verifies all of your DAO queries at compile-time.

Example DAO

```
@Dao
interface ColorDao {

    @Query("SELECT * FROM colors")
    fun getAll(): Array<Color>

    @Insert
    fun insert(vararg color: Color)

    @Update
    fun update(color: Color)

    @Delete
    fun delete(color: Color)
```

Query

```
@Dao
interface ColorDao {

    @Query("SELECT * FROM colors")
    fun getAll(): Array<Color>

    @Query("SELECT * FROM colors WHERE name = :name")
    fun getColorByName(name: String): LiveData<Color>

    @Query("SELECT * FROM colors WHERE hex_color = :hex")
    fun getColorByHex(hex: String): LiveData<Color>
```

Insert

```
@Dao
interface ColorDao {
    ...

    @Insert
    fun insert(vararg color: Color)

    ...
}
```

Update

```
@Dao
interface ColorDao {
    ...

    @Update
    fun update(color: Color)

    ...
}
```

Delete

```
@Dao
interface ColorDao {
    ...

    @Delete
    fun delete(color: Color)

    ...
}
```

Create a Room database

- Annotate class with `@Database` and include list of entities:

```
@Database(entities = [Color::class], version = 1)
```

- Declare abstract class that extends `RoomDatabase`:

```
abstract class ColorDatabase : RoomDatabase() {
```

  - Declare abstract method with no args that returns the DAO:

```
abstract fun colorDao(): ColorDao
```

Example Room database

```
@Database(entities = [Color::class], version = 1)
abstract class ColorDatabase : RoomDatabase() {
    abstract fun colorDao(): ColorDao
    companion object {
        @Volatile
        private var INSTANCE: ColorDatabase? = null
        fun getInstance(context: Context): ColorDatabase {
            ...
        }
    }
    ...
```

Create database instance

```
fun getInstance(context: Context): ColorDatabase {
    return INSTANCE ?: synchronized(this) {
        INSTANCE ?: Room.databaseBuilder(
            context.applicationContext,
            ColorDatabase::class.java, "color_database"
        )
        .fallbackToDestructiveMigration()
        .build()
        .also { INSTANCE = it }
    }
}
```

Get and use a DAO

Get the DAO from the database:

```
val colorDao = ColorDatabase.getInstance(application).colorDao()
```

Create new Color and use DAO to insert it into database:

```
val newColor = Color(hex = "#6200EE", name = "purple")

colorDao.insert(newColor)
```

Asynchronous programming

Long-running tasks

- Download information
- Sync with a server
- Write to a file
- Heavy computation
- Read from, or write to, a database

Need for async programming

- Limited time to do tasks and remain responsive
- Balanced with the need to execute long-running tasks
- Control over how and where tasks are executed

Async programming on Android

- Threading
- Callbacks
- Plus many other options

What is the recommended way?

Coroutines

Coroutines

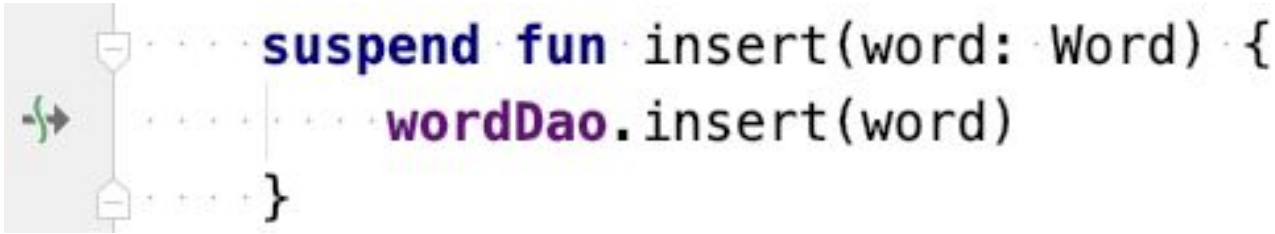
- Keep your app responsive while managing long-running tasks.
- Simplify asynchronous code in your Android app.
- Write code in sequential way
- Handle exceptions with `try/catch` block

Benefits of coroutines

- Lightweight
- Fewer memory leaks
- Built-in cancellation support
- Jetpack integration

Suspend functions

- Add `suspend` modifier
- Must be called by other `suspend` functions or coroutines



```
suspend fun insert(word: Word) {
    wordDao.insert(word)
}
```

Suspend and resume

- `suspend`

  Pauses execution of current coroutine and saves local variables

- `resume`

  Automatically loads saved state and continues execution from the point the code was suspended

Example

Add suspend modifier to DAO methods

```
@Dao
interface ColorDao {

    @Query("SELECT * FROM colors")
    suspend fun getAll(): Array<Color>

    @Insert
    suspend fun insert(vararg color: Color)

    @Update
    suspend fun update(color: Color)

    @Delete
    suspend fun delete(color: Color)
```

Control where coroutines run

Dispatcher	Description of work	Examples of work
`Dispatchers.Main`	UI and nonblocking (short) tasks	Updating LiveData, calling suspend functions
`Dispatchers.IO`	Network and disk tasks	Database, file IO
`Dispatchers.Default`	CPU intensive	Parsing JSON

withContext

```
suspend fun get(url: String) {

    // Start on Dispatchers.Main

    withContext(Dispatchers.IO) {
        // Switches to Dispatchers.IO
        // Perform blocking network IO here
    }

    // Returns to Dispatchers.Main
}
```

CoroutineScope

Coroutines must run in a `CoroutineScope`:

- Keeps track of all coroutines started in it (even suspended ones)
- Provides a way to cancel coroutines in a scope
- Provides a bridge between regular functions and coroutines

Examples: `GlobalScope`

`ViewModel` has `viewModelScope`

`Lifecycle` has `lifecycleScope`

Start new coroutines

- `launch` - no result needed

```
fun loadUI() {
    launch {
        fetchDocs()
    }
}
```

- `async` - can return a result

ViewModelScope

```
class MyViewModel: ViewModel() {

    init {
        viewModelScope.launch {
            // Coroutine that will be canceled
            // when the ViewModel is cleared
        }
    }
    ...
```

Example viewModelScope

```
class ColorViewModel(val dao: ColorDao, application: Application)
    : AndroidViewModel(application) {

    fun save(color: Color) {
        viewModelScope.launch {
            colorDao.insert(color)
        }
    }


    ...
```

Testing databases

Add Gradle dependencies

```
android {
    defaultConfig {
        ...
        testInstrumentationRunner "androidx.test.runner
         .AndroidJUnitRunner"
        testInstrumentationRunnerArguments clearPackageData: 'true'
    }
}

dependencies {
    testImplementation 'junit:junit:4.12'
    androidTestImplementation 'androidx.test.ext:junit:1.1.0'
    androidTestImplementation 'androidx.test.espresso:espresso-core:3.1.1'
}
```

Testing Android code

- `@RunWith(AndroidJUnit4::class)`
- `@Before`
- `@After`
- `@Test`

Create test class

```
@RunWith(AndroidJUnit4::class)
class DatabaseTest {

    private lateinit val colorDao: ColorDao
    private lateinit val db: ColorDatabase

    private val red = Color(hex = "#FF0000", name = "red")
    private val green = Color(hex = "#00FF00", name = "green")
    private val blue = Color(hex = "#0000FF", name = "blue")

    ...
```

Create and close database for each test

In `DatabaseTest.kt`:

```
@Before
fun createDb() {
    val context: Context = ApplicationProvider.getApplicationContext()
    db = Room.inMemoryDatabaseBuilder(context, ColorDatabase::class.java)
        .allowMainThreadQueries()
        .build()
    colorDao = db.colorDao()
}

@After
@Throws(IOException::class)
fun closeDb() = db.close()
```

Test insert and retrieve from a database

In `DatabaseTest.kt`:

```
@Test
@Throws(Exception::class)
fun insertAndRetrieve() {
    colorDao.insert(red, green, blue)
    val colors = colorDao.getAll()
    assert(colors.size == 3)
}
```

Summary

Summary

In Lesson 9, you learned how to:

- Set up and configure a database using the Room library
- Use coroutines for asynchronous programming
- Use coroutines with Room
- Test a database

Learn more

- 7 Pro-tips for Room
- Room Persistence Library
- SQLite Home Page
- Save data using SQLite
- Coroutines Guide
- Dispatchers - kotlinx-coroutines-core
- Coroutines on Android (part I): Getting the background
- Coroutines on Android (part II): Getting started
- Easy Coroutines in Android: viewModelScope
- Kotlin Coroutines 101

Pathway

Practice what you've learned by completing the pathway:

Lesson 9: App architecture (persistence)