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Saving Data on Android

FIRST EDITION

Learning Room, Firebase and SQLite with Kotlin

By the raywenderlich Tutorial Team

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Saving Data on Android

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Who This Book Is For

This book is for developers who are comfortable with Kotlin and want to implement the proper solution when managing persistence, local or remote, in Android applications.

If you're looking for more background on the Kotlin language, we recommend our book, *Kotlin Apprentice*, which goes into depth on the Kotlin language itself:

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If you want to learn more about Android app development in Kotlin, we recommend working through our classic book, *Kotlin Apprentice*:

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To follow along with this book, you need:

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- **Kotlin playground**: You can also use the Kotlin Playground available at the Kotlin home page at https://play.kotlinlang.org.
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About the Cover

Dragons are an extremely common and ancient piece of folklore in nearly all cultures around the world. Most dragons are thought to breathe fire, or even ice, but legend has it that green dragons breathe acid. Any warrior brave enough to charge a green dragon would have the story of her battle permanently etched on her armor and shield from the dragon's acid.

Saving data on Android etches the story of data in a persistent manner on the user's device. There's hardly an app out there that doesn't persist data in some way. After reading Saving Data on Android, you'll be armed and ready to charge fearlessly into battle with the dragons of development, to save your users' data!

Section 1: Saving Data Using Android SDK

Managing persistence is one of the main features that every mobile environment should provide, and Android is no different. In this chapter, you'll learn, through practical examples, how to use the API that Android SDK provides to persist data. You'll learn when and how to manage persistence depending on the type and quantity of data.

- **Chapter 1: Using Files**: Android contains most of the API of Java and so the abstractions into the java.io package which allow you to deal with Files. In this chapter, you'll learn how to create, write, update and delete data into files. Here you'll have the opportunity to manage security using encryption and permissions.
- **Chapter 2: Using SharedPreferences**: SharedPreferences are useful if you need to persist a small quantity of data like texts or a set of values of primitive types. In this chapter, you'll learn how to persist and recover a small quantity of data.
- **Chapter 3: SQLite Database**: Android also provides SQLite as a small and powerful DataBase Management System. In this chapter, you'll learn how to create a DB with SQLite and how to execute queries. You'll also learn how to manage the lifecycle of a DB from the creation to the upgrade or downgrade of versions.
- **Chapter 4: Content Provider**: Android also provides an abstraction on top of a DB SQLite or memory, that allows different applications to communicate and share information safely and securely. You can do this using ContentProvide which is one standard component of Android. In this chapter, you'll learn how to create a ContentProvider and how to use it to make applications to communicate.

Chapter 1: Using Files

By Jennifer Bailey

There are many ways to store data in an Android app. One of the most basic ways is to use **files**. Similar to other platforms, Android uses a disk-based file system that you can leverage programmatically using the **File API**. In this chapter, you'll learn how to use files to persist and retrieve information.

Reading and writing files in Android

Android separates the available storage into two parts, **internal** and **external**. These names reflect an earlier time when most devices offered built-in, non-volatile memory (internal storage) and/or a removable storage option like a Micro SD card (external storage). Nowadays, many devices partition the built-in, permanent storage into separate partitions, one for internal and one for external. It should be noted that external storage does not indicate or guarantee that the storage is removable.

There are a few functional differences between internal and external storage:

- **Availability**: Internal storage is always available. External storage, on the other hand, is not. Some devices will let you mount external storage using a USB connection or other option; this generally makes it removable.
- **Accessibility**: By default, files stored using the internal storage are only accessible by the app that stored them. Files stored on the external storage system are usually accessible by everything — however, you can make files private.

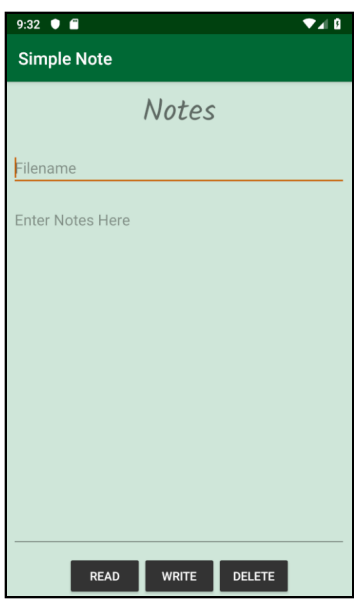
- **Uninstall Behavior**: Files saved to the internal storage are removed when the app is uninstalled. Files saved to the external storage are not removed, even when the app is uninstalled. The exception to this rule is if the files are saved in the directory obtained by `getExternalFilesDir`.

If you're unsure which method to use, here's a hint: Use internal storage when you don't want the user or any other apps to access the files, like important user documents and preferences. Use external storage when you want to allow users or other apps access to the files. This might include images you capture within the app.

Getting started

To get started, you'll build an app that uses internal storage. Inside this chapter's folder resources, locate **using-files** and open **projects**. Once there, open **SimpleNote** located inside **starter**. Wait for the project to sync, download its dependencies and set up the workplace environment. When finished, run the app on a device or in the simulator. For now, you can ignore the warnings in the code.

This app has a simple user interface with two `EditTexts`, one for the filename and one for a note. There are also three buttons along the bottom: **READ**, **WRITE** and **DELETE**. The user interface looks like this:



The SimpleNote App Interface

The sample for this project includes three sub-packages: **model**, **ui** and **app**.

- **model**: This package includes a simple data class to represent a single note in **Note.kt**. **NoteRepository.kt** contains the declaration of an interface with methods to add, get and delete a `Note`. `ExternalFileRepository`, `InternalFileRepository` and `EncryptedFileRepository` are classes that implement `NoteRepository` and override its methods. You'll be adding code to these classes later.
- **ui**: This package includes **MainActivity.kt**. `MainActivity` implements the `OnClick` methods for each button. Because the code to read, write, encrypt and delete is abstracted behind `NoteRepository` and placed into separate classes, the code to handle the button click events remains the same regardless of the type of storage being utilized. This code is dependent on a single repository, and only the concrete type of the repository needs to change.
- **app**: This package includes **Utility.kt**, which contains a utility function to produce `Toast` messages.

Using internal storage

The internal storage, by default, is private to your app. The system creates an internal storage directory for each app and names it with the app's **package name**. When you uninstall the app, files saved in the internal storage directory are deleted. If you need files to persist — even after the app is uninstalled — use external storage.

Are you ready to see internal storage in action?

Writing to internal storage

Open **MainActivity.kt**. Notice the code immediately above `onCreate()`:

```
private val repo: NoteRepository by lazy
{ InternalFileRepository(this) }
```

This is a lazy value. It represents an object of a class that implements `NoteRepository`. There's a separate implementation for each storage type demonstrated in this chapter.

The `repo` is initialized the first time it's used and will be utilized throughout **MainActivity**. This includes the button click events that call the add, get and delete methods required by `NoteRepository`.

In `onCreate()`, locate `btnWrite.setOnClickListener` add the following code for the **WRITE** button's click event:

```
// 1
if (edtFileName.text.isNotEmpty()) {
  // 2
  try {
    // 3
    repo.addNote(Note(edtFileName.text.toString(),
        edtNoteText.text.toString()))
  } catch (e: Exception) { // 4
    showToast("File Write Failed")
  }
  // 5
  edtFileName.text.clear()
  edtNoteText.text.clear()
} else { // 6
  showToast("Please provide a Filename")
}
```

Here's how it works:

1. Use an `if/else` statement to ensure the user entered the required information.
2. Put `repo.addNote` into a `try/catch` block. Writing a file can fail for different reasons like permissions or trying to use a disk with not enough space available.
3. Call `addNote()`, passing in a `Note` that contains the filename and text provided in the `EditText` fields.
4. If writing the file fails, display a `Toast` message and write the stacktrace of the error to Logcat.
5. To prepare the interface for the next operation, clear the text from `edtFileName` and `edtNoteText`.
6. If the user did not enter a filename, display a toast message within the `else` block. `showToast` is a utility function that exists in **Utility.kt**.

The code for the **READ** and **DELETE** button click events are similar to what you added for the **WRITE** button; these already exist in the sample project.

It's time for the next step!

Open **InternalFileRepository.kt** and locate `addNote`. Then, add the following to the body of the method:

```
context.openFileOutput(note.fileName, Context.MODE_PRIVATE).use
{ output ->
  output.write(note.noteText.toByteArray())
}
```

This code opens the file in `fileOutputStream` using the `Context.MODE_PRIVATE` flag; using this flag makes this file private to this app. The `FileOutputStream` is a `Closeable` resource so we can manage it using the `use` Kotlin function. The note's text is converted to a `ByteArray` and written to the file.

Run the program. Enter **Test.txt** for the file name and some text for the note. When you're ready, tap the **WRITE** button. If the write is successful, the `EditText` controls will clear. Otherwise, the stacktrace is printed to Logcat.

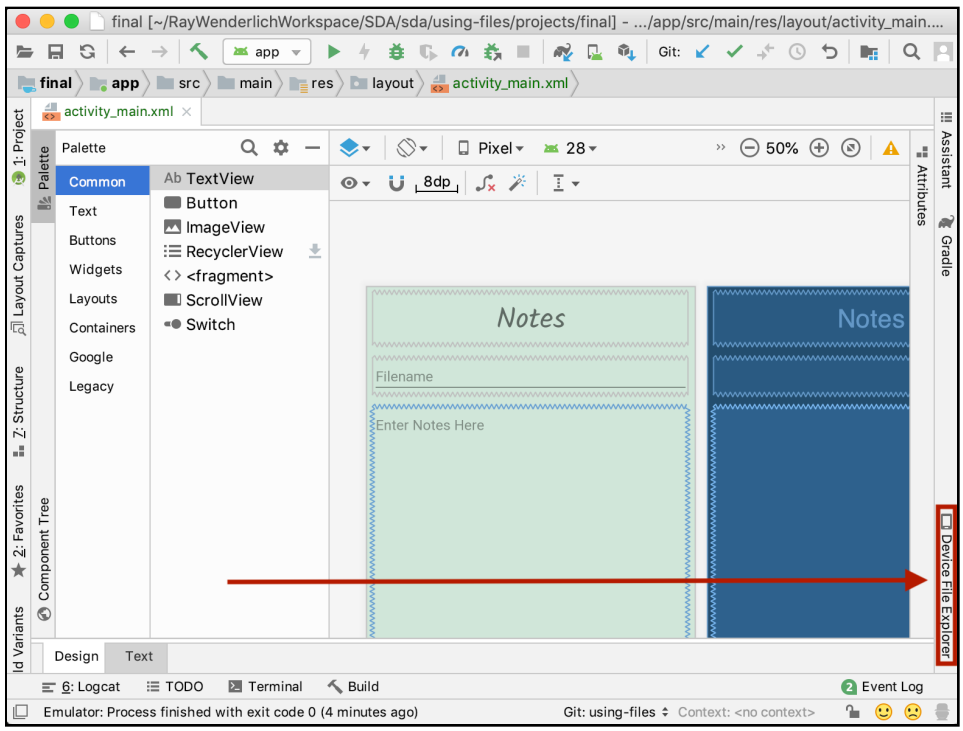
Now that you've learned how to read, write and delete files on the internal storage, wouldn't it be nice to see a visual representation of the files in the file system?

Viewing the files in Device File Explorer

In Android Studio, there's a handy tool named **Device File Explorer**. This tool allows you to view, copy and delete files that are created by your app. You can also use it to transfer files to and from a device.

> **Note**: A lot of the data on a device is not visible unless the device is rooted. For example, in **data/data/**, entries corresponding to apps on the device that are not debuggable are not expandable in the Device File Explorer. Much of the data on an emulator is not visible unless it's an emulator with a standard Android (AOSP) system image. Be sure to enable USB debugging on a connected device.

Open the Device File Explorer by clicking **View ▸ Tool Windows ▸ Device File Explorer** or by clicking the **Device File Explorer** tab in the window toolbar.

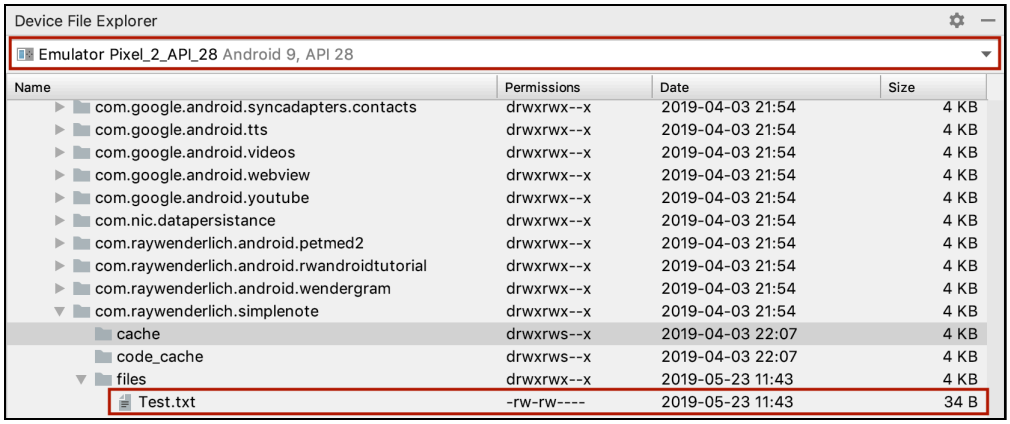


The Button to Open the Device File Explorer

The Device File Explorer displays the files on your device. Scroll down and locate the **data** folder. Open **data > data > com.raywenderlich.simplenote > files**; you'll see **Test.txt** and any other files you've saved. Files are saved in a directory with the same name as the app's package name.

> **Note**: The file location depends on the device; some manufacturers tweak the file system, so your app directory might not be where you expect it. If that's the case, you can locate the folder using the app's package name as this never changes.

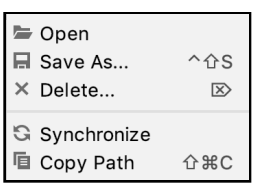
The files stored on the external storage are located in **sdcard/data/app_name/**.



Seeing the File in Device File Explorer

At the top of the Device File Explorer, there's a drop-down you can use to select the device or emulator. After making your selection, the files appear in the main window. You can expand the directories by clicking the triangle to the left of the directory name.

Right-click the filename, and a menu pops-up that allows you to perform different operations on the file.



Seeing the File in Device File Explorer

1. **Open** lets you open the file in Android Studio.
2. **Save As...** lets you save the file to your file system.
3. **Delete** allows you to delete the file.
4. **Synchronize** synchronizes the file system if it's changed since the last run of the app.
5. **Copy Path** copies the path of the file to the clipboard.

Now that you know how to write a file to internal storage and use the Device File Explorer to see what files are available, it's time to learn how to make your app read them.

Reading from internal storage

Replace the current `return` statement in the `getNote` in **InternalFileRepository** with the current code:

```
// 1
val note = Note(fileName, "")
// 2
context.openFileInput(fileName).use { stream ->
  // 3
  val text = stream.bufferedReader().use {
    it.readText()
  }
  // 4
  note.noteText = text
}
// 5
return note
```

Here's how it works:

1. Declare a `Note`, passing in a `fileName` and an empty string so that a valid object gets returned from this function even if the read operation fails.
2. Open and consume the `FileInputStream` with `use`.
3. Open a `BufferedReader` with `use` so that you can efficiently read the file.
4. Assign the text that was read to the file to `note.noteText`.
5. Return `note`.

Run the app and enter the name of a file you previously saved and then tap **READ**. The note's text displays in the app. And that's it! Your app can now write and read notes.

Up next, you'll write the code to delete a file.

Deleting a file from internal storage

Replace the existing `return` statement for the`deleteNote` function in **InternalFileRepository** with the following line of code:

```
return noteFile(fileName).delete()
```

The `delete` function of the `File` class returns a `Boolean` value to indicate whether the delete operation was successful; this function returns that value to where it was called in `MainActivity`.

Build and run the app. Delete a file by tapping the **DELETE** button; you'll see the appropriate message.

To confirm the file was deleted, use the Device File Explorer or try to delete the file a second time. If everything worked as expected, you'll see a message that indicates the file could not be deleted (because it's already gone).

Internal storage is great for storing private data in an app. But what if you want to store data temporarily? To do this, you can use **Internal Cache Files**.

Internal cache files

Each app has a special and private cache directory to store temporary files. Android may delete these files when the device is low on internal storage space, so it's not safe to store anything other than temporary files in this space. There's also no guarantee that Android will delete these files for you, so you must maintain this directory yourself.

To write to the internal cache directory, use `createTempFile` as shown in the following example:

```
File.createTempFile(filename, null, context.cacheDir)
```

A good use case for temporary files is when you're uploading images to a server. You may not need the image persisted on the device, but you still need to upload *some* file. In this case, a temporary file works well. You'd store the image in this temp file, upload it, and then delete the file upon completion.

Now that you have utilized the important features of internal storage, it's time to look at how to store files on **External Storage**.

Using external storage

External storage is appropriate for user data that you want to make accessible to the user or other apps. Files saved on the external storage system are not deleted — even when the app is uninstalled. The external storage is made up of standard public directories. Files saved to the external storage are world-readable, by default, and can be modified by enabling mass storage and transferring the files to the computer via USB.

External storage is not guaranteed to be accessible at all times; sometimes it exists on a physically removable SD card. Before attempting to access a file in external storage, you must check for the availability of the external storage directories, as well as the files. You can also store files in a location on the external storage system, where they **will be deleted** by the system when the user uninstalls the app.

Now that you know a bit more about external storage possibilities, it's time to modify the app to use external rather than internal storage. You'll start by adding the necessary permissions to the manifest.

Adding permissions in the manifest

To use external storage, you must first add the correct permission to the manifest. If you wish to only **read** external files, use the **READ_EXTERNAL_FILE** permission.

```
<uses-permission
  android:name="android.permission.READ_EXTERNAL_STORAGE" />
```

If you want to both **read and write**, use the **WRITE_EXTERNAL_STORAGE** permission.

```
<uses-permission
  android:name="android.permission.WRITE_EXTERNAL_STORAGE" />
```

Beginning with API level 19, reading or writing files in your app's **private** external storage directory does not require the above permissions. If your app supports Android API level 18 or lower, and you're saving data to the private external directory only, you should declare that the permission is requested only on the lower versions of Android by adding the `maxSdkVersion` attribute:

```
<uses-permission
  android:name="android.permission.WRITE_EXTERNAL_STORAGE"
  android:maxSdkVersion="18" />
```

In this app, you'll be reading and writing to the external storage, so add the **WRITE_EXTERNAL_STORAGE** permission inside the `<manifest>` element in **AndroidManifest.xml**.

Writing the notes to external storage

Now that the correct permissions are in place, it's time to write the file to the external storage. Open **ExternalFileRepository.kt** and add the following code to `addNote`:

```
// 1
if (isExternalStorageWritable()) {
  // 2
  FileOutputStream(noteFile(note.fileName)).use { output ->
    output.write(note.noteText.toByteArray())
  }
}
```

Here's how it works:

1. Check to see if the external storage is available.
2. Open a `FileOutputStream` with `use`.
3. Write `note.noteText` to the file.

Next, in **MainActivity.kt**, change the instance of the `NoteRepository` you're initializing to the following:

```
private val repo: NoteRepository by lazy
{ ExternalFileRepository(this) }
```

Finally, run the program to write a file to the external storage. To view the file using the Device File Explorer, look in **sdcard/data**, within the app's package name folder.

You'll implement the app's read function in the next step.

Reading from external storage

Replace the existing `return` statement of the `getNote` function with the following code:

```
val note = Note(fileName, "")
// 1
if (isExternalStorageReadable()) {
  // 2
  FileInputStream(noteFile(fileName)).use { stream ->
    // 4
    val text = stream.bufferedReader().use {
      it.readText()
    }
    // 5
    note.noteText = text
  }
}
return note
```

For the most part, the procedure here is the same as reading from the internal storage but with a small difference. Here's how it works:

1. Ensure the external storage is readable.
2. Open and consume the `FileInputStream`, with `use`, as you did before.
3. Open a `BufferedReader` with `use` so that you can efficiently read the file.
4. Assign the text that was read to the file to `note.noteText` and return the `note`.

The above code also relies on the following two functions:

```
fun isExternalStorageWritable(): Boolean {
  return Environment.getExternalStorageState() ==
Environment.MEDIA_MOUNTED
}

fun isExternalStorageReadable(): Boolean {
  return Environment.getExternalStorageState() in
      setOf(Environment.MEDIA_MOUNTED,
Environment.MEDIA_MOUNTED_READ_ONLY)
}
```

The `isExternalStorageWritable` function determines if the external storage is mounted and ready for read/write operations, whereas `isExternalStorageReadable` determines only if the storage is ready for reading.

After writing and reading files, you're ready to add the capability to delete a file from external storage.

Deleting a file from external storage

Insert the following code into `deleteNote` in the **ExternalFileRepository.kt** file:

```
return isExternalStorageWritable() &&
noteFile(fileName).delete()
```

The first part of the condition checks if the external storage can be written to or altered; the second part, if the first condition is true, returns the result of deleting the file. This way, you can be sure that the file will be deleted only if you can manipulate external storage.

Securing user data with a password

Security is important for the credibility of your app, especially when it comes to securing users' private data. Storing data on external storage allows the data to be visible to other apps. That's why, as a general rule, it's advised to avoid using external storage. Or at least doing so, without a strong security system and encryption.

You can prevent users from installing apps on external storage altogether. Even when an app-only uses internal storage, having it installed on external storage could allow user to copy your app binary and data. To prevent users from installing the app on external storage you can add `android:installLocation` with a value of `internalOnly` to the manifest file.

Another best practice you can use to enhance your app's security is to prevent the contents of the app's private data directory from being downloaded with `adb backup`. You do this by setting the `android:allowBackup` attribute to `false` in the manifest file. This overrides the default value of `true`.

Although these are good strategies to use to secure your app's files, the user can undermine them if the device is compromised or rooted. Even the built-in disk encryption is ineffective if the device is not secured with a lock screen.

One way to secure your data beyond the best practices listed above is to encrypt the files before writing them to the external file system with a user-provided password.

Using AES and Password-Based Key Derivation

The recommended standard to encrypt data with a given key is the **AES (Advanced Encryption Standard)**. In this example, you'll use the same key to encrypt and decrypt data - known as symmetric encryption. The preferred length of the key is 256 bits for sensitive data.

It's not realistic to rely on the user to select a strong or unique password, that's why it's never recommended to use passwords directly to encrypt the data. Instead, produce a key based on the user's password using **Password-Based Key Derivation Function** or **PBKDF2**.

PBKDF2 produces a key from a password by hashing it over many times with **salt**. This creates a key of a sufficient length and complexity, and the derived key will be unique even if two or more users in the system used the same password.

In this example, a `String` that represents the user's password has been hardcoded at the top of **EncryptedFileRepository.kt**: `val passwordString = "Swordfish"`.

Find `encrypt` and add the code inside the empty `try` block, replacing the `TODO`:

```
// 1
val random = SecureRandom()
// 2
val salt = ByteArray(256)
// 3
random.nextBytes(salt)
```

Here's how it works:

1. Generate a random value using the `SecureRandom` class. This guarantees the output is difficult to predict as `SecureRandom` is a cryptograpically strong random number generator.
2. Create a `ByteArray` of 256 bytes to store the **salt**.
3. Pass the salt to `nextBytes` which will fill the array with 256 random bytes.

Next, add the following code to the `random.nextBytes` call to *salt* the password.

```
// 4
val passwordChar = passwordString.toCharArray()
// 5
val pbKeySpec = PBEKeySpec(passwordChar, salt, 1324, 256) //1324
iterations
// 6
val secretKeyFactory =
SecretKeyFactory.getInstance("PBKDF2WithHmacSHA1")
// 7
val keyBytes =
secretKeyFactory.generateSecret(pbKeySpec).encoded
// 8
val keySpec = SecretKeySpec(keyBytes, "AES")
```

Here's how it works:

4. Convert the password into a character array.
5. Pass the password in `char[]` form, along with the salt, to `PBEKeySpec`, as well as the number of iterations, `1324`, and the size of the key, `256`. Increasing the number of iterations also increases the time it would take to operate on a set of keys during a brute-force attack.

6. Generate an instance of a `SecretKeyFactory` using **PBKDF2WtihHmacSHA1**.
7. Pass the `pbKeySpec` to the `secretKeyFactor.generateSecret` method and assign the `encoded` property which returns the key in bytes.
8. Finally, `keySpec` is produced to use when you initialize the **Cipher**.

All of these steps seem a bit complex, but it's the kind of thing that's always the same to use; only the data changes. There are still a few steps to do, so let's get to it!

Using an initialization vector

The recommended mode of encryption when using AES is the **cipher block chaining**, or **CBC**. This mode takes each next unencrypted block of data and uses the **XOR** operation with the previous encrypted block. One problem with this procedure is that the first block is less unique as subsequent blocks. If one encrypted message started the same as another message, the beginning blocks of the two messages would be the same. This would help an attacker to find out what the message(s) are. To solve this problem, you'll create an **initialization vector** or an **IV**.

An IV is a block of random bytes that are XOR'd with the leading block of the data. All subsequent blocks are dependent on the previous block, so using an IV uniquely encrypts the entire message.

Inside `encrypt`, immediately below where you created the `keySpec`, add the following code to create an IV:

```
// 9
val ivRandom = SecureRandom()
// 10
val iv = ByteArray(16)
// 11
ivRandom.nextBytes(iv)
// 12
val ivSpec = IvParameterSpec(iv)
```

Here's what's happening:

9. Create a new `SecureRandom` object so that you're not using a cached, seeded instance.
10. Create a byte array with a size of 16 to store the IV.

11. Populate `iv` with random bytes.

12. Create the `IvParameterSpec` with the random `iv` so that you can use it when performing the encryption.

Now that you have created `keySpec` and `ivSpec` it's time to use them to encrypt a note. In the next step, add the code to create a **Cipher** and encrypt the data to be stored and place the data, the salt and the iv into **HashMap** `map` to be returned by the method.

```
// 13
val cipher = Cipher.getInstance("AES/CBC/PKCS7Padding")
cipher.init(Cipher.ENCRYPT_MODE, keySpec, ivSpec)
// 14
val encrypted = cipher.doFinal(plainTextBytes)
// 15
map["salt"] = salt
map["iv"] = iv
map["encrypted"] = encrypted
```

Here's the explanation:

13. Create and initialize the **Cipher** using **AES/CBC/PKCS7Padding**. This specifies AES encryption with cypher block chaining. PKCS7 refers to an established standard for padding data that doesn't fit into the specified block size.

14. Encrypt the bytes of the data with the `cipher`.

15. Place the `salt`, `iv`, and `encrypted` bytes into a **HashMap**.

The IV and salt are considered public and can be stored with your data. However, make sure they are not reused or sequentially incremented.

Now the encrypt method can be used to encrypt the text of a note before that text is written to a file. To finish off the encryption of the file before storing it, insert the following code into `addNote`:

```
if (isExternalStorageWritable()) {
  ObjectOutputStream(noteFileOutputStream(note.fileName)).use
{ output ->
    output.writeObject(encrypt(note.noteText.toByteArray()))
  }
}
```

The code above creates an `ObjectOutputStream` with `use` and utilizes it to write the encrypted message out to the file. Before you run the app again, you have to change the instance of the `NoteRepository` in **MainActivity.kt** to this:

```
private val repo: NoteRepository by lazy
{ EncryptedFileRepository(this) }
```

Run the app and use it to write an encrypted file. If you then find and open the file with Device File Explorer, you'll see that it's filled with unreadable data because the file is encrypted.

Now you must add a mechanism to decrypt the file.

Decrypting the file

Locate `decrypt` and add the following code:

```
private fun decrypt(map: HashMap<String, ByteArray>): ByteArray?
{
  var decrypted: ByteArray? = null
  try {
    // 1
    val salt = map["salt"]
    val iv = map["iv"]
    val encrypted = map["encrypted"]
    // 2
    val passwordChar = passwordString.toCharArray()
    val pbKeySpec = PBEKeySpec(passwordChar, salt, 1324, 256)
    val secretKeyFactory =
SecretKeyFactory.getInstance("PBKDF2WithHmacSHA1")
    val keyBytes =
secretKeyFactory.generateSecret(pbKeySpec).encoded
    val keySpec = SecretKeySpec(keyBytes, "AES")
    // 3
    val cipher = Cipher.getInstance("AES/CBC/PKCS7Padding")
    val ivSpec = IvParameterSpec(iv)
    cipher.init(Cipher.DECRYPT_MODE, keySpec, ivSpec)
    decrypted = cipher.doFinal(encrypted)
  } catch (e: Exception) {
    Log.e("SIMPLENOTE", "decryption exception", e)
  }
  // 4
  return decrypted
}
```

Here's what's happening:

1. Retrieve the `salt`, `iv` and `encrypted` fields from the **HashMap**.
2. Regenerate the key from the password.
3. Decrypt the encrypted data.
4. Return the decrypted data.

Call the decrypt function after reading the file in `getNote`.

```
val note = Note(fileName, "")
if (isExternalStorageReadable()) {
  // 1
  ObjectInputStream(noteFileInputStream(note.fileName)).use
{ stream ->
    // 2
    val mapFromFile = stream.readObject() as HashMap<String,
ByteArray>
    // 3
    val decrypted = decrypt(mapFromFile)
    if (decrypted != null) {
      note.noteText = String(decrypted)
    }
  }
}
return note
```

Here's how it works:

1. Open an `ObjectInputStream` with `use` for reading data.
2. Read the data and store it into the `HashMap`.
3. Decrypt the file with `decrypt`; if it was successful, assign the decrypt text to `note.noteText`.

Build and run the code now. Notice the weird, encrypted, obfuscated data is now decrypted and understandable again! :]

Understanding Parcelization and Serialization

In computer science, ** marshaling** or **marshaling** is the process of transforming an object into a format that is suitable for transmission or storage. Android apps often transfer data from one activity to another, where **Parcelization** and **Serialization** are the means of marshaling objects.

By default — and because your app utilized `ObjectOutputStream` to write the file — the encrypted data, iv and salt values were all **Serialized** when written to the file.

Serializable

Serializable is a standard Java tagging interface. This interface has no operation but it can be used to define the corresponding type as serializable. An object is serializable when it can be converted into an array of bytes and vice versa. If an object is **Serializable** it can also be written into a file or read from a file. Serialization is not very easy though. When you restore an object you still need a compatible version of the class used during serialization. Implementing the **Serializable** interface isn't enough - some properties are implicitly not serializable. Some examples are **Thread** or **InputStream**. The Serialization process implies the use of **reflection**.

Reflection is the ability for an object to know things about itself. Therefore, using serializable can result in a lot of garbage collection which then translates to poor performance and battery drain. Fortunately, there's another way to marshal objects in Android.

Parcelable

Parcelable, like Serializable, is an interface. However, unlike Serializable, Parcelable is part of the Android SDK, not the standard Java interface. Because it's designed not to use reflection, it requires the developer to be explicit about the marshaling process, making it more tedious to use. However, despite this complication, using Parcelable can result in better app performance — although the gain in performance is usually imperceptible to the user.

Parcelable is often used when passing data between activities in a **Bundle**.

> **Note**: The Parcelable API is not for general purposes. It's designed to be a high-performance IPC transport. It's not appropriate to place Parcel data into persistent storage because any change to the underlying implementation of the data can render the old data unreadable.

Key points

- Files are a quick way to persist data in Android.
- The internal storage is a great place to store files that are specific and private to your app.
- Use the internal cache to store temporary files.
- Use external storage to store files that you want users or other apps to have access to.
- External files are persistent, even after the app is uninstalled.
- Internal files are deleted when the app is uninstalled.
- To write files to the external storage, the correct permissions must be set in the manifest.
- Because the external storage is not secure, it's a good idea to use AES encryption with a password-based generated key.
- As a general security practice, apps that store data files should not be allowed to be installed on external storage.
- Serializable and Parcelable are ways of marshaling data for transport or storage.
- Do not use Parcelable to store persistent data; if the Parcel is changed, the old data will not be read properly.

Where to go from here?

File encryption — and encryption in general — is a broad topic. To learn more about it, read the tutorial located at https://www.raywenderlich.com/778533-encryption-tutorial-for-android-getting-started.To dig deeper into file management on Android, also read the official documentation available on the Android Developer site at https://developer.android.com/guide/topics/data/data-storage.

Chapter 2: Shared Preferences

By Jennifer Bailey

Files are a quick and convenient way to store unstructured data in Android. But there are other convenient, and more organized, ways to store small bits of data: **SharedPreferences**.

Understanding SharedPreferences

The **SharedPreferences**, or **prefs** for short, API provides the means to read and write to a file that is formatted as **XML**. The API is especially useful when you need to store things like application-wide flags to style your app, user progress, data filters and so on.

The prefs file you create, edit and can delete is stored in the **data/data/{application package name}** directory. The location of this file can be obtained programmatically by calling `Environment.getDataDirectory()`. Like files, the data is app—specific and will be lost if the application data is cleared through settings or if the app is uninstalled.

You already learned that `SharedPreferences` should not be used to store large amounts of data, but rather small features of your app. As such, the data is structured into **key—value** pairs, where each value has an identifier key, which marks its location in the file. Then, by passing in the key, you can retrieve the last value you stored. If there is no value for the key, you can specify a default that will be returned instead. Furthermore, since the point of `SharedPreferences` is to store simple data, the only supported types to store are `Int`, `Float`, `Long`, `String` and `Set<String>`.

> **Note**: They are also the location where app **Preferences** are saved. However, the two should not be confused with one another.

The first step to using `SharedPreferences` is obtaining a reference to the app—specific file, let's see how to do that!

Getting a reference to the SharedPreferences file

Depending on how you want to use `SharedPreferences`, there are different ways to access or create the `SharedPreferences` file:

- `getSharedPreferences()` can be called from any `Context` in your app and allows you to specify a name for the file. It is handy if you need multiple `SharedPreferences` files with different names.
- `getPreferences()` is called from an `Activity` and does not allow you to specify a file name because it uses the default class name of that `Activity`. It is handy if you need to create different preference files for different activities.
- `getDefaultSharedPreferences()` is used for app settings and preferences at the **app level**, and returns the default prefs file for the entire app. You can use this to store data that is useful for your entire app, or features you set up every time a user starts your app.

But getting preferences is only half of the work. You still need to read and write data to the prefs.

Reading from preferences

Reading from prefs is pretty straightforward. Once you get ahold of a preference file, you can use aptly named functions to read the variables of the data types mentioned earlier in this chapter. You can use functions such as `getInt()`, `getString()` and `getLong()`, passing in a key and an optional default value to get the stored value. An example call, to get a `String`, by the key `username`, with a default value of an empty `String` is as follows: `preferences.getString("username", "")`.

You will learn more about reading data through the chapter's project, but for now, let's see how to write some data to `SharedPreferences`.

Writing to preferences

Writing to the `SharedPreferences` is slightly more complicated. To write to the file you must open it for editing, by creating an **Editor**. You can do that using `edit()` on your `SharedPreferences`. The **SharedPreferences.Editor** is essentially a pointer to the `SharedPreferences` file, in the app's data directory. Then you pass key—value pairs to methods such as `putInt()`, `putString()` and `putLong()`. Once the key—value pairs have been added to the **Editor**, call either `apply()` or `commit()` to finalize the changes, and save to the file.

Generally, it is a good practice to choose `apply()` to write the `SharedPreferences`. `apply()` will write the changes to the object out immediately, but then saves those changes to the disk asynchronously. If two `Editors` try to use `apply()` at the same time, the last one to call the function will be the one that has its changes saved. `apply()` will complete before the app switches states so you don't have to worry about it interfering with the lifecycle of your app. `commit()` writes the changes synchronously which can block the main thread and result in the app locking up, until everything is properly stored.

Now, it's time to look at an example of `SharedPreferences` in action.

Getting started

To get started with prefs, locate this chapter's folder in the provided materials named **using-sharedpreferences**, and open up the **projects** folder. Next, open the **organizedsimplenotes** app under the **starter** folder. Allow the project to sync, download dependencies and set up the workplace environment. Run the app on a device or in a simulator. For now, ignore any warnings in the code.

The app allows you to create, edit and delete notes that are saved in the internal file system. In the options menu items, there is an option to change the background color. You can also filter the notes by priority, or sort them by a specific sort order. Select a new background color, sort order and one or more priority filters. Now, quit the app and rerun it.

When the app reloads, the background color you selected persists. That is because the background color you selected was saved to prefs and applied when the app was rerun. The sort order and priority filters reset to defaults. They were not stored in prefs.

To see the saved value for the background color, open the **Device File Explorer** in Android Studio, as you did in the previous, chapter and navigate to the **data/data/com.raywenderlich.organizedsimplenote/shared_prefs** directory. You will see a file named **com.raywenderlich.organizedsimplenote_preferences.xml**. If you open the file, you will see something similar to the following, depending on the color you chose:

```
<?xml version='1.0' encoding='utf-8' standalone='yes' ?>
<map>
  <string name="NOTE_BACKGROUND_COLOR">Orange</string>
</map>
```

In the next steps, you will add the code to save and retrieve the sort order and priority filters to and from the prefs so that these settings can persist between runs of the app along with the background color.

Saving the user preferences

First, you have to create some constants which will represent the keys for the key—value pairs of data you need to save. Open **NotePrefs.kt** and insert the following declarations right below the declaration of `DEFAULT_PRIORITY_FILTER`:

```
  private const val KEY_NOTE_SORT_PREFERENCE =
"note_sort_preference"
  private const val KEY_NOTE_PRIORITY_SET = "note_priority_set"
```

Next, you have to create the function to write the sort order to the prefs file. Insert the code below into `saveNoteSortOrder()`, replacing the `TODO`:

```
sharedPrefs.edit()
    .putString(KEY_NOTE_SORT_PREFERENCE, noteSortOrder.name)
    .apply()
```

This code retrieves the **Editor** object from the app's prefs and puts the sort order in the preferences as a `String` with the key `KEY_NOTE_SORT_PREFERENCE`. It then uses `apply()` so that the changes will be written asynchronously to the disk.

Now, provide the code to write the selected priority filters. Insert the code below into `saveNotePriorityFilters()`, once again replacing the `TODO`:

```
sharedPrefs.edit()
    .putStringSet(KEY_NOTE_PRIORITY_SET, priorities)
    .apply()
```

The previous code puts `priorities`, a `Set` of `Strings`, representing the selected priority filters, into the prefs using `putStringSet()` with the key `NOTE_PRIORITY_SET`.

Awesome! The functions to write to the prefs are done. Next, you'll add the code to read the values.

Reading the user preferences

Currently, `getNoteSortOrder()` returns the default value of `NoteSortOrder.FILENAME_ASC`. Replace the returned value with the following:

```
NoteSortOrder.valueOf(
  sharedPrefs.getString(KEY_NOTE_SORT_PREFERENCE,
DEFAULT_SORT_ORDER)
      ?: DEFAULT_SORT_ORDER
)
```

The above code uses `getString()` to retrieve the sort order the user stored, or `FILENAME_ASC` as the default value if the key `KEY_NOTE_SORT_PREFERENCE` does not exist.

Next, write the function to read the priority filters. Right now `getNotePriorityFilters()` returns an empty `Set`. Replace `setOf()` with the following:

```
sharedPrefs.getStringSet(KEY_NOTE_PRIORITY_SET,
setOf(DEFAULT_PRIORITY_FILTER))
      ?: setOf(DEFAULT_PRIORITY_FILTER)
```

The code above reads a `Set` of `Strings` from the prefs with the key `KEY_NOTE_PRIORITY_SET`, and if nothing is found with that key, it will use a set with the priority of `"1"` inside, as the default.

Now that the functions to read and write the sort order and priority filters are written, you can use these functions in the `MainActivity`.

Reading and writing the prefs from MainActivity

Right now, in **MainActivity.kt**, you're using hardcoded values for the sort order and the priority filters, which you pass on to the `NoteAdapter`, to display notes in a different order and filter which notes should be in the list. The right way to do this, which involves `SharedPreferences`, is to read a user's preferred ways of sorting and filtering, from prefs, and then passing those values to the `NoteAdapter`.

To do this, change the way you create the `priorities` `Set` by changing the statement to the following:

```
private val priorities by lazy
{ notePrefs.getNotePriorityFilters().toMutableSet() }
```

Instead of creating an empty mutable set and then adding values to it, you're now reading from the preferences, in a lazy way. Once you create the `NoteAdapter`, the value will be assigned and you can use the `priorities`.

Another change you have to make is the creation of the `NoteAdapter`:

```
private val noteAdapter: NoteAdapter by lazy {
  NoteAdapter(this,
      priorities,
      notePrefs.getNoteSortOrder(), // Read from preferences
      ::showEditNoteDialog
  )
}
```

Instead of passing in a hardcoded value for `FILENAME_ASC` as the `NoteSortOrder`, you're reading from the preferences to get the ordering the user previously selected.

> **Note**: Do not attempt to modify a string set read from the prefs. The results can be unpredictable. Always make a copy of the set instead, if it is going to be modified, like in the case of this app. You can do that by calling `toMutableSet()`, because Kotlin internally creates a new object, instead of just copying the `Set` value.

The app can now load the saved preferences when the app launches, but it also needs to store the values anytime the menu options change. To do that, find `updateNoteSortOrder()` and insert the following, replacing the `TODO`:

```
notePrefs.saveNoteSortOrder(sortOrder)
```

The line of code above will save the `sortOrder` to the prefs. Finally, find `updateNotePrioritiesFilter()` at the bottom of the `MainActivity` and insert this line of code, once again replacing the `TODO`:

```
notePrefs.saveNotePriorityFilters(priorities)
```

The above statement will save the list of priority filters to the prefs. If you look in `onOptionsItemSelected()`, the above two functions you just wrote the code for are called anytime the appropriate menu options are changed.

Finally, run the app. You can now filter and sort notes to your heart's content and the app will save your personalized preferences. Once you come back, everything will be ready and waiting for you!

Key points

- **SharedPreferences** are a great way to store **small bits of data** for an app.
- User—specific app configuration data is often stored in `SharedPreferences`.
- **Preferences** are also stored in an app's default `SharedPreferences`, but they are not to be confused with each other.
- `SharedPreferences` are not a good choice to store structured data, like various entities, use a database for that.
- `SharedPreferences` are organized in **key—value pairs** that are ultimately written out to a file in .xml format.
- Each app has its own `SharedPreferences`. When the app is uninstalled or the data is deleted, these stored values are wiped away.
- You can create custom-named `SharedPreferences` files and store user's choices in them.

- To edit `SharedPreferences`, you first have to fetch its **Editor**, by calling `edit()`.
- When writing `SharedPreferences`, use `apply()` instead of `commit()` to perform an asynchronous, thread—safe write.

Where to go from here?

- The tutorial here https://www.raywenderlich.com/2705552-introduction-to-android-activities-with-kotlin on the utilization of SharedPreferences.
- To view the documentation on SharedPreferences, visit the developer guide here: https://developer.android.com/training/data-storage/shared-preferences.
- To read more about SharedPreferences, see the documentation found here: https://developer.android.com/reference/android/content/SharedPreferences.

Chapter 3: SQLite Database

By Jennifer Bailey

Using **files** and **shared preferences** are two excellent ways for an app to store small bits of data. However, sometimes an app needs to store larger amounts of data in a more structured manner, which usually requires a database. The default database management system (DBMS) that Android uses is called **SQLite**. SQLite is a library that provides a DBMS, based on SQL. Some distinctive features of SQLite include:

- It uses dynamic types for tables. This means you can store a value in any column, regardless of the data type.
- It allows a single database connection to access multiple database files simultaneously.
- It is capable of creating in-memory databases, which are very fast to work with.

Android provides the APIs necessary to create and interact with SQLite databases in the `android.database.sqlite` package.

Although these APIs are powerful and familiar to many developers, they are low-level and do require some time and effort to use. Currently, it is recommended to use the **Room Persistence Library** instead, which will provide an abstraction layer for accessing the data in your app's SQLite databases. One disadvantage to using the SQLite APIs is that there is no compile-time verification of the raw SQL queries, and if the database structure changes, the affected queries have to be updated manually. Another is that you need to write a lot of boilerplate code to connect and transform SQL queries and data objects.

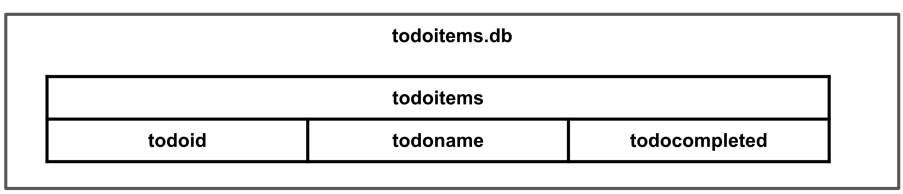
If you have written an app in the past that utilizes the SQLite APIs in Java, this chapter will show you how to use them with Kotlin, instead. However, if you have never seen an app that utilizes the SQLite APIs, this section will show you an example of how to use them in your apps. Overall, this section will give you a greater understanding and appreciation for the new and improved **Room Persistence Libraries**.

Understanding database schemas

The first step to creating an app that reads from a SQLite database is to decide on a database **schema**. The schema is the formal declaration of how the data in a database is **structured**. It is good practice to define constants that describe the database schema in a self-documenting way in their own class or file. These can be organized into subclasses for databases with multiple tables and should be visible throughout the scope of the project.

The schema you will define is going to create a database called **todoitems.db**, with one table inside. Inside this table will be three columns:

1. The **primary key** column will be an auto incrementing `Integer` named **todoitemid**.
2. The **todoname** column will contain the actual text of the TODO item.
3. The **todoiscompleted** column will contain a `Long` value that will represent whether a TODO item is completed or not.



The database schema

Understanding CRUD operations

CRUD stands for **Create**, **Read**, **Update** and **Delete**. These are the basic operations that can be done with a database, to store, maintain and utilize data. Each in turn:

- **Create**: This operation adds a new record to the database. In **SQL** or **Structured Query Language**, this is accomplished using an **Insert into** statement.

- **Read**: The read operation **queries** the database or searches and returns zero to many records meeting a specific criteria. In SQL, this is done by using a **Select from** statement.
- **Update**: The update operation performs a change to an existing record or set of records that meet a specific criteria. In SQL, the **Update** statement is used.
- **Delete**: The delete operation is used to delete records meeting specific criteria. In SQL, the **Delete from** statement is used to delete a record.
- To specify criteria, the **Where** clause is used in SQL, along with the commands listed above.

Fortunately, the SQLite APIs in Android provide a useful class called **SQLiteOpenHelper**, which will simplify the integration with the DB. This will reduce the amount of knowledge you must have of raw SQL. However, if you would like more information about SQL and how to syntactically use it with SQLite, refer to the documentation found in the **Where to go from here?** section at the end of this chapter.

Getting started

Open the starter app for this chapter and ignore the errors you get initially. Notice there are three sections in the **com.raywenderlich.sqlitetodo** package: **Model**, **View** and **Controller**.

- **Model** contains the class **TODO**, which represents a singular item on the TODO list.
- **View** contains the **MainActivity**, which is the class used to interact with the user.
- **Controller** contains two files that serve as a bridge between the data and the interface. **ToDoAdapter** retrieves the data from the database and places it into the **RecyclerView** list, whereas **ToDoDatabaseHandler** contains the code that interacts with the database.

Now, it's time to pull open the sample project and get ready to create the database schema utlilizing a **contract class**.

Creating the database constants using a contract class

In the **Model**, create a new file and name it **TodoDbSchema.kt**. Place the following code into the file:

```
object ToDoDbSchema {
  // 1
  const val DATABASE_VERSION = 1
  // 2
  const val DATABASE_NAME = "todoitems.db"
  object ToDoTable {
    // 3
    const val TABLE_NAME = "todoitems"
    object Columns {
      // 4
      const val KEY_TODO_ID = "todoid"
      // 5
      const val KEY_TODO_NAME = "todoname"
      // 6
      const val KEY_TODO_IS_COMPLETED = "iscompleted"
    }
  }
}
```

Here's what each part is:

1. The version of the database. Manually increment this number each time the database version is new, and you need to use the version to add **update** or **migration logic**.
2. The name of the database as it will be stored in the app-specific database folder on the device.
3. The name of the table will use to store the TODO items.
4. The column that contains the **unique primary key** for each TODO item.
5. The column that contains the text of the TODO item.
6. The column that will store a value that will be used to indicate whether or not you completed a TODO item.

Now, it's time to create your own database!

Using the SQLiteOpenHelper class

SQLiteOpenHelper is a helper class designed to help manage database creation and version management. To use it, you need to create a subclass of it and implement the `onCreate`, `onUpgrade` and optionally the `onOpen` methods. This class will then open the database if it exists, create it, if it does not exist, and upgrade it when necessary. It does all these things automatically, using the above-mentioned methods.

Now that the constants are in place and you've learned a bit about **SQLiteOpenHelper**, it's time to create the database and add the CRUD operations.

Open the **ToDoDatabaseHandler.kt** file and subclass the `SQLiteOpenHelper`, by adding the following code after the **class** declaration:

```
: SQLiteOpenHelper(context, DATABASE_NAME, null,
DATABASE_VERSION)
```

The above code makes the database handler class a subclass of **SQLiteOpenHelper**. This will allow the class to utilize the Android SQLite APIs in a simpler way. Your class declaration should now look like this:

```
class ToDoDatabaseHandler(context: Context) :
    SQLiteOpenHelper(context, DATABASE_NAME, null,
DATABASE_VERSION) {
...
```

Next up, you have to give the helper the schema data required to build the database.

Creating the database

First, the database must be created if it does not already exist. This is automatically done by the `onCreate` method, which will run only when it needs to. If the database already exists, this method will not run.

> **Note**: When testing an app that utilizes SQLite, you must uninstall the app to delete the old database and reinstall the app to recreate it or completely clear the data of an app.

Add the following code to the `onCreate` method, in the `ToDoDatabaseHandler`:

```
// 1
val createToDoTable = """
  CREATE TABLE $TABLE_NAME  (
    $KEY_TODO_ID INTEGER PRIMARY KEY,
    $KEY_TODO_NAME  TEXT,
    $KEY_TODO_IS_COMPLETED  LONG );
"""
// 2
db?.execSQL(createToDoTable)
```

The parts above:

1. Assign an SQL **Create** statement which creates the table described in the schema above, to the `createToDoTable` value.

2. Run the command using the database object provided by the `SQLiteOpenHelper`.

The above method will be run anytime the app is run and the database is not found. Otherwise, the database exists, and there's no reason to recreate it.

One of the downsides of SQL, in general, is having to write the statements perfectly. Be very mindful when creating SQL statements using concatenated strings. It is very easy to make an error in doing so. It can be helpful to print the query using a `Log` statement to check to see if the string is correct. The text of the query string is also displayed at the end of an error message in **Logcat** if the app crashes with an error. Additionally, you could use a local, or a Web SQL database terminal or environment, to try and validate the statement.

Now that the database has been created, you must add a mechanism for upgrading it. Add the following code into the `onUpgrade` method:

```
// 1
db?.execSQL("DROP TABLE IF EXISTS $TABLE_NAME")
// 2
onCreate(db)
```

The above:

1. Executes the SQL statement to drop the old the table if it exists.

2. Calls onCreate again to re-create the database, this time with an upgrade.

The `onUpgrade` method is the one that the framework calls automatically when a different version of the DB is detected. This happens when an instance of the **SQLiteOpenHelper** implementation is created with a different version number in its constructor.

The implementation of this method should provide the code that is necessary to upgrade to the new version of the schema. Since this is a very simple example, you're just dropping the previous table, and recreating it, using the new schema. But in real environments, and big apps, you'd usually do something called a **migration**.

Migration is the process of updating the database, without dropping it. For example, if you decide to add a new field to the TODO model, called `toDoPriority`, you would need to change the database as well, because you need to store that field, and retrieve it, but the old database doesn't have that field defined. You would then update the version number (e.g., from `1` to `2`) and write a SQL statement, to **update the table**, by adding a new column — `toDoPriority`.

In the next steps, you will add the CRUD operations to the database handler implementation.

Using ContentValues

Before you add items to the database, it is important to understand a construct known as **ContentValues**. This is a class that allows you to store values that a **ContentResolver** can process. The information that is stored in objects of this class is stored as key-value pairs.

The key consists of the column name for the piece of information being stored, and the value consists of the value to be stored in that column. A key-value pair for each column of the database in a particular row is **put** into the **ContentValues** object before it is then handed to another method, which will resolve the content and perform the database operation.

Simply put, ContentValues are similar to a **Map** structures and are used to define the columns and the values to be used in database operations. As such, you'll use them to insert data into the database and update existing models if needed.

Adding a TODO

Add the following code in the `createToDo` function, to insert a TODO into the table:

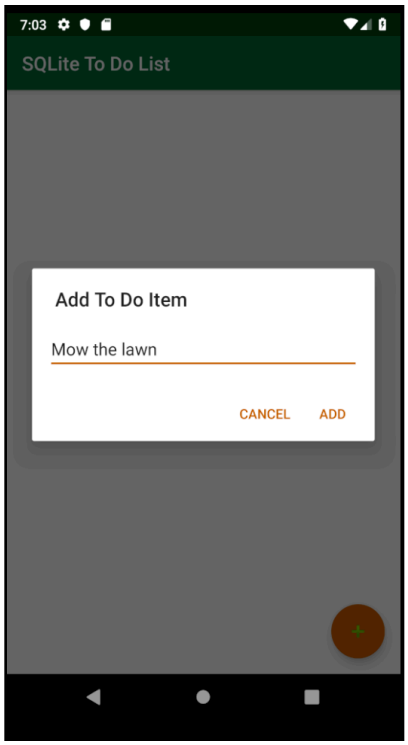
```
// 1
val db: SQLiteDatabase = writableDatabase
// 2
val values = ContentValues()
// 3
values.put(KEY_TODO_NAME, toDo.toDoName)
values.put(KEY_TODO_IS_COMPLETED, toDo.isCompleted)
// 4
db.insert(TABLE_NAME, null, values)
// 5
db.close()
```

With the above, you:

1. Get a writeable instance of the database and store it in the `db` value.
2. Create an object of the `ContentValues` class called `values`.
3. Take the text of the TODO from the `toDo` object's `toDoName` field and put it into `values`, for the `KEY_TODO_NAME` key, using `toDoName` as the pair's value.
4. Put the key-value pair for the `isCompleted` field into the `value` object, as well.
5. Close the database, to avoid potential leaks.

Running the program

Run the program on an emulator and use the **Floating Action Button** with the plus sign icon to add a TODO item:



Adding an item

When you enter the text for the item, tap the **add** button.

Now that you've added the code to create the database and added an item, take a look at the new database.

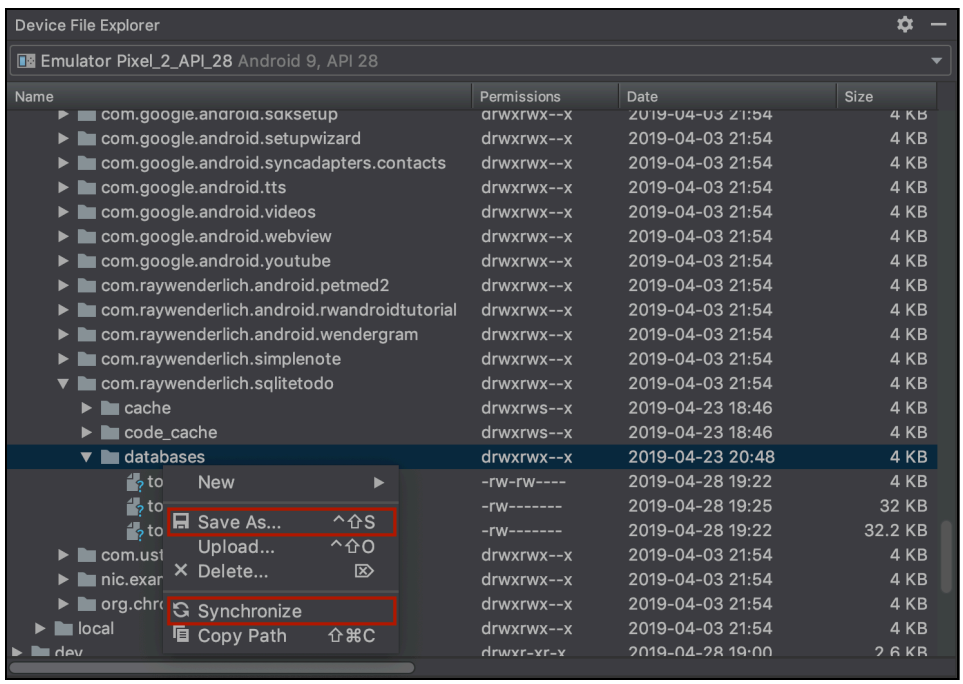
> **Note**: The item you added won't be displayed in the **RecyclerView** yet, but stay tuned; you will add that capability after a few more steps.

Viewing the SQLite database

Each app has its own folder to store databases on the device just like files. To look at the database that was just created, open the **Device File Explorer** as you did in Chapter 1, "Using Files." It can be found on the bottom right-hand corner of Android Studio as a collapsed, vertical pane.

Once in the Device File Explorer:

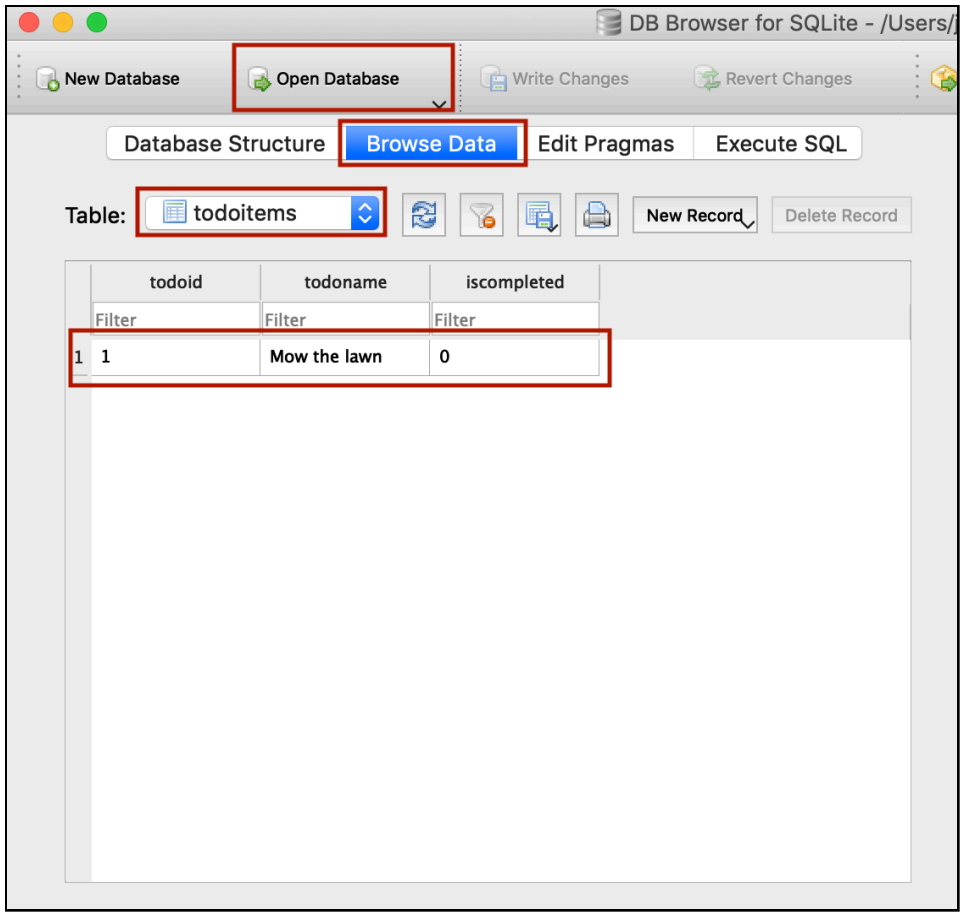
- Expand the **data** ▸ **data** ▸ **com.raywenderlich.sqlitetodo** ▸ **databases** folder.
- Right-click on the databases folder and select **Synchronize**.
- Then select **Save As...**.
- Save the entire folder to the location of your choice.



The database folder for the app and context menu of Device File Explorer

To view the database, you will need a tool that will allow you to open the .db file. A tool such as the SQLite Browser works nicely; you can find it here: https://sqlitebrowser.org/dl/. Download and install the tool.

Select **Open Database** and then select the **Browse Data** tab. Drop-down the **Table:** list and select **todoitems**. Now the records in the table will be listed in the main area of the window and you can see the record that you added, along with its unique id and completed status.



The database folder for the app and context menu of Device File Explorer

> **Note**: Another tool you can to view the database on the command line is sqlite3, which you can find, here: https://developer.android.com/studio/command-line/sqlite3.

Now that you've successfully added a record to your database and viewed it in the file system, it is time to write the rest of the CRUD operations!

Reading from a database

Before the record added in the previous step can be displayed, the app must have the capability to read the records from the database. First, the database must be queried for the records to display. Then, you will use a tool called the **Cursor** to iterate through the records and add them to a list.

Understanding the cursor

In Android, a `Cursor` is assigned to the result set of a query being run against the database. The `Cursor` is then used to iterate over the result set in a type-safe manner. It iterates through the result set **row by row**, **field by field**.

Internally, the rows of data that are returned by a query are stored in the `Cursor` reads through the data-keeping track of its current position. To start iterating, the current position must be moved to point to a valid row of data, such as the first row. Then a loop structure is utilized to keep reading while a next record exists, to read in the result set.

In the **ToDoDatabaseHandler.kt** file in the `readToDos` function replace the line of code `return ArrayList()` with the following code:

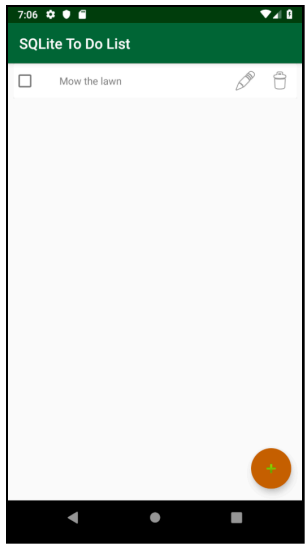
```
// 1
val db: SQLiteDatabase = readableDatabase
// 2
val list = ArrayList<ToDo>()
// 3
val selectAll = "SELECT * FROM $TABLE_NAME"
// 4
val cursor: Cursor = db.rawQuery(selectAll, null)
// 5
if (cursor.moveToFirst()) {
  do {
    // 6
    val toDo = ToDo().apply {
      toDoId =
cursor.getLong(cursor.getColumnIndex(KEY_TODO_ID))
      toDoName =
cursor.getString(cursor.getColumnIndex(KEY_TODO_NAME))
      isCompleted =
cursor.getInt(cursor.getColumnIndex(KEY_TODO_IS_COMPLETED)) == 1
    }
    // 7
    list.add(toDo)
  } while (cursor.moveToNext())
}
// 8
```

```
  cursor.close()
  // 9
  return list
```

With the above, you:

1. Get a readable instance of the database.
2. Create an `ArrayList<ToDo>` to store the records.
3. Construct the **Select** query to get the records.
4. Create a `Cursor` using the **Select** query on the database.
5. Starting at the **beginning**, use the **Cursor** to move through all the records one at a time.
6. Assign the fields of each record to the corresponding attribute of a new **TODO** item.
7. Add the **TODO** item to the `list`.
8. Close the cursor, to avoid memory leaks
9. Return the list of **TODO** items as a result.

Now, run the app, and the record added in the previous step can be displayed.



The added to-do item

So far, you've added a lot of code to the project. The app is now able to create a database, update the database, add records and read the records. Next, you will add the capability to **update an existing record**, and finally, to **delete records**.

Updating a TODO

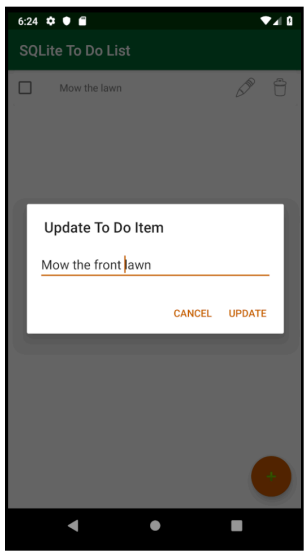
To add the capability to update a record, replace the line of code `return 0` in the `updateToDo` function with the code below:

```
// 1
val todoId = toDo.toDoId.toString()
// 2
val db: SQLiteDatabase = writableDatabase
// 3
val values = ContentValues()
values.put(KEY_TODO_NAME, toDo.toDoName)
values.put(KEY_TODO_IS_COMPLETED, toDo.isCompleted)
// 4
return db.update(TABLE_NAME, values, "$KEY_TODO_ID=?",
arrayOf(todoId))
```

With this code, you:

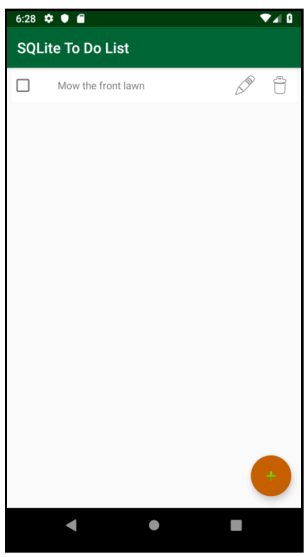
1. Prepare the `todoId` argument, for the **Update** clause.
2. Get a writable instance of the database.
3. Create a **ContentValues** object to contain the key/value pairs, and put the TODO item's property values in it.
4. Run the update query on the database and return the result of the operation.

Run the app. Tap the **edit icon** that looks like a pencil next to the record. Update the record to a new value and tap **Update**.



Update a record

Now, the record should reflect any changes you made as it is displayed in the **RecyclerView**.



Updated record

> **Note**: The update function you just completed is used in multiple places in the app. First, it was used in the previous example when changes were made to the name of the TODO item. The app also updates TODO items when the completed checkbox is checked.

There is one more bit of functionality to add to this app. The app must also be able to delete TODO items.

Deleting a TODO

In order to delete an item from the database, add the following code to the `deleteToDo` function:

```
val db: SQLiteDatabase = writableDatabase
db.delete(TABLE_NAME, "$KEY_TODO_ID=?", arrayOf(id.toString()))
db.close()
```

The above section of code simply gets an instance of the writeable database, runs a **Delete** command against it utilizing the correct TODO item **id**, and closes the database. Run the app and tap the **Delete** icon that looks like a wastebasket and the TODO item magically disappears.

You have successfully written all the CRUD operations for this TODO list app! Now, before you are finished, you will add a unit test to the program with **Robolectric** to see how to unit test the **model** portion of the program.

Unit Testing with Robolectric

You're able to view the contents of the database using the command line or a third-party tool. Wouldn't it also be nice to run a JUnit test on the model portion of the app? This can often be overlooked in the development and testing process.

To create some simple unit tests, you will use a framework called **Robolectric**. Simply put, Robolectric is a framework that allows you to write Android-powered unit tests and run them on a desktop JVM while still using the Android API. Robolectric enables you to run your Android tests in your integration environment without any additional setup, which makes it a convenient choice.

Now, you will create a unit test to test the **insert** functionality of the database to determine if the names of the TODO items are inserting into the database correctly.

To get started, open **build.gradle(Module:app)** and add the following code into the **android** section:

```
testOptions {
  unitTests {
    includeAndroidResources = true
  }
}
```

This will tell gradle to use the `includeAndroidResources` flag, and the name pretty much explains what that means! Next, add the following dependency in the **dependencies** section:

```
testImplementation "org.robolectric:robolectric:3.6.1"
```

Sync the gradle file after making these changes. Next, open **ToDoDatabaseHandler.kt** and add the following code inside the class, after `deleteToDo()`:

```
// 1
fun clearDbAndRecreate() {
  clearDb()
  onCreate(writableDatabase)
}

fun clearDb() {
  writableDatabase.execSQL("DROP TABLE IF EXISTS $TABLE_NAME")
}

// 2
fun getAllText(): String {
  var result = ""
  val cols = arrayOf(KEY_TODO_NAME, KEY_TODO_IS_COMPLETED)
  val cursor = writableDatabase.query(TABLE_NAME, cols,
      null, null, null, null, KEY_TODO_ID)
  val indexColumnName =
cursor.getColumnIndexOrThrow(KEY_TODO_NAME)
  while (cursor != null && cursor.moveToNext()) {
    result += cursor.getString(indexColumnName)
  }

  cursor.close()
  return result
}
```

Here's what's happening above:

1. You will erase and recreate the database once the testing is done. This will allow the test to be run multiple times and ensure that residual test data isn't left in the database.
2. `getAllText()` has one job, to create a `String` that consists of the TODO item names in the database all concatenated together. In the test you will write, you will see if the database contains the values you expect to see after inserting a few items.

Now, to create the test. Unit tests are contained in the **test** folder. Right click on **com.raywenderlich.sqlitetodo (test)** and select **New** > **Kotlin File/Class**. Name the class **ToDoDatabaseTest** and click **OK**. Open the file and add the code:

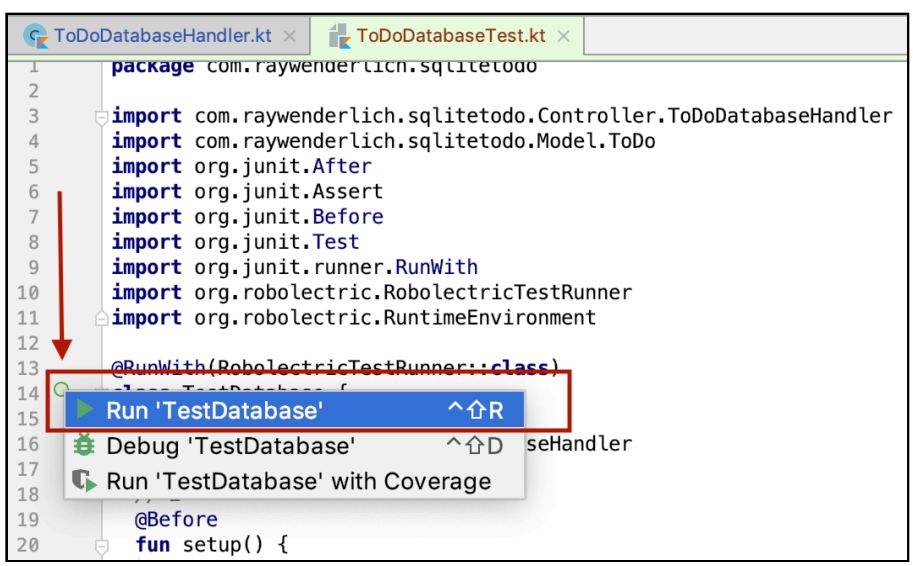
```
@RunWith(RobolectricTestRunner::class)
class TestDatabase {
  // 1
  lateinit var dbHelper: ToDoDatabaseHandler

  // 2
  @Before
  fun setup() {
    dbHelper =
ToDoDatabaseHandler(RuntimeEnvironment.application)
    dbHelper.clearDbAndRecreate()
  }


  @Test
  @Throws(Exception::class)
  fun testDbInsertion() {
    // 3
    // Given
    val item1 = ToDo(0, "Test my Program", false)
    val item2 = ToDo(0, "Test my Program Again", false)

    // 4
    // When
    dbHelper.createToDo(item1)
    dbHelper.createToDo(item2)

    // 5
    // Then
    val allText = dbHelper.getAllText()
    val expectedData = "${item1.toDoName}${item2.toDoName}"
    Assert.assertEquals(allText, expectedData)
  }

  // 6
```

```
    @After
    fun tearDown() {
      dbHelper.clearDb()
    }
  }
```

With the above, you:

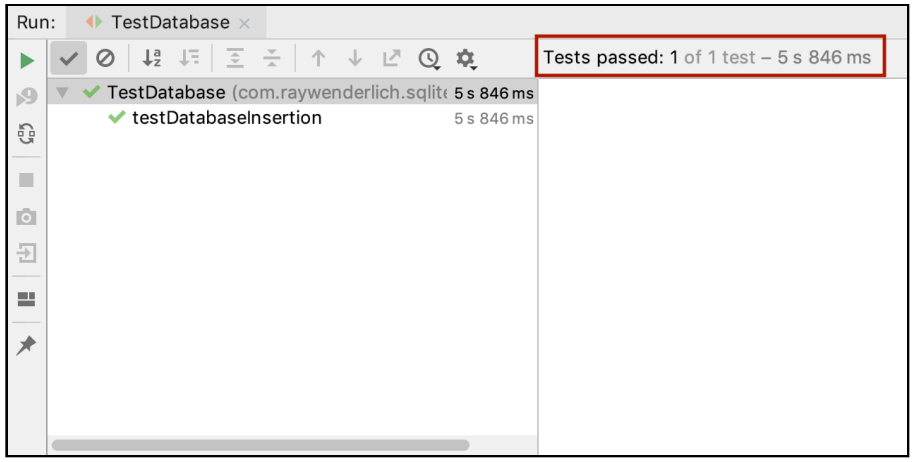
1. First, declare a database helper property, which you will test.
2. Perform setup by initializing the database, then clear and recreate the database to start with a fresh copy every time. The function annotated with `@Setup` will be the first function to run before every test.
3. The test is written in **cucumber style** or **Given/When/Then**. You first create two TODO items with two different names. Given those items...
4. ...when they are added to the database...
5. ...then Assert that **getAllText** matches the expected value.
6. Clear the database after the test, just to be sure.

To run the test, click the green arrow next to the class declaration and select **Run 'TestDatabase'**:



Run the test

Then you can see the result of the test at the bottom of the screen:

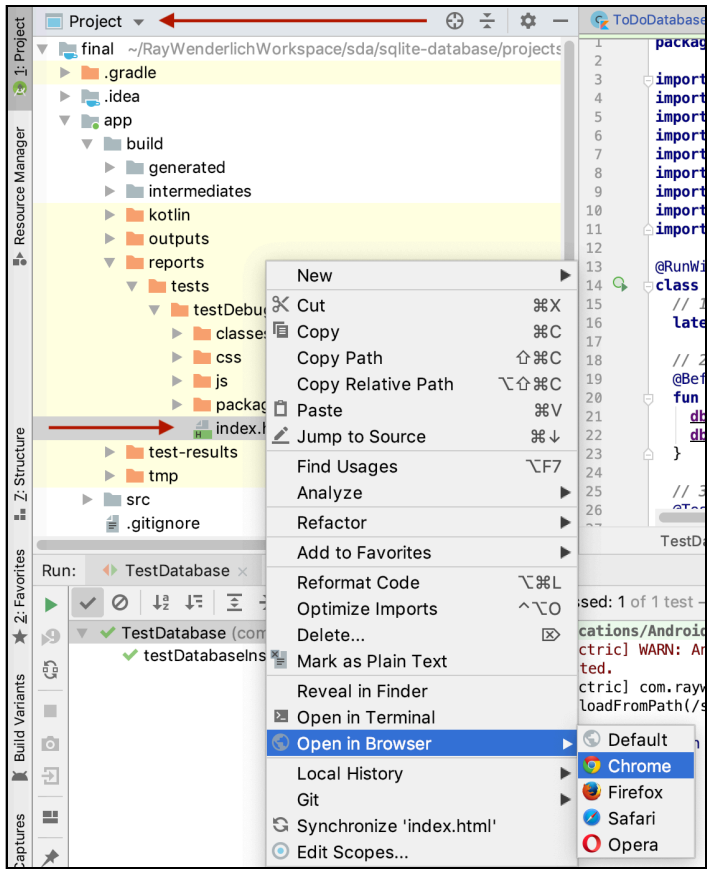


The test passed

The positive result indicates that the values returned from the database handler matched the expected string based on the two items that were manually created and inserted.

This proves that the name fields were inserted into the database correctly. If you don't believe it yet, can also debug the test, to see and compare the values yourself!

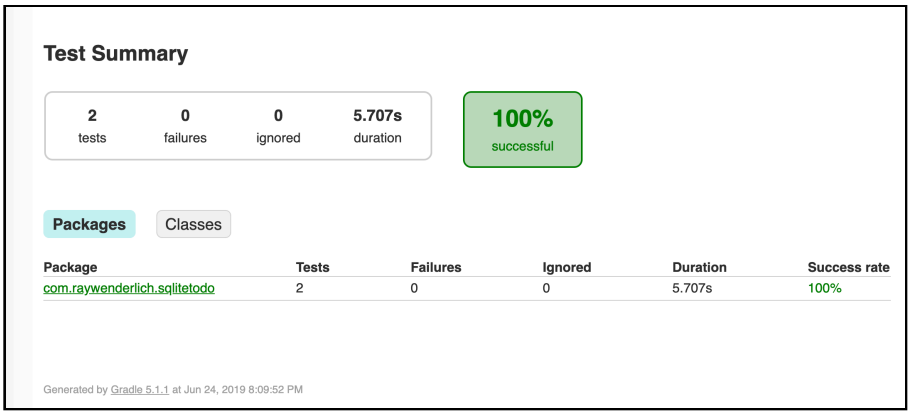
You can add a function in this file for each element of the file you would like to test, and eventually reach a wide degree of coverage.



Generate test summary

Another neat feature of Robolectric is the .HTML report it can produce. To see this report, make sure you are in project view utilizing the dropdown at the top-left of the editor. Expand the **Gradle** pane with the tab on the right-hand of the screen, then expand **app ▸ tasks ▸ verification** and right-click on **testDebugUnitTest**. Select **Run 'starter:app'** with the green arrow beside it.

This will create the report. Then browse to **app/build/reports/tests/debug/index.html**, right-click the file and select **Open in Browser**. Then you can see a fantastic report of your testing, which you can see on the next page.



Test report

Excellent work! Now you can check the box next to the **Write a unit test for my database model** TODO item on your list!

Key points

- When creating an SQLite database, you should define a **database schema** — a group of `String` constants, used to define your **database structure**.
- A database needs to be **created** and **updated**, according to the context of the app, and the **version of the database**.
- If an app doesn't have a database with the same name as in your schema, it will create one, using the defined schema.
- If the app already has a database with the same name, it will run the **update** process, but only if the database version **changed**.
- You should avoid **dropping the database** if it changes, and try to **migrate** the structure between versions.
- Every database consists of the four standard operations - **Create**, **Read**, **Update**, and **Delete**, or **CRUD** for short.
- To help you avoid so much **SQL** code, and to simplify the operations, Android utilizes the **SQLiteOpenHelper**.

- To store data for operations, the SQLiteOpenHelper uses **ContentValues**.
- `ContentValues` are just a key-value pair structure, just like a Map, which is used to insert or update data in the database.
- You can inspect the database by copying it from the **Device File Explorer**, and opening it with a tool, like the **SQLite Browser** or **DB Browser**.
- It is a good practice to write some **Unit tests** for your database, to be sure everything works as expected, **without running the application**.

Where to go from here?

If you would like to know more about SQLite and the syntax that makes up SQLite queries, a more in-depth guide for SQLite can be found in SQLite's Language Guide, which you can access here: https://sqlite.org/lang.html.

This "Unit Testing with Robolectric" article is also an interesting guide about how using Robolectric with Android, which you can read here: https://github.com/codepath/android_guides/wiki/Unit-Testing-with-Robolectric.

Chapter 4: ContentProvider

By Jennifer Bailey

Being able to persist structured data in a SQLite database is an excellent feature included in the Android SDK. However, this data is only accessible by the app that created it. What if an app would like to share data with another app? **ContentProvider** is the tool that allows apps to share persisted files and data with one another.

Content providers sit between the app's data source and provide a means to manage this data. This can be a helpful organizational tool in an app, even if the app is not intended to share its data externally with other apps. Content providers provide a standardized interface that can connect data in one process with code running in another process. They encapsulate the data and provide mechanisms for defining data security at a granular level. A content provider can be used to aggregate multiple data sources and abstract away the details.

Although it can be a good idea to use a content provider to better organize and manage the data in an app, this is not a requirement if the app is not going to share its data.

One of the simplest use cases of a content provider is to gain access to the Contacts of a device via a content provider. Another common built-in provider in the Android platform is the user dictionary. The user dictionary holds spellings of non-standard words specific to the user.

Understanding content provider basics

In order to get data from a content provider, you use a mechanism called

ContentResolver. The content resolver provides methods to query(), update(), insert() and delete() data from a content provider. A request is made to a content resolver by passing a URI to one of the SQL-like methods. These methods return a **Cursor**.

> **Note**: Cursor is defined and discussed in more detail in the previous SQLite chapter. A cursor is essentially a pointer to a row in a table of structured data that was returned by the query.

To interact with a content provider via a content resolver there are two basic steps:

1. Request permission from the provider by adding a permission in the manifest.
2. Construct a query with an appropriate content URI and send the query to the provider via a content resolver object.

Understanding Content URIs

To find the data within the provider, use a **content URI**. The content URI is essentially the address of where to find the data within the provider. A content URI always starts with `content://` and then includes the **authority** of a provider which is the provider's symbolic name. It can also include the names of tables or other specific information relating the query. An example content URI for the user dictionary looks like:

```
content://user_dictionary/words
```

Oftentimes, providers allow you to append an ID value to the end of the URI to find a specific record, or a string such as **count** to denote that you want to run a query that counts the number of records. You must refer to the provider documentation to figure out what a specific content provider exposes.

Requesting permission to use a content provider

The application will need **read access permission** for the specific provider. Utilize the `<uses-permission>` element and the exact permission that was defined by the provider. The provider's application can specify which permissions that requesting applications must have in order to access the data. Users can see the requested permissions when they install the application. The code to request read permission

of the user dictionary is:

```
<uses-permission
android:name="android.permission.READ_USER_DICTIONARY">
```

The above permission is added inside the **manifest** tag in the **AndroidManifest.xml** file.

Permission types

The types of permission that can be granted by a content provider include:

- Single read-write provider-level permission – This permission controls both read and write access to the whole provider. It is one permission to rule them all :].
- Separate read and write provider-level permission – Read and write permission can be set separately for the whole provider.
- Path-level permission – Read, write or read/write permission can be applied to each content URI individually.
- Temporary permission – Temporary access can be granted to an application even if it doesn't have the permissions that would otherwise be required. This means that only applications that need permanent permissions for your providers are apps that continually access your data.

Constructing the query

The statement to perform a query on the user dictionary database looks like this:

```
cursor = contentResolver.query(
    // 1
    UserDictionary.Words.CONTENT_URI,
    // 2
    projection,
    // 3
    selectionClause,
    // 4
    selectionArgs,
    // 5
    sortOrder
)
```

The **contentResolver** object that is part of a **context** is utilized to call the query function and a list of arguments can be passed if necessary. The only required argument is the content URI. Below is an explanation of each of the parameters.

1. The content URI of the provider including the desired table.
2. The columns definitions to return for each row, this is a string array.
3. The selection clause, similar to a **WHERE** clause only excluding the where. A `?` is used in place of arguments.
4. The arguments to be utilized for the selection clause that fill in the `?`.
5. The sort order such as `"ASC"` or ```"DESC"```.

> **Note**: Allowing raw SQL statements from external sources can lead to malicious input from SQL injection attempts. Using the selection clause with `?` representing a replaceable parameter and an array of selection arguments instead can prevent the user from making these attempts.

A content provider not only allows data to be read by an outside application, the data can also be updated, added to or deleted.

Inserting, updating and deleting data

The insert, update and delete operations look very similar to the query operation. In each case, a function is called on the content resolver object and the appropriate parameters passed in.

Inserting data

Below is a statement to insert a record:

```
newUri = contentResolver.insert(
        UserDictionary.Words.CONTENT_URI,
        newValues
)
```

newValues is a **ContentValues** which is populated with key-value pairs containing the column and value of the data to be inserted into the new row. **newURI** contains the content URI of the new record in the form `content://user_dictionary/words/<id_value>`.

Updating data

To update data, call **update** on the content resolver object and pass in content values that include key-values for the columns being updated in the corresponding row.

Arguments should also be included for selection criteria and arguments to identify the correct records to update. When populating the content values, you only have to include columns that you're updating, and including column keys with a null value will clear out the data for that column. One important consideration when updating data is to sanitize user input. The developer guide to protecting against malicious data has been included in the **Where to go from here** section below. An integer is returned from **update** that contains the count of how many rows were updated.

Deleting data

Deleting data is very similar to the other operations. Call **delete** on the content resolver object passing in arguments for the selection clause and selection arguments to identify the group of records to delete. A value is returned with an integer count of how many rows were deleted.

Adding a contract class

A contract class is a place to define constants used to assemble the content URIs. This can include constants to contain the authority, table names and column names along with assembled URIs. This class must be created and shared by the developer creating the provider. It can make it easier for other developers to understand and utilize the content provider in their application.

MIME types

Content providers can return standard MIME types like those used by media, or custom MIME type strings, or both. MIME types take the format `type/subtype` an example being `text/html`. Custom MIME types or **vendor-specific** MIME types are more complicated and come in the form of: `vnd.android.cursor.dir` for multiple rows. They come in the form of `vnd.android.cursor.item` for single rows. The **vnd** stands for **vendor** and is not part of the package name of the app. The subtype of a custom MIME type is provider-specific and is generally defined in the contract class for the provider.

The **getType** method of the provider returns a String in MIME format. If the provider returns a specific type of data, the common MIME type for that data should be returned. If the content URI points to a row or a table of data, a vendor specific formatted MIME type including the authority and the table name should be returned such as `vnd.android.cursor.dir/vnd.com.raywenderlich.contentprovidertodo.provider.todoitems`. This MIME type is for multiple rows in the todoitems table of an app with the authority

com.raywenderlich.contentprovidertodo.provider. A content URI can also perform pattern matches using content URIs that include wildcard characters.

- * – Matches a string of any valid characters of any length.
- # – Matches a string of numeric characters of any length.

Now that you've learned a little bit about content providers, it is time to create one of your own.

Getting Started

Locate this chapter's folder in the provided materials, named **content-provider**, and open up the **projects** folder. Next, open the **ContentProviderToDo** app under the **starter** folder. Allow the project to sync, download dependencies, and setup the workplace environment. For now, ignore the errors in the code.

Adding the provider package

It is a good idea to keep the provider classes in their own package. You will also include the contract class in this package. Right click on the **com.raywenderlich.contentprovidertodo.Controller** folder and select **new** > **package**. A dialog pops up prompting for the name of the new package, type in **provider** and click **OK**.

Adding the contract class

Now add the **ToDoContract.kt** class. Right click the new **provider** package and select **New** > **Kotlin File/Class**. In the resulting dialog enter the name **ToDoContract**, for the "Kind" dropdown select "File" and press **OK**. A Kotlin file will be created in the **provider** directory. Insert the following declarations into the **Contract.kt** file beneath the package declaration:

```
// The ToDoContract class
object ToDoContract {
  // 1
  // The URI Code for All items
  const val ALL_ITEMS = -2

  // 2
  //The URI suffix for counting records
  const val COUNT = "count"
```

```
    // 3
    //The URI Authority
    const val AUTHORITY =
"com.raywenderlich.contentprovidertodo.provider"

    // 4
    // Only one public table.
    const val CONTENT_PATH = "todoitems"

    // 5
    // Content URI for this table. Returns all items.
    val CONTENT_URI = Uri.parse("content://$AUTHORITY/
$CONTENT_PATH")

    // 6
    // URI to get the number of entries.
    val ROW_COUNT_URI = Uri.parse("content://$AUTHORITY/
$CONTENT_PATH/$COUNT")

    // 7
    // Single record mime type
    const val SINGLE_RECORD_MIME_TYPE = "vnd.android.cursor.item/
vnd.com.raywenderlich.contentprovidertodo.provider.todoitems"

    // 8
    // Multiple Record MIME type
    const val MULTIPLE_RECORDS_MIME_TYPE =
"vnd.android.cursor.item/
vnd.com.raywenderlich.contentprovidertodo.provider.todoitems"

    // 9
    // Database name
    const val DATABASE_NAME: String = "todoitems.db"

    // 10
    // Table Constants
    object ToDoTable {
      // The table name
      const val TABLE_NAME: String = "todoitems"

      // The constants for the table columns
      object Columns {
        //The unique ID column
        const val KEY_TODO_ID: String = "todoid"
        //The ToDo's Name
        const val KEY_TODO_NAME: String = "todoname"
        //The ToDo's category
        const val KEY_TODO_IS_COMPLETED: String = "iscompleted"
      }
    }
}
```

1. The constant **ALL_ITEMS** is the code used for the URI when the query method

should return all the items in the database.

2. **count** is the suffix used on the URI when the count of items in the table is requested.
3. **AUTHORITY** is the prefix of the URI that serves as the symbolic name for the provider.
4. **CONTENT_PATH** corresponds to the name of the **todoitems** table.
5. **CONTENT_URI** is created by concatenating the authority, or name of the provider with the path, or the name of the table. This is then parsed into a URI that is used to get all the records from the provider.
6. **ROW_COUNT_URI** A second URI that utilizes the same authority but has the count content type. This URI is used to retrieve the number of records in the table.
7. **SINGLE_RECORD_MIME_TYPE** is the complete, custom mime type for URIs that return a single record.
8. **MULTIPLE_RECORD_MIME_TYPE** is the custom MIME type for URIs that will return multiple records. Notice the use of **dir** instead of **item**, item is used for a single record mime type.
9. **DATABASE_NAME** contains the name of the database.
10. **ToDoTable** is an inner object that contains the name of the main table and definitions for the columns in the database.

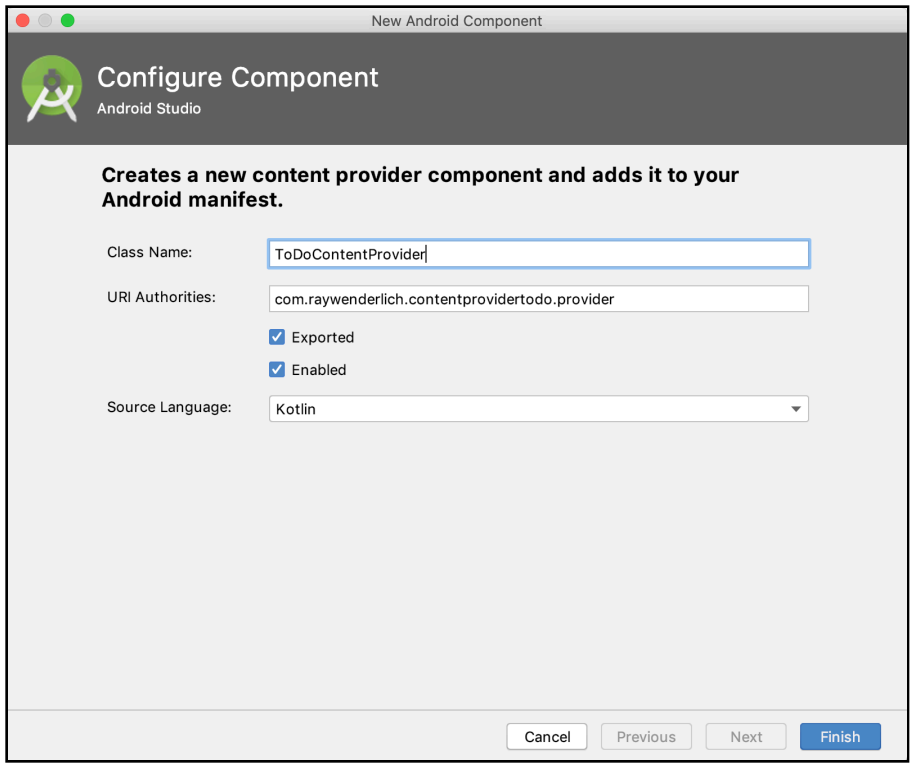
The **Contract** class contains all the constant definitions you need for your content provider. This class can be distributed to client apps that would like to use the provider and will provide insight into what this provider has to provide.

Adding the content provider

Android Studio has a neat feature to automatically add content classes. A content provider class extends **ContentProvider** from the Android SDK and implements all the required methods. By using the automated method of adding the content provider class, many of these method stubs will be provided for you. It will be your job to fill in the functions in the content provider one by one. Ready to get started? :]

Right click the provider package and select **New** > **Other** > **Content Provider**. Provide the class name **ToDoContentProvider** and the URI authority **com.raywenderlich.contentprovidertodo.provider**. Also check the boxes for

exported and enabled. Ensure that the source language is Kotlin, and press Finish.



Add a Content Provider dialog

The class name field provides the name of the new class that will be created in the **provider** package. The URI Authorities field can contain a semicolon-separated list of one to many URI authorities that identify the data under the purview of the content provider. Checking the exported field means that the component can be used by components of other applications. This automatically adds a `<Provider>` element into **AndroidManifest.xml**. Checking enabled allows the component to be instantiated by the system.

Now that you have added the template for your content provider, quickly open up the **AndroidManifest.xml** file to see the **provider** tag that has been added.

```
    <provider
      android:name=".Controller.provider.ToDoContentProvider"
      android:authorities="com.raywenderlich.contentprovidertodo"
      android:enabled="true"
      android:exported="true">
    </provider>
```

Notice how the location, the authority and the permissions are included in this tag as we specified through the dialog. Now the methods must be implemented in the content provider.

Implementing the methods in the content provider

> **Note**: As you add code to the method stubs in the provider, be sure to replace the **TODO** comments with the new code. Also, you may need to press **alt** + **enter** and import libraries as you go along. If given the choice between constants defined in the **ToDoDbSchema** or the new **ToDoContract**, choose **ToDoContract**. The goal is to have the content provider depending on the contract so that it serves as an abstract layer above the database handler. This design allows for the data source to be swapped out as long as it meets the same specifications as the previous data source, and no other code that is dependent on the database will be affected, in this app or other apps that utilize the contract.

Open up the file you just created in the **provider** package called **ToDoContentProvider.kt**. There are six **TODO** tags, one for each method that is required to implement. Notice how the class inherits from the **ContentProvider** class in the Android SDK. Before implementing the methods, add the following declarations inside the class above all the overridden method stubs:

```
    // 1
    // This is the content provider that will
    // provide access to the database
    private lateinit var db : ToDoDatabaseHandler
    private lateinit var sUriMatcher : UriMatcher

    // 2
    // Add the URI's that can be matched on
    // this content provider
    private fun initializeUriMatching() {

      sUriMatcher = UriMatcher(UriMatcher.NO_MATCH)
      sUriMatcher.addURI(AUTHORITY,CONTENT_PATH,
URI_ALL_ITEMS_CODE)
      sUriMatcher.addURI(AUTHORITY, CONTENT_PATH + "/#",
URI_ONE_ITEM_CODE)
      sUriMatcher.addURI(AUTHORITY, CONTENT_PATH + "/" + COUNT,
```

```
                        URI_COUNT_CODE)
    }

    // 3
    // The URI Codes
    private val URI_ALL_ITEMS_CODE = 10
    private val URI_ONE_ITEM_CODE = 20
    private val URI_COUNT_CODE = 30
```

1. Add an instance of the database handler as the content provider sits between the database and the rest of the program, also create a URI matcher to help construct the URI strings.
2. Create a function called **initializeURIMathching**. In this function, add each URI that this content provider can match with. This provider will accommodate a URI to retrieve a single record with an id hence the #, a URI to get all the records, and a URI to get a count of the number of records. Each URI includes the authority, the content path, any arguments represented by special characters, and a unique code.
3. Declare some constants that represent the numeric code for the URI. The contract class gives descriptive names to the corresponding values these codes will match with. These codes are unique and chosen by the developer.

The next step is to start implementing the stub methods one by one. The template doesn't always put them in the most logical order by default. You can reorder them if you like.

Implementing onCreate

Insert the code below into the **onCreate** method stub replacing the **TODO** marker:

```
db = ToDoDatabaseHandler(context)
initializeUriMatching()
return true
```

The **onCreate** prepares the content provider by instantiating the database handler object, calling the **initializeUriMatching** function to initialize the URI matcher, and returns true to signal that this content provider was created successfully.

Implementing getType

Next, implement the **getType** function by replacing the entire stub with the code below:

```
override fun getType(uri: Uri) : String? =
when(sUriMatcher.match(uri)) {
  URI_ALL_ITEMS_CODE -> MULTIPLE_RECORDS_MIME_TYPE
  URI_ONE_ITEM_CODE -> SINGLE_RECORD_MIME_TYPE
  else -> null
}
```

The **getType** function accepts a Uri and matches it with the URI code. Then it returns the correct MIME type. These constants are defined in the contract that has made the code for this function more self-descriptive.

Now that the trivial details are out of the way, the CRUD operations of the content provider can be implemented.

Implementing query

The **query** function queries the database and returns the results. This function has been designed so that it can perform multiple types of queries, depending on the URI. Insert the code below into the body of the function:

```
var cursor : Cursor? = null
when(sUriMatcher.match(uri)) {
  URI_ALL_ITEMS_CODE -> { cursor = db.query(ALL_ITEMS)}
  URI_ONE_ITEM_CODE -> { cursor =
db.query(uri.lastPathSegment.toInt()) }
  URI_COUNT_CODE -> { cursor = db.count()}
  UriMatcher.NO_MATCH -> { /*error handling goes here*/ }
  else -> { /*unexpected problem*/ }
}
return cursor
```

Here you declare a cursor object and assign it to null. Based on the provided uri the URI matcher returns the corresponding code and the **when** statement calls the correct function on the database handler object to retrieve the results and assign them to the curser. The cursor is then returned.

Modifying the adapter

To test the content provider you just created, open **ToDoAdapter.kt** and add the following code inside the class before the **onCreateViewHolder** method:

```
  private val queryUri = CONTENT_URI.toString() // base uri
  private val queryCountUri = ROW_COUNT_URI.toString()
  private val projection = arrayOf(CONTENT_PATH) //table
  private var selectionClause: String? = null
  private var selectionArgs: Array<String>? = null
  private val sortOrder = "ASC"
```

These declarations provide the parameters you will need to pass to the `contentResolver` methods to query, update, insert and delete from the database. Next you will utilize the content provider by calling the content resolver's functions.

The adapter needs to know how many rows there are to properly configure the recyclerview. Locate `getItemCount` and insert the code below into the body of the function, directly above the `return` statement:

```
// Get the number of records from the Content Resolver
val cursor =
context.contentResolver.query(Uri.parse(queryCountUri),
  projection, selectionClause,
  selectionArgs,sortOrder)
// Return the count of records
if(cursor != null) {
  if(cursor.moveToFirst()) {
    return cursor.getInt(0)
  }
}
```

The query above utilizes the query string **queryCountURI**, which is appended with **/count** to query the provider for the count of records instead of returning all the records or a single item. Now wouldn't it be neat if another app could utilize these queries as well?

Now, find the comment that states `// TODO: Add query here to get all items` in **onBindViewHolder**. Replace the comment with this code:

```
// 1
val cursor =
context.contentResolver.query(Uri.parse("$queryUri"),
  projection,
  selectionClause,
  selectionArgs, sortOrder)

// 2
if(cursor != null) {
  if(cursor.moveToPosition(position)) {
    val toDoId =
cursor.getLong(cursor.getColumnIndex(KEY_TODO_ID))
    val toDoName =
cursor.getString(cursor.getColumnIndex(KEY_TODO_NAME))
    val toDoCompleted=
cursor.getInt(cursor.getColumnIndex(KEY_TODO_IS_COMPLETED)) > 0
    val toDo= ToDo(toDoId, toDoName, toDoCompleted)
    holder.bindViews(toDo)
  }
}
```

1. Calling **query** on the content resolver returns a cursor that will allow the app to iterate through all the records in the table, create a to-do item and bind the fields of the recycler view's row to the fields of that to-do item.

2. Create a ToDo item from the fields in the query and bind it to the view.

Lastly, add the code to insert a record. Then you can test the basic functionality of the content provider.

Implementing insert

Open **ToDoContentProvider.kt** and replace the **TODO** in the body of the insert method with the following code:

```
val id = db.insert(values!!.getAsString(KEY_TODO_NAME))
return Uri.parse("$CONTENT_URI/$id")
```

If you have multiple import options for `KEY_TODO_NAME`, use

```
import
com.raywenderlich.contentprovidertodo.Controller.provider.ToDoCo
ntract.ToDoTable.Columns.KEY_TODO_NAME
```

When inserting a to-do item, the only relevant information that is provided is the name of that item. Completed is false by default and the id field is provided by the insert method itself. The database handler returns the id, and the content provider uses this id to return a URI where this provider can access the new record.

Next, open **ToDoAdapter.kt** and find **insertToDo**. Replace the comment in the body with:

```
// 1
var values = ContentValues()
values.put(KEY_TODO_NAME, toDoName)
// 2
context.contentResolver.insert(CONTENT_URI, values)
```

1. Create and populate a content values object.

2. Run the insert query on the content resolver to insert the record.

After all your hard work it is time to run the app and add a couple items! Build and run the app. Click the button in the lower left corner and add some items to your TODO list. They will be displayed in the list as you add them. Nice work! :] Note that "update" and "delete" buttons will not actually do anything, yet. You'll add the functionality to update (edit) an item, next.

Implementing update

To implement the update function, open **ToDoContentProvider.kt** and copy the code below into the body of the **update** function:

```
var toDo = ToDo(values!!.getAsLong(KEY_TODO_ID),values!!
                .getAsString(KEY_TODO_NAME), values!!
                .getAsBoolean(KEY_TODO_IS_COMPLETED))
return db.update(toDo)
```

First, you create a ToDo item by extracting the values utilizing the key values defined in the contract. Then pass this toDo item to **db** to update the database.

Now open **ToDoAdapter.kt** and replace the `TODO` comment in the **editToDo** function with the following:

```
// 1
var values = ContentValues()
values.put(KEY_TODO_NAME,view.edtToDoName.text.toString())
values.put(KEY_TODO_ID, toDo.toDoId)
values.put(KEY_TODO_IS_COMPLETED, toDo.isCompleted)
// 2
context.contentResolver.update(Uri.parse(queryUri), values,
selectionClause,
    selectionArgs)
// 3
notifyDataSetChanged()
```

1. Create and populate the content values object.
2. Run the update query to update the record.
3. Notify the adapter that the dataset has changed so the recyclerview will update.

Run the app and use the pencil icon to update an item that you added previously. The app can now display, insert and update items. But what about deleting them? You will add the ability to delete items in the next steps.

Implementing delete

Deleting a record is simple. Open **ToDoContentProvider.kt** and copy the following code into the body of **delete** replacing the **TODO** statement:

```
return db.delete(parseLong(selectionArgs?.get(0)))
```

This gets the id for the record to delete out of the **selectionArgs** and pass that value to the database handler to delete the record from the underlying database. The

number of rows that are deleted is returned.

Next open **ToDoAdapter.kt** and add this code to the body of **deleteToDo** replacing the comment:

```
// 1
selectionArgs = arrayOf(id.toString())
// 2
context.contentResolver.delete(Uri.parse(queryUri),
selectionClause, selectionArgs)
// 3
notifyDataSetChanged()
```

1. Populate **selectionArgs** with the id of the record to delete.
2. Run the query to delete the record.
3. Notify the adapter that the dataset has changed so the recyclerview will update.

Run the app, you are now able to delete items from the list. Great! Now you have created your very own content provider and content resolver in one. Even though it is not required to utilize a content provider when outside apps aren't accessing the data, sometimes it can provide an organizational layer of abstraction that can improve an app's overall architecture. Now, if you'd like, you can tackle an additional challenge and create a client app that will utilize the content provider.

Challenge: Creating a client

For an additional, interesting challenge, make a copy of the app you just created that creates a content provider and see if you can remove the database and transform it into a client that utilizes the content provider.

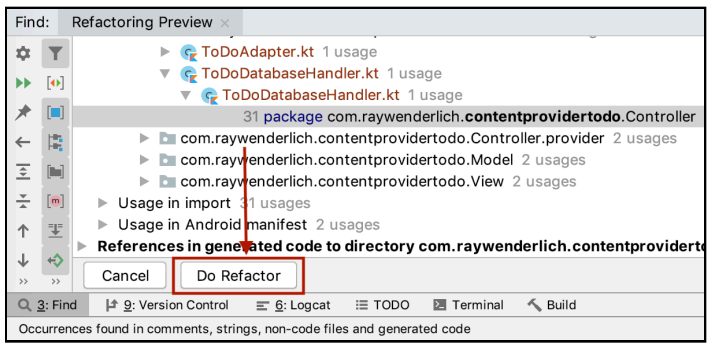
Challenge Solution: Creating a client

It is easy to create a client app that utilizes the provider you just created in the previous steps. You can achieve this by making a copy of the provider app and deleting the database and content provider from it. This proves the content provider is shared with an external app. The steps are as follows:

1. Locate your finished contentprovider app in the file system and make a copy of the project folder. Append the word **client** to the name of the folder so you can tell the difference between the two apps. For example copy the starter folder and call the resulting copy **starter_client**.

2. Open the app in Android Studio by going to **File** > **Open...** and select the new folder and click **OK**.

3. Rename the package in the project to **com.raywenderlich.contentprovidertodoclient** by right clicking on the package and selecting **Refactor** > **Rename...**. A dialog emerges asking if you'd like to rename the directory or the package. Click **Rename Package**. You are then prompted for the new name so type that in and click **Refactor**. The last step is to click the **Do Refactor** button at the bottom of the editor.



Do Refactor button to rename the package

4. Open the **build.gradle** app module and change the app id to **com.raywenderlich.contentprovidertodoclient**.

5. Open the **strings.xml** file and change the name element to **Content Provider To Do List Client**.

6. Open the manifest and add the following permission just inside the `<manifest>` tag. This allows the client to use whatever permissions the provider set.

```
<uses-permission android:name =
"com.raywenderlich.contentprovidertodo.provider.PERMISSION"/>
```

7. Delete the `<provider>` tag and its contents. This app does not provide data, it simply relies on the data shared by the other app.

8. Remove the files **Model/ToDoDbSchema.kt**, **Controller/provider/ToDoContentProvider.kt** and **Controller/ToDoDatabaseHandler.kt** by right clicking them, selecting **Refactor** > **Safe Delete...**. Uncheck any boxes that would search for usages and hit OK. If the **Usages Detected** dialog pops up simply press **Delete Anyway**. Allow the editor to sync the gradle dependencies if prompted to.

9. Once those files are removed, run the app. Any items you've added in the

previous app will show in the new app. But how is this possible? You just deleted the database handler class as well as the schema and the content provider. If you create, update or delete any to-do items and then run the previous app that contains the content provider, those changes will reflect in that app as well. The two apps are sharing data through the same content provider.

10. Congratulate yourself! You just created two apps that are sharing the same data, think of the possibilities! :]

Key Points

- Content providers sit just above the data source of the app, providing an additional level of abstraction from the data repository.
- A content provider allows for the sharing of data between apps
- A content provider can be a useful way of making a single data provider if the data is housed in multiple repositories for the app.
- It is not necessary to use a content provider if the app is not intended to share data with other apps.
- The content resolver is utilized to run queries on the content provider.
- Using a content provider can allow granular permissions to be set on the data.
- Use best practices such as selection clauses and selection arguments to prevent SQL Injection when utilizing a content provider, or any raw query data mechanism.
- Data in a content provider can be accessed via exposed URIs that are matched by the content provider.

Where to go from here

See Google's documentation on content provider here: https://developer.android.com/guide/topics/providers/content-providers.

Learn more specifics about content provider permissions here: https://developer.android.com/guide/topics/providers/content-provider-basics#Permissions.

Learn more about how to protect against malicious data from this guide found here:

https://developer.android.com/guide/topics/providers/content-provider-basics#Injection

Learn more about different MIME types here: https://en.wikipedia.org/wiki/Media_type#mime.types.

Find out more about using content providers with Storage Access Framework here: https://developer.android.com/guide/topics/providers/document-provider.

Section 2: Using Room

At Google I/O 2018, Google presented a set of new components for Android development with the name of Architecture Components. The goal was to provide a set of solutions for the most common problem in the development of Android applications. The solution for persistence is Room which is the topic of this section. You'll learn how to use this library in the most common scenarios.

- **Chapter 5: Room Architecture**: In this first chapter of the section, you'll learn what Room is and how it works. You'll see what the main components are, how to configure the library and start creating a Database.
- **Chapter 6: Entity Definition**: You can define a database as a set of entities and relations. In this chapter, you'll learn how to create a DB with Room starting from the entities. You'll create, step by step, a sample application using the annotations provided by the framework.
- **Chapter 7: Mastering Relations**: As said in the previous chapter, entities and relations are the most important concepts in a relational DB. In this chapter, you'll learn how to define relations and how to read related data efficiently.
- **Chapter 8: The DAO Pattern**: Data Access Object is the pattern Room has implemented to execute queries on top of a specific set of entities. In this chapter, you'll learn how to define relations between entities and how to optimize queries between them.
- **Chapter 9: Using Room with Google's Android Architecture Component**: Room is not the only Architecture Component. Google also announced components like Lifecycle, LiveData, and DataModel. In this chapter, you'll learn how to use Room with the other architecture components.
- **Chapter 10: Data Migration**: Every Database has a lifecycle and needs to be updated. Applications continuously change and it's important to update the schema of a DB without losing any data or relations. In this chapter, you'll learn how to manage data migrations with Room in a simple and declarative way.

Chapter 5: Room Architecture

By Aldo Olivares

In the previous section, you learned all the basics behind data storage on Android. You learned how to work with permissions, shared preferences, content providers and **SQLite**.

Shared preferences are very useful when you need to store and share simple data, such as user preferences as key-value pairs. The main drawback is that you can't store large amounts of data since it's not efficient and there's no way to use queries to retrieve information.

SQLite is a fast, lightweight local database natively supported by Android that allows you to store large amounts of data in a structured way. The only downside of SQLite is that its syntax is not very intuitive since the way to interact with it can be very different from platform to platform.

Therefore, in this chapter, you are going to learn about one of the most popular libraries that helps you simplify your interaction with SQLite: **Room**.

Along the way, you will also learn:

- How Object Relational Mappers work.
- About Room's integration with Google's architecture components
- The basics behind entities, DAOs and Room databases.
- The advantages and disadvantages of Room.
- The app you are going to build in the rest of this section.

Let's dive in!

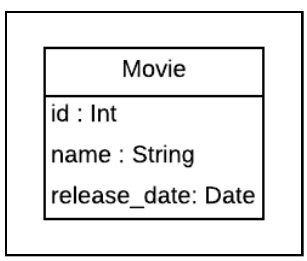
Object Relational Mappers

Before using Room properly in your projects, you first need to learn what Room is.

Room is a data persistence library commonly known as **O**bject **R**elational **M**apper or **ORM**. ORMs are tools that allow you to retrieve, delete, save and update the contents of a relational database using the programming language of your choice.

ORMs are implemented as libraries or frameworks that provide an additional layer of abstraction called the data layer which allows you to better interact with your database using a syntax similar to the object-oriented world.

To better understand how ORMs work, imagine that you have a `Movie` class with three properties: An `id`, a `name` and a `release_date`.



This is a class diagram that represents the `Movie` class. Just like most object-oriented languages, each of these properties has a certain data type such as `Int`, `String` or `Date`

With the help of an ORM, this `Movie` class can easily be used to create a new table in your database. In an ORM, classes represent a table inside your database and each property a column. For example, our previous `Movie` class would be translated into a table like this:

id	name	release_date

Each of the columns would also have the data type that best represents the original data type of the original property. For example, a `String` would be translated as a `varchar` and an `Integer` as an `Int`.

The way to create new records inside the tables differs from each implementation. For instance, some ORMs automatically create new entries each time a new instance of the class is created. Other ORMs such as Room use Data Access Objects or DAOs to query your tables.

This is a simple example of how you would use a DAO in Room to create new `Movie` records in the previously mentioned table:

```
movieDao.insert(Movie(1, "Harry Potter", "10-11-05"))
movieDao.insert(Movie(2, "The Simpsons", "03-10-02"))
movieDao.insert(Movie(3, "Avengers", "08-01-10"))
```

And your table now look like this:

id	name	release_date
1	Harry Potter	10-11-05
2	The Simpsons	03-10-02
3	Avengers	08-01-10

Easy, right?

> **Note**: Room can autogenerate the primary key, in this case, `ID`. You will learn how to do that in a later chapter.

Now, let's take a look at how Room and Google's architecture components work and interact with each other.

Room and Google's architecture components

Android has been around for quite some time. In the beginning, Android apps were very simple and most performed trivial tasks, including calculators, calendars and to-do lists. But things have changed and mobile apps are more complex than ever. Now, there are media players, social networks, chat apps and even fast-paced 3D games.

As apps became more complex, the code followed suit. Developers adopted their own practices on how to develop the architecture of their apps. Some programmers preferred to use an MVVM architecture with SugarORM while others preferred to use

MVP with greenDAO and Firebase. This led to confusion since there was no recommended or official way of doing things.

Therefore, at the 2018 I/O conference Google announced **Jetpack**, a set of libraries focused on creating a robust architecture for your apps by eliminating boilerplate code and simplifying complex tasks such as database interactions and background tasks.

Jetpack is focused on four areas of Android Development:

- **Architecture** contains components that allow you to create robust apps that are scalable, maintainable and easy to test. It includes libraries such as **ViewModel**, **LiveData**, **WorkManager** and **DataBinding**.
- **UI** contains widgets, helpers, animation, transition and utility components that allow you to design apps with a good, easy-to-use interface.
- **Foundation** provides components that bring backwards compatibility with other Android tools and libraries. It includes **Android KTX** and **AppCompat**.
- **Behavior** helps your app integrate with Android's native services, such as permissions and notifications. It includes the **Download Manager**, **Media** and **Preferences** APIs.

At this point you might be wondering...*What does all of this have to do with Room?*

Well, Room is part of the architecture components previously mentioned and it is Google's ORM meant to replace other libraries such as greenDao or SugarORM.

An app built with Room and Google's architecture components usually relies on a set of components you're going to see in detail in the following sections.

Database

On a device, the data is stored on a local SQLite database. Room provides an additional layer on top of the usual SQLite APIs that avoids having to create a lot of boilerplate code using the `SQLiteOpenHelper` class.

For instance, suppose you want to create a simple database that stores a question table for a quiz app, like the one you are going to be building in the next chapter. A traditional implementation using the standard SQLite APIs would look something like this:

```
private const val SQL_CREATE_ENTRIES =
        "CREATE TABLE question (" +
                "question_id INTEGER PRIMARY KEY," +
                "text TEXT"

private const val SQL_DELETE_ENTRIES = "DROP TABLE IF EXISTS
question"

class QuizDbHelper(context: Context) : SQLiteOpenHelper(context,
DB_NAME, null, DATABASE_VERSION) {
    companion object {
        const val DATABASE_VERSION = 1
        const val DB_NAME = "question_database.db"
    }
    override fun onCreate(db: SQLiteDatabase) {
        db.execSQL(SQL_CREATE_ENTRIES)
    }
    override fun onUpgrade(db: SQLiteDatabase, oldVersion: Int,
newVersion: Int) {
        db.execSQL(SQL_DELETE_ENTRIES)
        onCreate(db)
    }
    override fun onDowngrade(db: SQLiteDatabase, oldVersion:
Int, newVersion: Int) {
        onUpgrade(db, oldVersion, newVersion)
    }
}
```

On the other hand, with Room the code becomes much more concise and easier to understand:

```
@Database(entities = [(Question::class)], version = 1)
abstract class QuestionDatabase : RoomDatabase() {
  abstract fun questionsDao(): QuestionDao
}
```

As you can see, the amount of boilerplate code was drastically reduced since Room handles most of the database interaction for you under the hood.

Entities

Entities in Room represent tables in your database and are usually defined in Kotlin as data classes. Let's take a look at the following Entity that is used to define a question table:

```
@Entity(tableName = "question") //1
data class Question(
    @PrimaryKey //2
    @ColumnInfo(name = "question_id") //3
    var questionId: Int,
    @ColumnInfo(name = "text")
    val text: String)
```

Room gives you many annotations that allow you to define how your data class is going to be translated into an SQLite table.

Taking each commented section in turn:

1. The `@Entity` annotation tells Room that this data class is an `Entity`. You can use many different parameters to tell Room how this `Entity` is going to be translated into an **SQLite** table. In this case, you are using the `tableName` parameter to define the name for the table.
2. The `@PrimaryKey` annotation is mandatory and each `Entity` must have at least one field annotated as the primary key. You could also use the `primaryKeys` parameter inside your `@Entity` annotation to define your primary key.
3. The `@ColumnInfo` annotation is optional but very useful since it allows specific customization for your column. For example, you can define a custom name or change the data type.

DAOs

DAO stands for Data Access Object. DAOs are interfaces or abstract classes that Room uses to interact with your database using annotated functions. Your DAOs will typically implement one or more CRUD operations on a particular `Entity`.

The code for a DAO that interacts with the question `Entity` defined above would look like this:

```
@Dao //1
interface QuestionDao {

  @Insert(onConflict = OnConflictStrategy.REPLACE) //2
  fun insert(question: Question)

  @Query("DELETE FROM question") //3
  fun clearQuestions()

  @Query("SELECT * FROM question ORDER BY question_id") //4
  fun getAllQuestions(): LiveData<List<Question>>

}
```

Step-by-Step:

1. The DAO annotation marks this interface as a Data Access Object. DAOs should always be abstract classes or interfaces since Room will internally create the necessary implementation at compile time for you according to the query methods that you provide.
2. The `@Insert` annotation declares that this method is going to perform a create operation by performing an **INSERT INTO** query using the object that you received as a parameter to create a new record.
3. The `@Query` annotation executes the query passed as a parameter. In this case, you are performing a delete operation by executing a **DELETE FROM** query.
4. This is another `@Query` annotated method that retrieves all the questions from your database.

Don't worry if something does not make sense right now. You will be learning much more about DAOs in the **The DAO Pattern** chapter.

Repository

This class acts as a bridge between your data sources and your app. The repository class handles the interaction with your Room database and other backend endpoints such as web services and Open APIs.

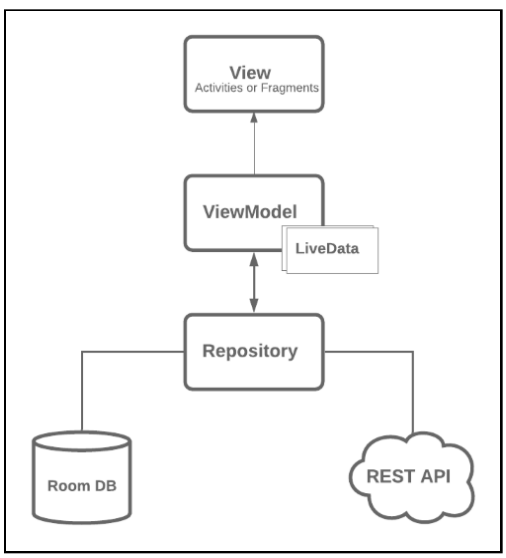
ViewModel

Just like the `Repository` acts as a bridge between your data sources and your app, the `ViewModels` act as a bridge between your repository and your user interface. The `ViewModel` communicates the data coming from your `Repository` to your Views and has the advantage of surviving configuration changes since it's lifecycle-aware.

LiveData

`LiveData` is a data holder class that implements the `Observer` pattern. This means it can hold information and be observed for changes. Your views such as `Fragments` or `Activities` observe `LiveData` objects returned from your `ViewModels` and update the relevant widgets as needed.

The interaction between the above components can be illustrated by the following diagram:



You will be learning much more about the above components in the upcoming chapters, , this is all you need to know.

Room advantages and concerns

Room uses a local SQLite database to store your data. Therefore, most of the advantages and disadvantages of SQLite apply to Room as well.

These are some of the main advantages of using SQLite to store data:

- **Portability**: SQLite is available for most platforms and can be used with many popular programming languages such as Java, Kotlin and Python.
- **Lightweight**: SQLite is probably the most lightweight database out there, making it suitable for devices with low memory, like smartphones.
- **Good Performance**: Compared to reading directly from a file, Sqlite is much faster since you only load the data that you need rather than reading and holding an entire file in memory.

The main disadvantage of using SQLite is that, since it relies on local file storage, your data will be lost if the user decides to delete the app's data. It is usually recommended that you have a backup on a remote database or service such as Firebase.

Frequently asked Room questions

Are ORMs really necessary? Can't I just use plain old SQLite?

Of course you can use plain old SQLite! In fact, Android standard libraries include many utilities and classes that help you work directly with SQLite. The only downside with this approach is that you often have to deal with a lot of boilerplate code that can slow down your development.

Are there other ORMs for Android besides Room?

Sure! There many ORMs out there like greenDao or SugarORM.

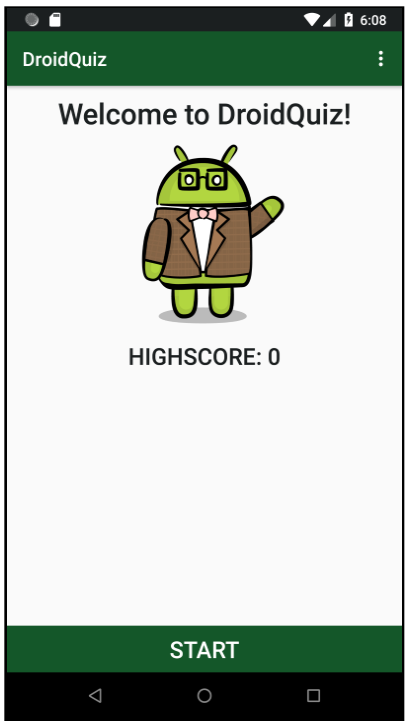
What are the advantages of using Room vs other ORMs?

The main advantage of using Room vs ORMs is that Room offers the best integration with other architecture components like ViewModel and LiveData and since it is developed by Google you can be sure this library will be maintained and improved for a very long time to come.

Your app

This chapter has been full of theory and concepts and you are probably wondering when you are actually going to start writing some code.

Well, the rest of the following chapters are going to be focusing solely on how to apply the previously mentioned concepts to build a fun quiz app called **DroidQuiz**. This app will allow your users to test their Android knowledge with a set of questions stored in a Room database:



DroidQuiz will help you learn about many important concepts behind Room:

- How to add the appropriate dependencies to your `build.gradle` file for Room and most of the architecture components such as `LiveData`.
- How to create a local SQLite database using Room.
- How to use Database Access Objects or DAOs to interact with your Database.
- How to use Google's Android architecture components such as `LiveData` and `ViewModel` to interact with your Room database.

- How to create indices and relationships between your tables.
- How to test your database, migrations, and `ViewModels`.
- And much more!!!

As you can see, there is a lot to learn, but this section will guide you through every, single step needed to build a final version of the app.

Key points

- Room is an ORM developed by Google as a part of Jetpack's architecture components to simplify the interaction with your SQLite database and to reduce the amount of boilerplate code.
- Entities in Room represent tables in your database.
- DAO stands for Data Access Object.
- The `Repository` class handles the interaction with your Room database and other backend endpoints.
- The `ViewModel` communicates the data coming from your repository to your views and has the advantage of surviving configuration changes since it's lifecycle-aware.
- `LiveData` is a data holder class that can hold information and be observed for changes.
- ORM stands for Object Relational Mapper.
- Shared preferences are very useful when you need to store and share simple data such as user preferences as key-value pairs.
- The main disadvantage of using shared preferences is that you can't store large amounts of data since it's not efficient and there's no way to use queries to search for information.

- SQLite is a fast and lightweight local database natively supported by Android that allows you to store large amounts of data in a structured way.
- SQLite is available for most platforms and can be used with many popular programming languages.
- Because SQLite is lightweight, it's suitable for devices with restricted memory such as smartphones and smart TVs.
- ORMs provide an additional layer of abstraction that allows you to interact with your relational database with an Object-Oriented Language syntax.

Chapter 6: Entity Definitions

By Aldo Olivares

In the previous chapter, you learned the architecture behind Room. You also learned about ORMs, Jetpack Architecture Components and the advantages and disadvantages of SQLite.

In this chapter, you'll cover all you need to know about Room entities. Along the way, you will learn:

- The properties of SQLite tables.
- How to add Room's dependencies to your gradle files.
- How to create SQLite tables using Room annotations.
- How to define primary keys and column names.

I hope you're ready to get started!

> **Note**: This chapter assumes you have a basic knowledge of Kotlin and Android. If you're new to Android, you can find a lot of beginner Android content to get you started on our site at https://www.raywenderlich.com/category/android. If you know Android, but are unfamiliar with Kotlin, take a look at our tutorial, "Kotlin for Android: An Introduction" at https://www.raywenderlich.com/174395/kotlin-for-android-an-introduction-2.

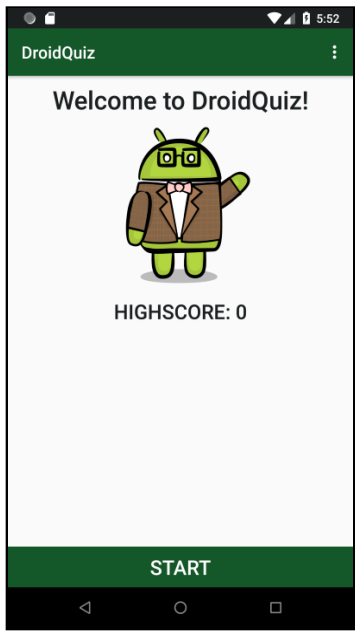
Getting started

Have you ever played trivia games and thought, "There should be a game like this but with questions for Android developers"? Well, the sample app you will be working on, **DroidQuiz**, is a trivia game that allows you to answer a series of questions to test your knowledge of Android.

In this chapter, you're only going to build entities that represent the tables of your database. If you've had some previous experience with SQL, you probably know that this can be somewhat annoying or painstaking to accomplish. Additionally, in "Chapter 3, SQLite Database," you saw how, with SQL syntax, it can sometimes be hard to deduce which parts of it caused an error (if by some chance you get one). The Room database, and its **annotation-driven** system of creating entities and queries, make this process *tremendously easier*.

Start by opening the starter project for this chapter in Android Studio 3.2 or greater by going to **File ▸ New ▸ Import Project**, and selecting the **build.gradle** file in the root of the project.

Once the starter project finishes loading and building, run the app on a device or an emulator.



Right now, the app is just an empty canvas, but that is about to change!

Tables and entities

Most databases consist of **tables** and **entities**. If you were to draw a parallel with object-oriented programming, you could think of entities as a **class definition**, which defines what the objects in the table should look like and how their respective properties behave. Once you create those objects — instances of classes, or entities in your case — you can store somewhere *in memory*, which is the table. The table as such is a **container** for all the created objects of some entity type.

This is a very brief, high-level description of how databases work, which is why it's also beneficial to see real-life examples.

Tables

If you reached this section of the book you're probably already familiar with relational databases, tables and SQLite. However, it is important to review other key concepts before you proceed to create your entities using Room.

> **Note**: In this chapter, I am only going to cover the basics of database tables; if you want to learn more, check out the SQLite chapters of the previous section of the book.

Simply put, tables are structures similar to spreadsheets or two-dimensional arrays that let you store records as rows with one or more fields defined as columns — or, as mentioned above, a container for entity data.

For example, this is how a table that stores information about movies could look:

ID	Title	Description	ReleaseDate	Rating
1	Harry Potter	Wizard Movie	10-11-2001	4.4
2	Simpsons	Simpsons Movie	01-02-2002	4.5
3	Hunger Games	Apocalyptic Movie	03-04-2008	5
4	MIB	Men in Black	08-01-1998	4.2
5	X-Men	Mutant Movie	05-05-2001	3.2

Columns represent a field or property of your data like the Title, Description, ReleaseDate or Rating. Columns usually have specific data types such as **INTEGER**, **VARCHAR**, **FLOAT** or **DATETIME** that help preserve the integrity of the information stored in your database.

For most of the tables, the first column will be used to store a **primary key** that uniquely identifies the record. Primary keys are values often represented as a series of integers that are incremented one by one (1,2,3,4,5,...). This is not always the case since you could also use any string that represents a unique value for each entry — like a randomly generated hash or a social security number if you have more complex security requirements. As such, the primary key is, at its core, the differentiating agent between records. You can quickly look up records by primary keys or compare two records to see if they are the same.

Primary keys also help you create relationships by defining a **foreign key** that references a primary key of another table. For example, say that you have an **Orders** table that stores the number of Blu-ray sales for each movie like below:

OrderID	MovieID	OrderDate
1	1	08-08-2018
2	2	01-01-2019
3	1	02-03-2018
4	2	20-09-2017
5	5	02-02-2019

In this case, the **MovieID** is a foreign key that identifies a unique movie record in your Movies table. Therefore, if you want to retrieve extra details about an available movie, you would only need to retrieve the movie row from your Movies table with that particular ID. As such, you don't have to store all of the data about ordered movies in the **Orders** table, you can just look up movie details using the foreign key. This makes each order object very light while holding enough data to look up more detailed information.

Although not all the database management systems will force you to have a primary key, it is strongly recommended that you have one for each of your tables since it makes it much easier to retrieve information using queries. But, usually, when working with databases, you can specify you want a primary key, and it gets auto-generated, so you don't have to worry about it.

Rows represent a record in your database and can contain as many columns as needed to represent your data. **Row** and **record** are terms that are often used interchangeably just like **column** and **field**. However, when creating a database, you will need to make sure that your team is on the same page regarding naming conventions.

In the Movie table example, you have five rows each representing a different movie record added to your database. The **ID** column shows the primary key for each movie. **Title** and **Description** are String values, **ReleaseDate** is a Date field and **Rating** is a Float. This will help you form the appropriate entity within the Android project so that Room can create the database and tables.

Entities

To create a table using Room you need to create an **entity**, just like you did above. Entities in Room are defined by using a series of different **annotations** on classes. The following are the most common annotations that you will use when defining an entity:

@Entity

The `@Entity` annotation declares that the annotated class is a Room entity. For each entity, a table is created in the associated SQLite database to save your data. To add the annotation, simply use the following approach:

```
@Entity
data class Movie(
    //...
)
```

The above code would create a **Movie** table in your database. By default, Room always uses the name of your class as the table name, but you can use the `tableName` property of the `@Entity` annotation to set a different name like shown below:

```
@Entity(tableName = "movies")
data class Movie(
    //...
)
```

Now that the class is declared as an entity, you can use it in Room's setup, which you'll see in a bit.

@PrimaryKey

The `@PrimaryKey` annotation allows you to define a primary key for your table. It is very important to remember that each entity in Room **must have** at least one field defined as primary key:

```
@Entity
data class Movie(
    @PrimaryKey var id: Int,
    var title: String?,
    var description: String?,
    var releaseDate: String?,
    var rating: Float
)
```

You can also let Room generate the primary keys automatically for you, using the `autogenerate` property of the `@PrimaryKey` annotation:

```
@Entity
data class Movie(
    @PrimaryKey(autogenerate = true) var id: Int,
    var title: String?,
    var description: String?,
    var releaseDate: String?,
    var rating: Float
)
```

In the above code, the id is the primary key for your Movie table, and it is going to be automatically generated by Room incrementing the value each time by one (1,2,3,4,5,...). It is important to remember that if you set `autogenerate` to `true`, the type affinity for the field must be **INTEGER**, or `Int` in Kotlin.

@ColumnInfo

In the same way that the `tableName` property of the `@Entity` annotation allows you to customize the name of your table, the `@ColumnInfo` annotation lets you change the name of your columns — class properties in Kotlin:

```
@Entity
data class Movie(
    @PrimaryKey(autogenerate = true) var id: Int,
    var title: String?,
    var description: String?,
    @ColumnInfo(name = "release_date") var releaseDate: String?,
    var rating: Float
)
```

This annotation is particularly useful because you will often want to follow different naming conventions for your class properties and your database columns, such as `releaseDate` vs `release_date` naming.

@Ignore

Room translates all of your class properties into database columns by default. If there is a field that you don't want to be converted into a column, you can use the `@Ignore` annotation to tell Room to ignore it:

```
@Entity
data class Movie(
    @PrimaryKey(autogenerate = true) var id: Int,
    var title: String?,
    var description: String?,
    @ColumnInfo(name = "release_date") var releaseDate: String?,
    var rating: Float,
    @Ignore var poster: Bitmap?
)
```

In the above code, you use the `@Ignore` annotation to tell Room that you don't want the `poster` field to be converted as a column in your Movie table. You can also use the `ignoredColumn` property of the `@Entity` annotation to declare which fields you want to ignore:

```
@Entity(ignoredColumns = arrayOf("poster"))
data class Movie(
    @PrimaryKey(autogenerate = true) var id: Int,
    var title: String?,
    var description: String?,
    @ColumnInfo(name = "release_date") var releaseDate: String?,
    var rating: Float,
    var poster: Bitmap?
)
```

@Embedded

The `@Embedded` annotation can be used on an entity's field to tell Room that the properties on the annotated object should be represented as columns on the same entity.

For example, say that you have a **User** table that contains address information. Your entity could look like this:

```
@Entity
data class User(
    @PrimaryKey val id: Int,
```

```
    val firstName: String?,
    val street: String?,
    val state: String?,
    val city: String?,
    @ColumnInfo(name = "post_code") val postCode: Int
)
```

However, thanks to the `@Embedded` annotation you can represent the address fields as a separate class but Room will still generate a single table:

```
data class Address(
    val street: String?,
    val state: String?,
    val city: String?,
    @ColumnInfo(name = "post_code") val postCode: Int
)

@Entity
data class User(
    @PrimaryKey val id: Int,
    val firstName: String?,
    @Embedded val address: Address?
)
```

Both implementations will generate a single **User** table with six fields: `id`, `firstName`, `street`, `state`, `city` and `postCode`.

There are more annotations available, but these are by far the most commonly used when creating your entities.

Now that you know the theory, it is time to put it into practice!

Creating your entities

Since you'll be working on with Room, make sure you've opened the `starter` project, located in the **entity-definitions ▸ projects** folder.

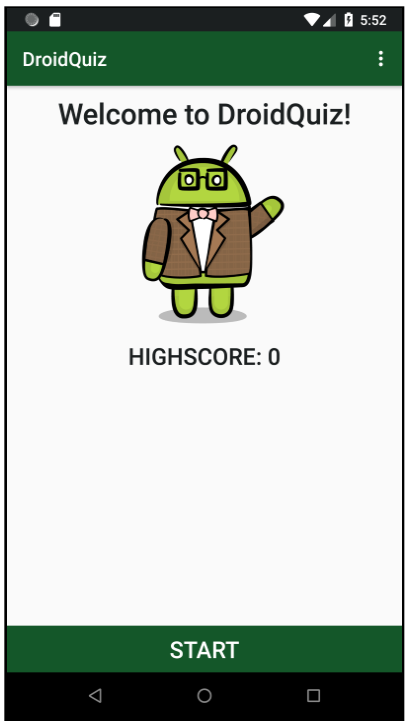
Now, once Android studio finishes indexing the code, you need to add the appropriate dependencies to your **build.gradle** files to use Room. To ensure forward compatibility with future versions of Android, you will use **Androidx** artifacts for this project.

Open the app-level **build.gradle** file and add the following lines under the dependencies block:

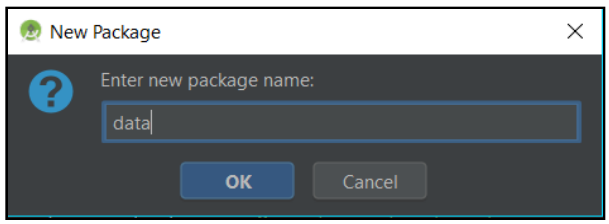
```
//Room
implementation "androidx.room:room-common:$room_version"
kapt "androidx.room:room-compiler:$room_version"
implementation "androidx.room:room-runtime:$room_version"
```

Press **Sync Now** and wait until Android Studio finishes syncing your new dependencies.

Build and run your app one more time just to make sure that the project is still working properly after the updates to your gradle files.



Create a new package under the root directory of your app by right-clicking on **droidquiz** and selecting **New ▸ Package** and name it **data**.



Inside the **data** package, you will store all the code related to your Room database including your entities and data access objects.

Create a new package inside the **data** package and name it **model**. Inside the **model** package, you will store the data classes that will be converted to entities using annotations.

The DroidQuiz app will consist of a very simple database with two tables — a **Question** table and an **Answer** table.

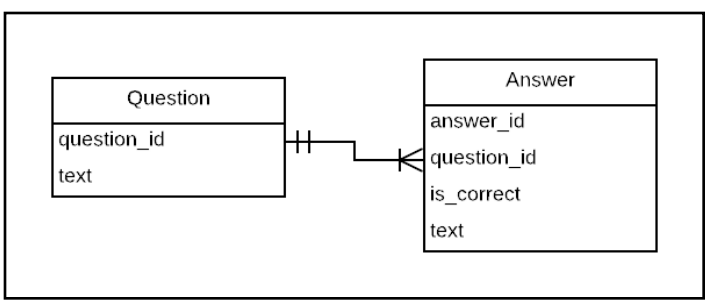
The Question table will have two columns:

- **question_id**: A self incrementing `Int` that will act as the primary key.
- **text**: A `String` that represents the text of the question.

The Answer table will have four columns:

- **answer_id**: The primary key for this table.
- **question_id**: A foreign key that references a question in the **Question** table.
- **is_correct**: A `boolean`, which indicates if this is one of the correct answers or not.
- **text**: A `String` that represents the text of the answer.

Here is how the entity-relationship diagram would look:



Each question can have one or more answers, but each answer will only have one associated question, thus creating a **one-to-many** relationship. Easy, right?

In this chapter, you will solely focus on defining entities, without foreign key relationships. You will learn how to create relations later on in the book.

Create a new class under the **model** package by right-clicking on **model** and selecting **New ▸ Kotlin File/Class**, and name it **Question**.

Fill or replace the file content with the following code:

```
@Entity(tableName = "questions") // 1
data class Question(
    @PrimaryKey(autoGenerate = true) // 2
    @ColumnInfo(name = "question_id") // 3
    var questionId: Int,
    val text: String
)
```

> **Note**: Remember to use **Alt** + **Enter** on PC or **Option** + **Return/Enter** on a Mac to import any missing dependencies.

The code does the following, step by step:

1. The `@Entity` annotation tells Room that this data class should be converted into an entity. The `tableName` property indicates that the table name should be **questions**.
2. `@PrimaryKey` makes the `questionId` field of your `Question` class a primary key of the table. The `autogenerate` property declares that Room will generate the primary key for you as an auto-incremented integer.
3. `@ColumnInfo` allows you to customize your column's properties like the name or the type affinity - `Integer`, `Text`, `Float`, etc.

Now, create another class under the **model** package and name it **Answer**.

Once again, fill or replace the file content with the following code:

```
@Entity(tableName = "answers")
data class Answer(
    @PrimaryKey(autoGenerate = true)
    @ColumnInfo(name = "answer_id")
    val answerId: Int,
    @ColumnInfo(name = "question_id")
```

```
    val questionId: Int,
    @ColumnInfo(name = "is_correct")
    val isCorrect: Boolean,
    val text: String
)
```

The code is very similar to the `Question` class, so there is not much need to explain the steps. With this, your entities are ready, and it is time to create your database!

Create a new package under the data directory and name it **db**.

Now, create a new class under the **db** package and name it **QuizDatabase**. Replace everything inside with the following:

```
@Database(entities = [(Question::class), (Answer::class)],
version = 1)
abstract class QuizDatabase : RoomDatabase()
```

Similar to your entities, Room uses the `@Database` annotation to define which class should be used to generate your database tables, connections and queries.

The `@Database` annotation should always include at least two properties:

- `entities`: These should include an array of all the the entities associated with your database.
- `version`: This is the current version of your database, which is used to migrate everything once things change.

> **Note**: It is very important that you declare your class as an abstract class that extends from `RoomDatabase` or Room will throw an error.

There are many ways to get an instance of your database at runtime, but, for this app, you will create a property inside your `Application` class.

Create a new class under the root package of your project — **droidquiz** — and name it **QuizApplication**.

Replace everything inside the `QuizzApplication` class with the following:

```
class QuizApplication : Application() {
  // 1
  companion object {
    lateinit var database: QuizDatabase // 2
      private set
  }

  override fun onCreate() {
    super.onCreate()
    database = Room
        .databaseBuilder(
            this,
            QuizDatabase::class.java,
            "quiz_database"
        ) // 3
        .build()
  }
}
```

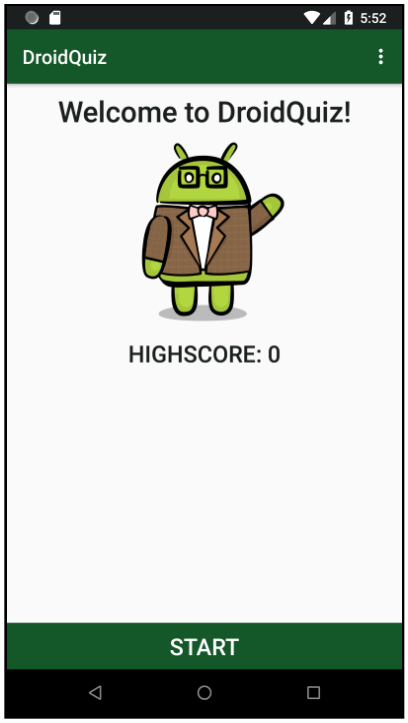
Taking each commented section in turn:

1. Makes this class extend `Application`, so that it runs with the app launch.
2. Creates a private database property that will hold a reference to your Room database.
3. The `databaseBuilder()` method creates an instance of your Room database at runtime. The first parameter accepts a `Context` instance. The second parameter expects the class that you annotated as your Room database. The third parameter allows you to define a name for your SQLite database.

Now, add your `QuizApplication` class to your manifest file by adding the following attribute to your application tag inside your **AndroidManifest.xml** file:

```
android:name=".QuizApplication"
```

Finally, build and run your app to verify that everything is still working properly:



While the changes are still not visually noticeable since you haven't added any DAOs, you have already created your first SQLite tables using Room entities. Good job!

If you compare it to the very first implementation you've had with writing your SQLite helper, you understand how and why Room is becoming more and more popular among Android developers.

Key points

- Tables are structures similar to spreadsheets or two-dimensional arrays that let you store **records objects**, as **rows** with one or more **fields** defined as **columns**.
- The `@Entity` annotation declares that the annotated class is a Room entity, and you will need to generate a table.
- The `@PrimaryKey` annotation allows you to define a primary key for your table to **uniquely differentiate data**.

- The `@ColumnInfo` annotation lets you change the names for your columns, so you can use **different naming conventions** in Kotlin and in SQL.
- The `@Ignore` annotation tells Room to ignore a certain property from your class so it does not get converted into a column in the database.
- The `@Embedded` annotation can be used on an entity's field to tell Room that the properties on the annotated object should be represented as columns on the same entity. This way you can **organize your data** clearly while writing the same SQL.

Where to go from here?

In this chapter, you learned a lot about SQLite tables, Room and entities. If you want to learn more about entities, I suggest the following resources:

- This official Android developer's guide page, "Defining Data Using Room Entities," which you can find here: https://developer.android.com/training/data-storage/room/defining-data) on how to define data using Room entities on how to define data using Room entities.
- This official Android developer's guide page, "Entity," which you can find here: https://developer.android.com/reference/android/arch/persistence/room/Entity.

In the next chapter, you're going to learn even more about Room entities by creating your first relations.

Chapter 7: Mastering Relations

By Aldo Olivares

In the previous chapter, you learned all you need to know about tables, entities and annotations. You also learned how to create your database and how to get a runtime instance of it by using the `Room.databaseBuilder` method.

In this chapter, you are going to learn even more about entities by creating relations between them using foreign keys and the `@Relation` annotation. Along the way, you will learn:

- How to create a relationship using primary keys and foreign keys.
- How to define a one to many relationship in Room.
- How to represent different kinds of relationships using entity-relationship diagrams.
- How to use the `@Embedded` annotation.
- How to use the `@ForeignKey` annotation.
- How to use the `@Relationship` annotation.

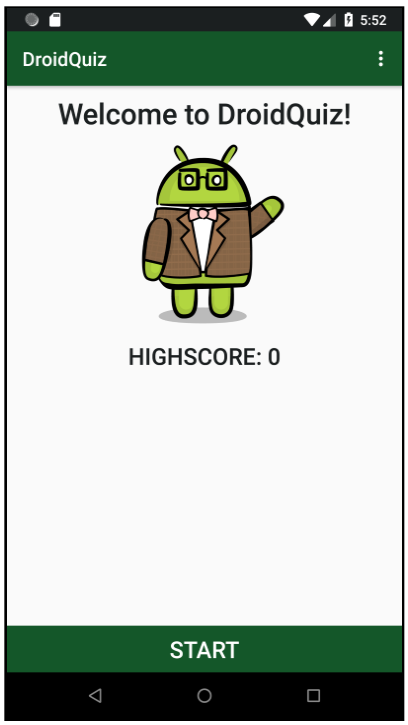
Ready? Let's get started.

> **Note:** This chapter assumes you have basic knowledge of Kotlin and Android. If you're new to Android, check out our Android tutorials. If you know Android, but are unfamiliar with Kotlin, take a look at Kotlin For Android: An Introduction.

Getting started

If you are following along with your own app, open it up. If not, don't worry you can use the starter project for this chapter, which you can find in the attachments. Now, open the app in Android Studio 3.2 or greater by going to **File ▸ New ▸ Import Project**, and selecting the **build.gradle** file in the root of the project.

Once the starter project finishes loading and building, run the app on a device or emulator.



The DroidQuiz application

Great! The app is working as expected.

The code is basically the same as the previous chapter. But, if you are just getting started, here is a quick recap of the packages and the code:

- The **data** package contains the **db** package and the **model** package. The **db** package contains the class that creates your Room database, while the **model** package contains all of the code for the entities created in the previous chapter.
- The **view** package contains the code for all of the activities of your app.

You are no doubt eager to start writing some code. But, before that, you will need to learn a bit of theory first!

Relations and entity-relationship diagrams

In this chapter, we are going to create a relation between the `Question` entity and the `Answer` entity that you created in the previous chapter. The only problem is... you know... relationships are always hard to understand even if it is just between two single tables. Therefore, in this section, we are going to talk about a little tool that will help you to better understand the different kinds of relations between tables: **entity-relationship diagrams**.

You might have heard of entity-relationship diagrams before. They are quite common in software design and it's one of the first things they teach in college in courses such as **Databases 101** or **Introduction to Relational Databases**. An entity-relationship diagram, ER diagram or **ERD** is a kind of flowchart that illustrates the relationships between the components of a system representing something like a school or a company using a set of symbols that include rectangles, ovals and connecting lines.

ER diagrams are commonly created during the initial design of a database schema to determine the tables, their fields and the nature of the relationship between them.

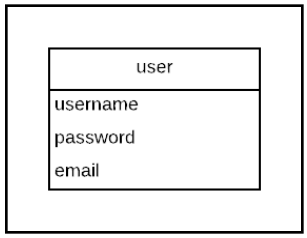
Many different ERD notations have been created over the years to serve different purposes. The notation that we are using in this section is called **Crow's Foot** notation. Although ER diagrams may have different elements depending on the notation system, they usually share similar components that include the following:

Entity

Represents a component, object or a concept of a system. Concepts described by an entity can be concrete, such as a student or a car, or abstract, such as an event or a schedule. Entities are translated as tables when creating your database schema. They are commonly illustrated as rectangles in most ER diagrams:

The Student entity

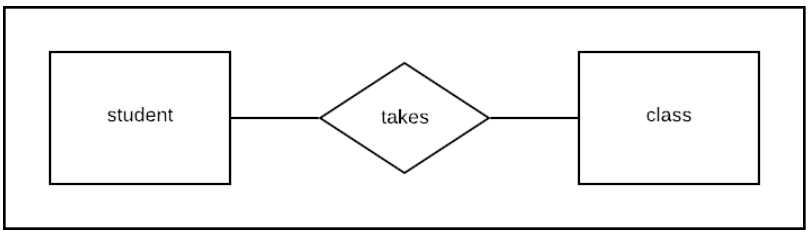
Entities in Crow's Foot notation also include a list of attributes or properties that define them. For a user entity, its attributes could be username, password and email.



The User entity

Relationship

A relationship tells you how two entities interact with each other and it's usually represented as a verb surrounded by a diamond. For example, think about a student entity and a class entity. Their relationship could be described as follows:



Relation between entities

In this ER diagram, the relationship is described as "takes" and you could read it left to right:

A student takes a class.

Or right to left:

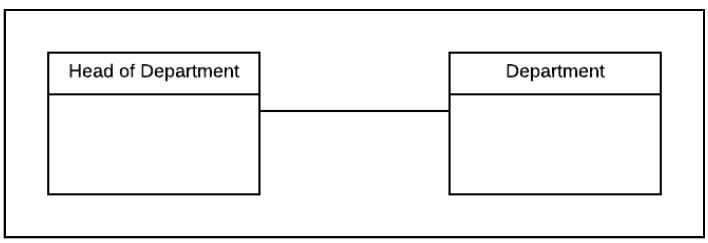
A class is taken by a student.

> **Note:** Not all ER diagrams illustrate the relationship between their entities since it is often easy to infer from the context. In Crow's Foot notation, it is usually omitted.

Cardinality

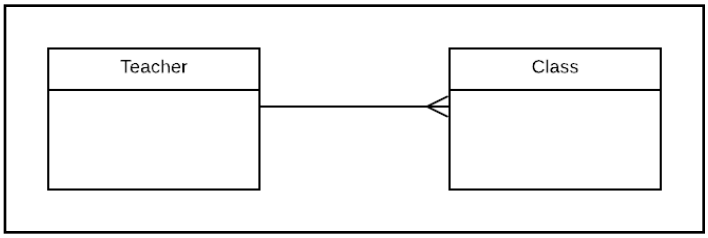
Last but not least, the cardinality tells you the kind of relationship two entities have. There are three main cardinal relationships:

One to one: When one entity can only be related to one and only one instance of the other entity. For example, a department on a company can only have one head of department, and that head of department can only lead one department:



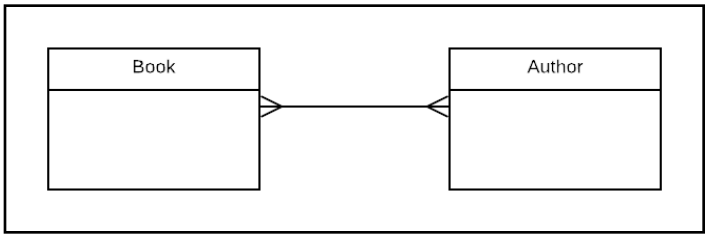
One to One relation

One to many: When one entity can be related to many instances of another entity. For example, a teacher can teach many classes in a single semester, but a class can only have one teacher:



One to Many relation

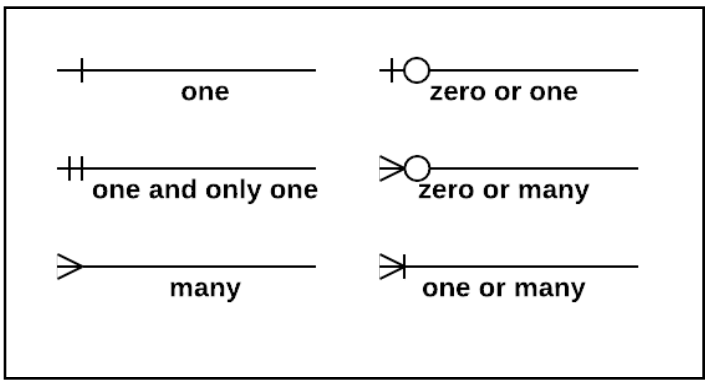
Many to many: When many instances of an entity can also be related to many instances of another entity. For example, a book (like this one) can have many authors, and authors can write many books:



Many to Many relation

Cardinalities can also have constraints that indicate the minimum and maximum numbers in the relationships: *One and only one*, *zero or one*, *zero or many* and *one or many*.

Here is the full list of cardinalities and constraints that you can find:

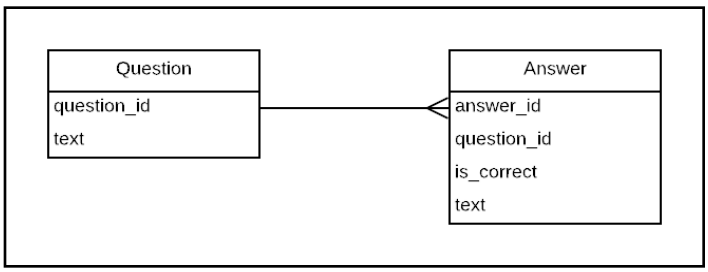


ER Cardinalities

Now that you know how ER diagrams work, you will now learn how to create relationships using **Roms Entities**.

Creating your relations

As briefly mentioned in the previous chapter, you will only need to create one relationship between the entities in your app, and its ER diagram looks like this:



One to Many relation between Question and Answers

Why don't you use your recently acquired knowledge to guess which kind of relationship is this?

Well, if you said "a one to many relationship," you are correct.

With the above ER diagram, you are saying: "One question can have one or more answers and each answer can only be related to one and only one question". Just think about it and it makes a lot of sense since each question of the DroidQuiz app will have at least one correct answer and two incorrect answers. The beauty of this design is that you can easily expand it or modify it to have something like two correct answers and two incorrect answers or 3 correct answers and 2 incorrect answers... You get the point.

Now, you will see how easy it is to define foreign keys and one to many relationships between your Room entities. In fact, you can do it by adding a single line of code.

Open the **answer.kt** file under the **data ▸ model** package.

The `Answer` entity already has a `question_id` field that you can use as a foreign key that points to the `question_id` field of your `Question` entity. The problem is that you still have not told Room that this is actually a foreign key. For this, you need to use the `foreignKeys` property of the `@Entity` annotation to define the relationships.

Add a `foreignKeys` property to the `@Entity` annotation of your `Answer` class like this:

```
@Entity(tableName = "answer",
    foreignKeys = [//1
        ForeignKey(entity = Question::class,//2
            parentColumns = ["question_id"],//3
            childColumns = ["question_id"],//4
            onDelete = CASCADE)//5
    ])
```

Taking each commented section in turn:

1. `foreignKeys` allows you to define a relationship between this and another entity. This property accepts an array of `ForeignKey` objects that you can use to define foreign key constraints.
2. The first parameter in the constructor of a `ForeignKey` object accepts the entity to which this entity is related. In this case, you are passing the `Question` class since you want to create a foreign key constraint to the `Question` entity.
3. `parentColumns` accepts the column names in the parent entity as an array. Since you want to match each answer to a single question, you are going to pass the primary key of your Question entity: `question_id`.
4. `childColumns` accepts the column names in the current entity to use as foreign keys.
5. `onDelete` tells Room what to do in case the parent entity is deleted from the database. For example, what would happen to your answers if the respective question is deleted? When you enter `CASCADE` for the value of `onDelete`, be sure to use the import for `androidx.room.ForeignKey.CASCADE`.

There are several options for `onDelete`:

1. **CASCADE**: If a record is deleted from the parent entity each row in the child entity that was associated with the parent entity is also deleted. For this app, you are using this option since you want to delete the answers if the question is deleted.
2. **NO_ACTION**: If the parent record is deleted or modified, no action is taken.
3. **RESTRICT**: This constraint means that, if a record in the parent entity has one or more records mapped to it in the child entity, the app is prohibited from deleting or updating the parent record.

4. **SET_DEFAULT**: If the parent record is deleted, the foreign key in the child record gets a default value.
5. **SET_NULL**: If the parent record is deleted or updated, the foreign key in the child record gets a NULL value.

One important thing to remember is that, if you define a foreign key constraint, SQLite requires that you create a unique index in the parent entity for the mapped columns. It is also recommended in the documentation that you create an index on the child table to avoid full table scans when the parent table is updated. If you don't, Room will throw a compile time warning.

Therefore, modify your annotation like this:

```
@Entity(tableName = "answer",
    foreignKeys = [
        ForeignKey(entity = Question::class,
            parentColumns = ["question_id"],
            childColumns = ["question_id"],
            onDelete = CASCADE)
    ],
    indices = [Index("question_id")])//only this line changes
```

You will need to add the import for `androidx.room.Index`, or you can just import `andoidx.room.*`.

The `indices` property allows you to define an index for one or more columns in your entity by passing an array with the column names. This takes care of the index for the child entity, now you need to define it for the parent entity.

Open **Question.kt** and modify the `@Entity` annotation like below:

```
@Entity(tableName = "question", indices =
[Index("question_id")])
```

Again, you will need to add the import for `androidx.room.Index`.

Just like the `Answer` entity, this code is telling Room that you want to create an index for the `question_id` primary key field.

Build and run your app to verify everything is working properly.

Now, say you want to retrieve a list of all the questions with their respective answers. To do this, you would need to write two different queries: One to retrieve the list of all the questions and another to retrieve the answers based on the `question_id`. Your Daos would look like this:

```
@Query("SELECT * FROM question ORDER BY question_id")
fun getAllQuestions(): LiveData<List<Question>>

@Query("SELECT * FROM answer WHERE question_id = :questionId")
fun getAnswersForQuestion(questionId: Int): List<Answer>
```

While the above approach is not bad, Room offers a better way to work with **one-to-many** relations: The `@Relation` annotation.

`@Relation` is a very handy annotation that automatically retrieves records from related entities. You can apply it to a `List` or `Set` of objects and Room will take care of the rest for you. To see the `@Relation` in action, create a new class under the **data ▸ model** package and name it **QuestionAndAllAnswers**.

Replace everything inside with the following:

```
class QuestionAndAllAnswers {
    @Embedded//1
    var question: Question? = null

    @Relation(parentColumn = "question_id",//2
              entityColumn = "question_id")
    var answers: List<Answer> = ArrayList()//3
}
```

Step by step:

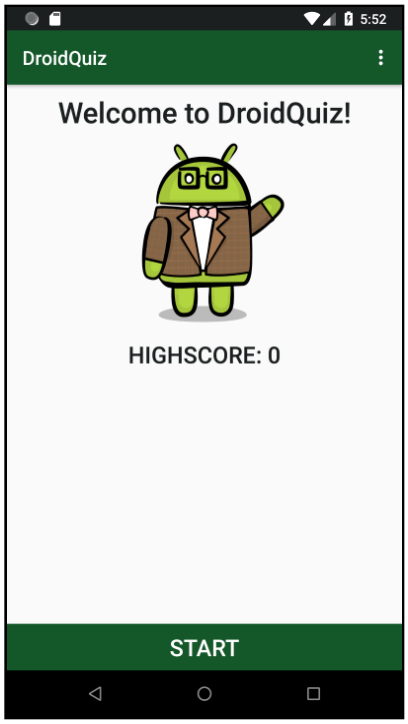
1. Since you want to be able to access all the fields in the `Question` entity, we are using the `@Embedded` annotation to retrieve all the properties from that entity. If you need a reminder of how annotations like `@Embedded` work, take a look at the **Tables and Entities** section of the previous chapter.
2. The `@Relation` annotation accepts at least two parameters:

- `parentColumn` indicates the primary key of the parent entity.
- `entityColumn` indicates the field (usually the foreign key) on this entity that maps to the primary key of the parent entity.

3. The `answers` list will contain the `Answer` objects related to the `question` property.

> **Note:** It is important to remember that the `@Relation` annotation can only be used in Pojo classes. Entities in Room can't have relations.

And that's it! **build and run** the app again to verify everything is still working fine.



The final DroidQuiz application

While the app has not visually changed, you now have a good foundation about how Room works and your Database is almost ready.

In the next chapter, you will learn how to interact with your **Entities** by creating your first **Database Access Objects**.

Key points

- An entity relation diagram, ER diagram or **ERD** is a kind of flowchart that illustrates the relation between the components of a system.
- Entities represent a component, object or a concept of a system. They are usually translated as tables in your database.
- Entities in Crow's Foot notation also include a list of attributes or properties that define them.
- An attribute that can uniquely identify a record of your entity is known as a key attribute and they usually become primary keys in your database.
- A relationship tells you how two entities interact with each other and it is usually represented as a verb.
- The cardinality of an ERD tells you the kind of relationship that two entities have.
- **One to one relationship:** When one entity can only be related to one and only one instance of the other entity.
- **One to many relationship:** When one entity can be related to many instances of another entity.
- **Many to many relationship:** When many instances of an entity can also be related to many instance of another entity.

Chapter 8: The DAO Pattern

By Aldo Olivares

In the previous chapter, you learned about different kind of relations, such as **one-to-one**, **one-to-many** and **many-to-many**. You also learned how to create them using annotations.

Now, you are going to learn how to retrieve, insert, delete and update data from your database using **Database Access Objects**.

Along the way, you will also learn:

- What DAOs are and how they work.
- How to create DAOs using Room annotations.
- How to prepopulate the database using a provider class.
- How to perform **INSERT INTO** queries using `@Insert` annotated methods.
- How to perform **DELETE FROM** queries using `@Delete`annotated methods.
- How to use the `@Query` annotation, to read data from the database.

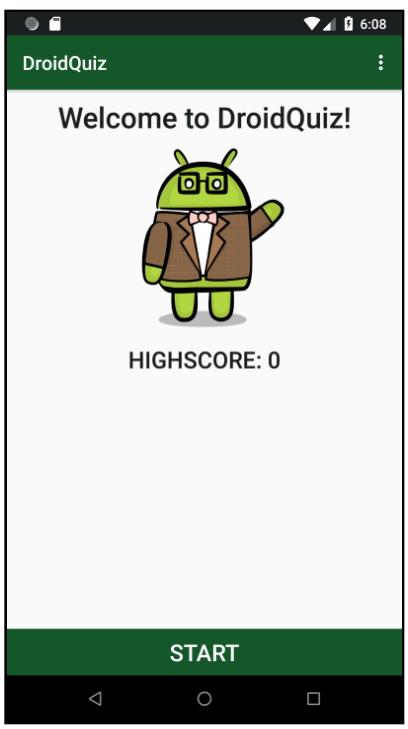
Ready? Dive in!

Getting started

Download the starter project attached to this chapter and open it using **Android Studio 3.4** or above. Once Gradle finishes building your project, take some time to familiarize yourself with the code. If you have been following along, to this point, you should already be familiar with the project since it is the same as the final project from the last chapter. If you are just getting started, here is a quick recap of the code:

- The **data** package contains two packages: **db** and **model**. The **db** package contains the `QuestionDatabase` class, which defines your Room database. The **model** package contains your entities: `Question` and `Answer`.
- The **view** package contains all your activities: `MainActivity`, `QuestionActivity` and the `ResultActivity`.

Now **Build** and **Run** the app to verify that everything is working properly:



Cool! Now you are ready to start creating some Database Access Objects in order to manipulate the data.

Using DAOs to query your data

Database Access Objects are commonly known as **DAOs**. DAOs are objects that provide access to your app's data, and they are what make Room so powerful since they abstract most of the complexity of communicating to the actual database. Using DAOs instead of query builders or direct queries makes it very easy to interact with your database. You avoid all the hardship of debugging query builders, if something breaks, and we all know how tricky SQL can be! They also provide a better **separation of concerns** to create a more structured application and improve its testability.

In Room, the DAOs are defined as **interfaces** or **abstract classes**. The only difference between both implementations is that the abstract class can *optionally* accept a `RoomDatabase` instance, as a constructor parameter. They are also convenient for defining large database transactions, using the `@Transaction` annotation on a method, and calling multiple different methods within.

If you are wondering why DAOs are defined as abstract classes or interfaces, it is because Room takes care of creating each DAO implementation at compile time, by generating the business logic code for your definitions.

> **Note**: Remember that Room does not support database access on the main thread by default since performing long running operations such as database transactions might cause your app to freeze or crash. If you still want to take this risk, you will need to explicitly call `allowMainThreadQueries()` on your database builder.

But, alright, that's enough theory. Think about all the operations that you will need to perform on your database to make the DroidQuiz app work:

- You will need to **get the list of all the questions** currently stored in your database.
- You will also need to be able to **create new questions** when your app is created.
- Finally, you will also have to **delete questions** at some point.

With the above in mind, create a DAO in your project that perform **CREATE**, **READ**, and **DELETE** queries in your database. You will see how easy it is to create DAOs in Room.

Create a new interface under the **db** package and name it **QuizDao**. To turn your new interface into a DAO, simply add the `@Dao` annotation like below:

```
@Dao
interface QuizDao {
}
```

Now, add the following code to the interface:

```
@Insert(onConflict = OnConflictStrategy.REPLACE)
fun insert(question: Question)

@Insert(onConflict = OnConflictStrategy.REPLACE)
fun insert(answer: Answer)
```

The `@Insert` annotation is a shortcut that allows you to automatically create an **INSERT INTO** query, that creates a new record in the appropriate table, with the object passed as a parameter. In this case, the first method is going to create a new record in your **Question** table using the `question` object passed as a parameter and the second method is going to create a new record in your **Answer** table.

You might have also noticed the `onConflict` parameter in the `@Insert` annotation. It allows you to define an `OnConflictStrategy`, which will be used to specify what happens in case there is a conflict when creating a new entry. There are several options:

- **ABORT** this is the default option and instructs Room to abort the transaction, return an error and roll back any changes made by the current SQL statement.
- **FAIL** makes the transaction fail and return an error.
- **IGNORE** makes the transaction ignore the conflict and continue as expected.
- **REPLACE** replaces the old data with the new values and continues the transaction.
- **ROLLBACK** aborts the current transaction and rolls back any changes made.

That is all you need to create a DAO to insert new questions and answers into your Database. Now, create the methods to delete questions.

Add the following method:

```
@Query("DELETE FROM questions")
fun clearQuestions()
```

The above code uses the `@Query` annotation to execute a **DELETE FROM** query in your `questions` table. Since there is no **WHERE** clause, this will just delete all the records in your `questions` table, which is what you will need later.

> **Note**: Notice how, if you examine the query `String`, there's some degree of autocomplete available. Room knows which entity definitions you've created and which fields exist within. You can use this to write queries, and to easily connect to those definitions, knowing that autocomplete is here to help you write them.

Room also offers the `@Delete` annotation to automatically create **DELETE FROM** querys. A method annotated with `@Delete` will delete its parameter objects from the database. For example, if you wanted to delete a single question from your database, you could do something like this:

```
@Delete
fun deleteQuestion(question: Question)
```

> **Note**: If you want to learn more about `@Delete`, you can check out the official documentation here: https://developer.android.com/reference/android/arch/persistence/room/Delete.html.

Finally, add the following methods:

```
@Query("SELECT * FROM questions ORDER BY question_id") // 1
fun getAllQuestions(): List<Question>

@Transaction // 2
@Query("SELECT * FROM questions") // 3
fun getQuestionAndAllAnswers(): List<QuestionAndAllAnswers>
```

Just like `deleteQuestion()`, the above methods use `@Query` to create SQL statements. Taking each commented section in turn:

1. This statement is retrieving all the question records in your database and **ordering** them by `question_id`. The response is returned as a `List` of `Question` objects.

2. `@Transaction` tells Room that the following SQL statements should be executed in a **single transaction**. This is specially useful when you want to query multiple tables like in the case of your one to many relation between the `questions` table and the `answers` table.
3. Finally, you are creating a select statement to retrieve all the questions from your `questions` table. Notice that this method is returning a list of your `QuestionAndAllAnswers` class so Room will immediately take the answers associated with each question and store them inside the properties of your class.

And that's it! Those are all the DAO definitions you will need.

For this app, you won't be doing any updates to the data; therefore, you didn't use the `@Update` annotation. With `@Update`, the implementation of the annotated method will simply update its parameters in the database if they already exist or wont create any if they don't. But since you're using the `OnConflictStrategy.REPLACE` when inserting data anyways, you have a way to update the data, after all.

Now, to provide the `QuizDao` for usage, you simply need to add a function to `QuizDatabase`. Open up **QuizDatabase.kt**, and add the following code within:

```
abstract fun quizDao(): QuizDao
```

Your code should now look like this:

```
@Database(
    entities = [(Question::class), (Answer::class)],
    version = 1
)
abstract class QuizDatabase : RoomDatabase() {

    abstract fun quizDao(): QuizDao
}
```

Now, when you need to access the `QuizDao` and its functions, you simply have to retrieve it from the `QuizDatabase` instance you create on app startup.

Creating a provider class

Now that your DAO methods are ready, you will create a provider class, that you will need later on, to prepopulate your database. Create a new class under the **data** package, name it **QuestionInfoProvider** and add the following method:

```
private fun initQuestionList(): MutableList<Question> {
  val questions = mutableListOf<Question>()
  questions.add(
      Question(
          1,
          "Which of the following languages is not commonly used
to develop Android Apps")
  )
  questions.add(
      Question(
          2,
          "What is the meaning of life?")
  )
  return questions
}
```

This method creates a `MutableList` of two questions with the respective `id` and `text` fields. You will use these questions later when prepopulating your database.

But you will also need to have answers for the above questions, so add the following method:

```
private fun initAnswersList(): MutableList<Answer> {
  val answers = mutableListOf<Answer>()
  answers.add(Answer(
      1,
      1,
      true,
      "Java"
  ))
  answers.add(Answer(
      2,
      1,
      false,
      "Kotlin"
  ))
  answers.add(Answer(
      3,
      1,
      false,
      "Ruby"
  ))
  answers.add(Answer(
```

```
        4,
        2,
        true,
        "42"
    ))
    answers.add(Answer(
        5,
        2,
        false,
        "35"
    ))
    answers.add(Answer(
        6,
        2,
        false,
        "7"
    ))
    return answers
}
```

Just like `initQuestionsList()`, this method is creating a `MutableList`, but with `Answer` objects. Each answer corresponds to a `Question` of the previous method, using the `questionId` property to match each of them.

Now, add the following properties at the top of your class:

```
var questionList = initQuestionList()
var answerList = initAnswersList()
```

The above properties are immediately initialized with the list of questions and answers that `initQuestionList()` and `initAnswersList()` return.

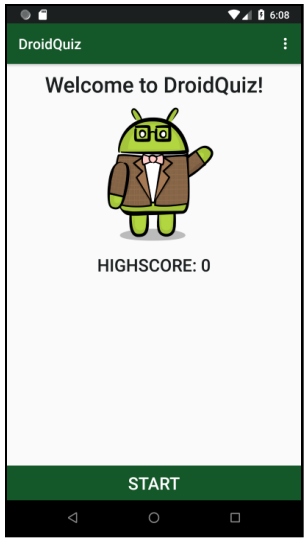
Finally, make this class a singleton by changing the `class` keyword to `object`. Your code should now look like this:

```
object QuestionInfoProvider {

  var questionList = initQuestionList()
  var answerList = initAnswersList()

  private fun initQuestionList(): MutableList<Question> {
    val questions = mutableListOf<Question>()
    questions.add(
      Question(
        1,
        "Which of the following languages is not commonly used
to develop Android Apps"))
    questions.add(
      Question(
        2,
```

```
            "What is the meaning of life?"))
        return questions
    }

    private fun initAnswersList(): MutableList<Answer> {
        val answers = mutableListOf<Answer>()
        answers.add(Answer(
            1,
            1,
            true,
            "Java"
        ))
        answers.add(Answer(
            2,
            1,
            false,
            "Kotlin"
        ))
        answers.add(Answer(
            3,
            1,
            false,
            "Ruby"
        ))
        answers.add(Answer(
            4,
            2,
            true,
            "42"
        ))
        answers.add(Answer(
            5,
            2,
            false,
            "35"
        ))
        answers.add(Answer(
            6,
            2,
            false,
            "7"
        ))
        return answers
    }
}
```

The reason you use the object keyword is to make this class a singleton so that we never really have to instantiate this class ourselves since you are only interested in the utilities that this class provides.

And that's it! **Build** and **Run** your app to verify that it is still working as expected:



Sweet! Although the UI is still not working, your database and DAOs are pretty much ready to use. You'll connect the business logic in the following chapters.

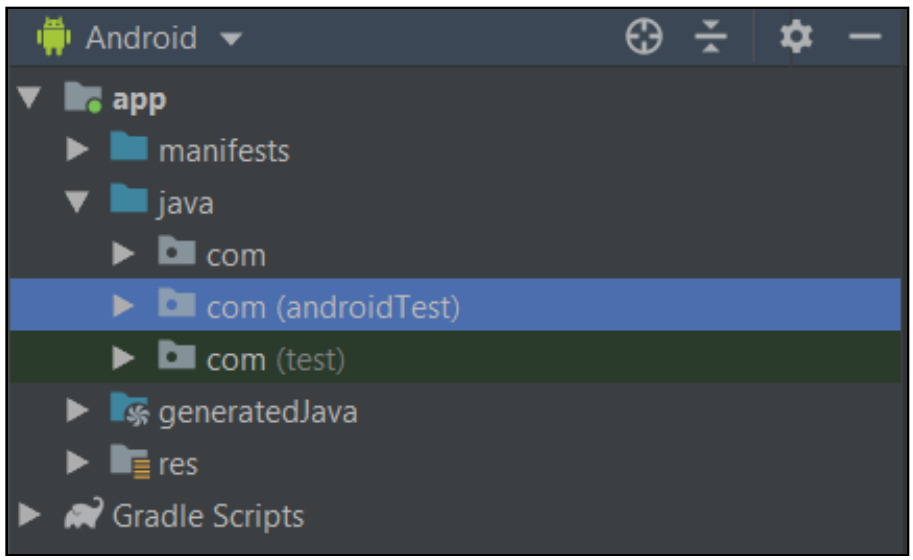
Testing your database

Although your app's UI is not working yet, you can still interact with your database by performing some tests such as adding or deleting questions to verify its functionality.

Now, to test your database, you could start writing code in your activities that inserts or deletes data and prints the results. You could also wait until you have all your `ViewModels` and wire it to your UI. The problem with this approach is that you might end up with a ton of code that you will have to delete at the end anyway. Also, you might forget to delete some of your `print()` statements and expose sensitive data from your users.

To avoid the above issues, you are going to use a very useful testing framework for Andriod called **Espresso**.

In your project, there's a **com.raywenderlich.droidquiz** package with **(androidTest)** next to it.



Under that package, there is a **QuizDaoTest.kt** file. Open it by double-clicking and replace the contents inside with the following code:

```
@RunWith(AndroidJUnit4::class)
class QuizDaoTest { // 1
  @Rule
  @JvmField
  val rule: TestRule = InstantTaskExecutorRule() // 2

  private lateinit var database: QuizDatabase // 3
  private lateinit var quizDao: QuizDao // 4
}
```

Briefly, the above:

1. Creates a test class for your `QuizDao` called `QuizDaoTest`.
2. Specifies that all tasks executed using Google's Architecture Components should be executed synchronously on the **main thread**. This is very important since unit tests should be executed sequentially and synchronously.
3. Creates a `lateinit var` that will hold a reference to your Room database.
4. Creates a `lateinit var` that will hold a reference to your `QuizDao`.

Next, add the following code:

```
@Before
fun setUp() {
  val context: Context =
InstrumentationRegistry.getInstrumentation().context // 1
  try {
    database = Room.inMemoryDatabaseBuilder(context,
QuizDatabase::class.java) //2
        .allowMainThreadQueries() //3
        .build()
  } catch (e: Exception) {
    Log.i(this.javaClass.simpleName, e.message) //4
  }
  quizDao = database.quizDao() //5
}
```

`@Before` is used to specify a method that should be executed before any test is run. Here is what's happening above:

1. Gets the context for this test and assigns it to `context`.
2. Creates an in-memory version of your database. This means that all data will safely be deleted at the end of your test.
3. `allowMainThreadQueries()` allows you to execute queries on the main thread. You need to call this method on your database builder, or Room will throw an error.
4. Logs an exception if the database can't be built.
5. Initializes your `QuizDao`.

Next, add the following code:

```
@Test
fun testInsertQuestion() {
  // 1
  val previousNumberOfQuestions = quizDao.getAllQuestions().size
  //2
  val question = Question(1, "What is your name?")
  quizDao.insert(question)
  //3
  val numberOfQuestions = quizDao.getAllQuestions().size
  // 4
  val numberOfNewQuestions =
      numberOfQuestions - previousNumberOfQuestions
  // 5
  Assert.assertEquals(1, numberOfNewQuestions)
  // 6
```

```
    quizDao.clearQuestions()
    // 7
    Assert.assertEquals(0, quizDao.getAllQuestions().size)
  }
```

The `@Test` annotation specifies that this method is a test that you want to execute. Here's what is going on:

1. Calls the `getAllQuestions()` method of your DAO and store the size of currently available questions.
2. Creates a `Question` and inserts it in your database.
3. Gets the new amount of questions from the database.
4. Calculates the delta from new and previous amount of questions in the database.
5. Uses `assert()` to let the test know you're expecting only one new question in the database. If the assertion fails, it means the `Question` you created was not stored in the database, or it was stored more than once.
6. Clears all the questions from the database after the first assertion.
7. Verifies that there are no questions in the database, after you've cleared it.

Add the following method:

```
  @Test
  fun testClearQuestions() {
    for (question in QuestionInfoProvider.questionList) {
      quizDao.insert(question)
    }
    Assert.assertTrue(quizDao.getAllQuestions().isNotEmpty())
    Log.d("testData", quizDao.getAllQuestions().toString())
    quizDao.clearQuestions()
    Assert.assertTrue(quizDao.getAllQuestions().isEmpty())
  }
```

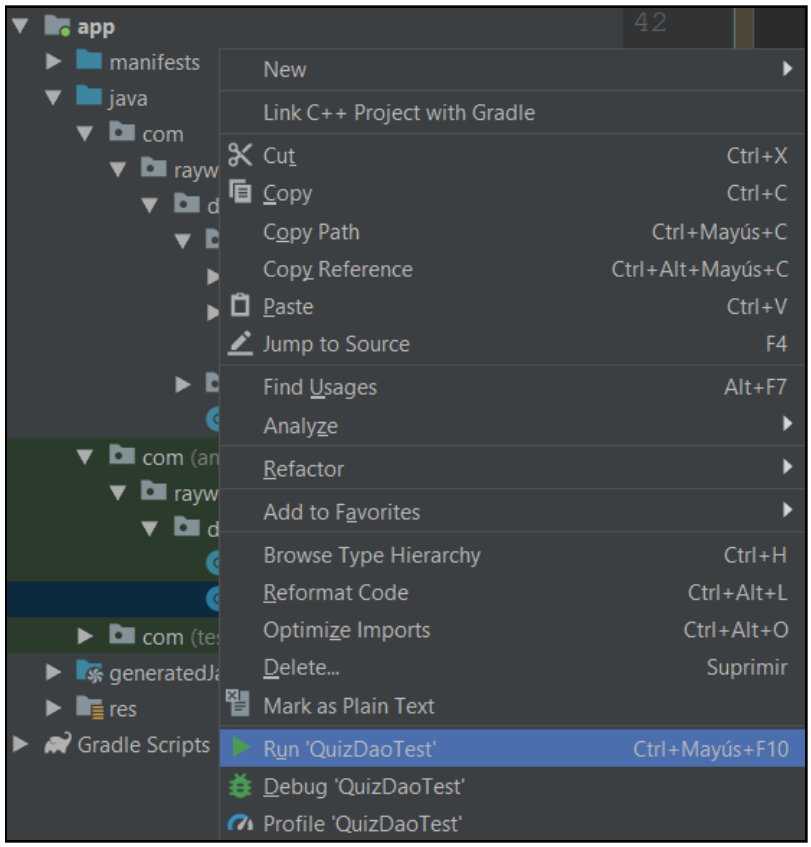
This test simply verifies the correct functionality of your `clearQuestions()` method by inserting and deleting all the question records in your `QuestionInfoProvider`. It also logs the data saved, so you can see the data does exist within the database.

Finally, add the following method:

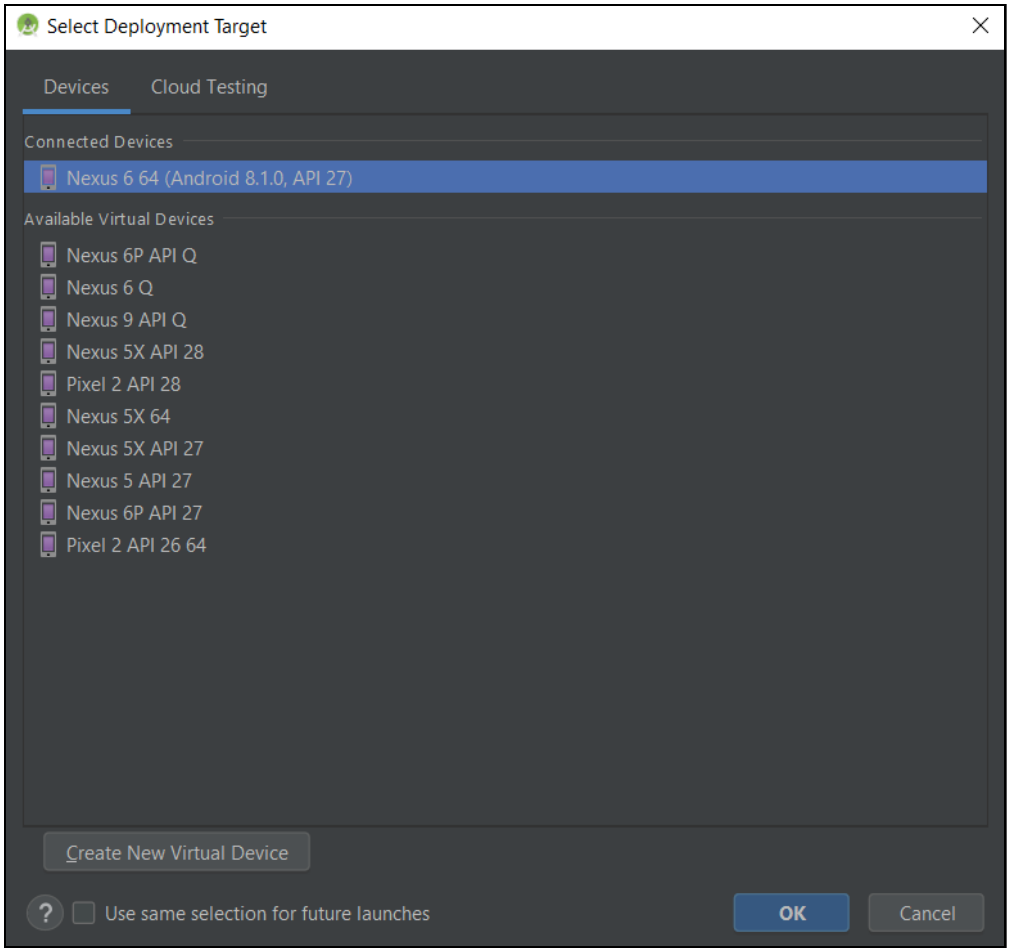
```
  @After
  fun tearDown() {
    database.close()
  }
```

Contrary to the `@Before` annotation that specifies methods that should be executed before any test is run, `@After` specifies which methods should be executed after each of the tests has concluded. Generally speaking, methods annotated with `@After` are used to release resources allocated with `@Before`. In this case, you are closing the connection to your database.

When you run an Espresso test, it will install your app on a device or emulator, then execute all the code in your tests. Under the **com.raywenderlich.droidquiz** with the **(androidTest)** notation, right-click your `QuizDaoTest` and select **Run 'QuizDaoTest'**. You can also click the green arrow next to the test class name, or click the arrow next to an individual test.



When asked to select a deployment target select your emulator and click **OK**.



Your project will build, install, and execute all your tests. If you followed every step properly all the tests should pass.

You have now interacted with your database without adding a single line of code to your activities. You also know that your DAOs work as expected and can confidently proceed to focus on the other layers of your architecture such as your **ViewModels** and **Views**.

If you need even more proof of the awesome work you did in this chapter, you can add some `Log.d()` statements to the tests, to print out the data being read from the in-memory database. But the tests should be proof enough!

Key points

- **Database Access Objects** are commonly referred to as **DAOs**.
- DAOs are objects that provide access to your app's data by abstracting most of the complexity behind **querying and updating** your database.
- In Room, DAOs can be defined as **interfaces** or **abstract classes**.
- The `@Insert` annotation is a marker, which allows you to automatically create an **INSERT INTO** query.
- `@Insert` can take an `OnConflictStrategy` parameter, that allows you to specify what happens in case there is a conflict when creating a new database entry.
- `@Query` allows you to perform any kind of **queries** in your database. You can also use **autocomplete**, to easily connect to **entities** and their **property definitions**.
- `@Transaction` tells Room that the following SQL statements should be executed in a **single transaction**.
- `@Delete` allows you to automatically create **DELETE FROM** queries, but it requires a parameter to be removed; e.g., a `Question` object.
- `@Update` updates a record in the database **if it already exists**, or omits the changes, if it doesn't, leaving the database **unchanged**.
- Writing tests with **Espresso** is a good way to see if your database code works properly.
- You can run Espresso tests, **without manually going through the app**, in less than a few seconds.
- Inserting the data and reading from the databse in Espresso is safe, because you can work with an **in-memory** version of the database.
- In-memory databases **clear up after tests end**, so there's no need to do extra cleanup, other than to `close()` the database, to avoid leaks.

Where to go from here?

You now know how to create DAOs to interact with your database. You can download the final project by opening the attachment on this chapter, and if you want to learn more about DAOs in Room, you can explore the following resources:

- Google's guide, "Accessing data using Room DAOs," found at https://developer.android.com/training/data-storage/room/accessing-data.
- The official documentation about Room DAOs, found at https://developer.android.com/reference/android/arch/persistence/room/Dao.

In the next chapter, you are finally going to see your UI working by integrating your Room database and DAOs with other architecture components such as **LiveData** and **ViewModels**.

Chapter 9: Using Room with Google's Architecture Components

By Aldo Olivares

In the previous chapters, you learned how to create the most important components of a Room Database: your **data access objects (DAOs)** and your **entities**.

While having your DAOs and entities is usually enough to interact with your database, you still need a way to display all the information to the user, all the while handling lifecycle of the app and configuration changes. This is where Google's architecture components such as the **ViewModel** and **LiveData** come to the rescue!

In this chapter, you will learn:

- What `LiveData` and `ViewModel` components are, and how to use them.
- How to make your DAOs return `LiveDatas` instead of simple data objects.
- How to create `ViewModels` that are **lifecycle-aware** and **observe** them in your activities.
- How to create a **Repository** that acts as a bridge between your `ViewModels` and your DAOs.
- How to **prepopulate** your database using a provider class.

Dive in!

> **Note**: This chapter assumes you have basic knowledge of Kotlin and Android. If you're new to Android, check out our Android tutorials here: https://www.raywenderlich.com/category/android. If you know Android but are unfamiliar with Kotlin, take a look at, "Kotlin For Android: An Introduction," here: https://www.raywenderlich.com/174395/kotlin-for-android-an-introduction-2.

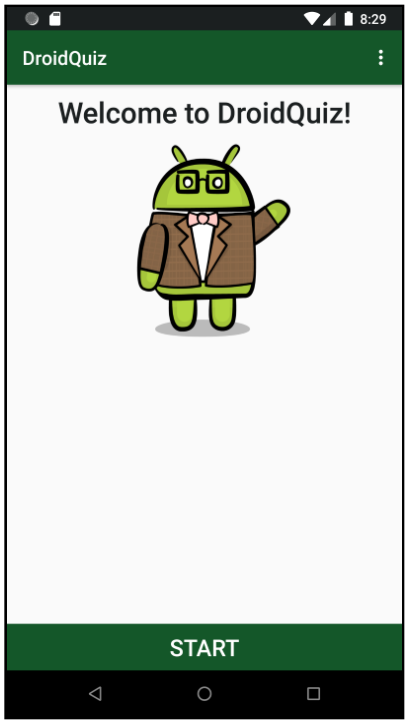
Getting started

Start with the starter project attached to this chapter and open it using **Android Studio 3.4**, or greater, by going to **File ▸ New ▸ Import Project** and selecting the **build.gradle** file, or by using the **File ▸ Open Existing Project**, and selecting the starter project directory.

If you have been following along until this point, you should already be familiar with the code since it is the same as the final project from the last chapter. But, if you are just getting started, here is a quick recap:

- The **data** package contains two packages: **db** and **model**. **db** contains the `QuizDatabase` and your DAOs. The **model** package contains your entities: `Question` and `Answer`.
- The **view** package contains all the activities for your app: `MainActivity`, `QuestionActivity` and `ResultActivity`.

Once the starter project finishes loading and building, run the app on a device or emulator:



Looks like everything is working as expected. You're ready to start working on connecting Room to your app. But, first, let's talk about `LiveData`.

Using LiveData with a repository

To use `LiveData`, you first need to learn what a `LiveData` is. To put it simply, `LiveData` is an **observable piece of data**, which is **aware of the Android lifecycle**. You could, for simplicity's sake, think of an `Observable` from Reactive Extensions, but which also listens to the Android lifecycle. As such, you can listen to its updates, by adding `Observers`.

Furthermore, by knowing the lifecycle state at all times, it has smart internal mechanisms, which stop potential observers from being updated, unless the lifecycle is *active* — your app and the screen with `LiveDatas` is visible. Because of this, you can easily avoid updating the UI, when the app is not active — e.g. when it's in the background.

According to the documentation, there are six main advantages of using `LiveData` vs other similar libraries:

- **Ensures your UI matches your data state**: Since `LiveData` implements the observer pattern, you can be sure that your UI widgets such as `Buttons`, `ListViews`, `RecyclerViews` or `TextViews` will always be updated with the **latest information**.
- **No memory leaks**: Since `LiveData` observers are bound to the lifecycle of other components, they will be destroyed as soon as the associated component is destroyed.
- **No crashes due to stopped activities**: When an `Activity` becomes *paused* or *stopped* it won't receive any new `LiveData` notifications.
- **No more manual lifecycle handling**: Google made sure that `LiveData` components are lifecycle-aware by default, so you don't have to manually control them.
- **Proper configuration changes**: Since `LiveData` is lifecycle-aware, and it caches the latest piece of data emitted, your Android components will receive the last emitted state, after configuration changes.
- **Sharing resources**: `LiveData` can be extended to wrap system services, so they can be shared in your app.

`LiveData` sounds awesome, right? Well, you are going to use it to wrap the results of your DAO queries, and as such, activities and fragments you use will automatically be notified of any changes. But, to do this, you need to add the `LiveData` dependency to your project, and change the DAO definitions, to return `LiveDatas`.

Adding LiveData to the project

If you check out your app's `build.gradle` file, you can find the following code:

```
// architecture components
implementation "androidx.arch.core:core-common:$androidx_common"
implementation
"androidx.lifecycle:lifecycle-common:$lifecycle_components"
implementation
"androidx.lifecycle:lifecycle-extensions:$lifecycle_components"
```

By adding the `core` and `lifecycle` dependencies, you add some of Android Jetpack's fundamental components, which are related to the Android lifecycle. This also includes the `LiveData` component, so you can use it, without changing anything.

Now, open **QuizDao.kt** under the **data > db** package. Take a look at `getAllQuestions()` and `getQuestionAndAllAnswers()`:

```
@Query("SELECT * FROM question ORDER BY question_id")
fun getAllQuestions(): List<Question>

@Transaction
@Query("SELECT * FROM question")
fun getQuestionAndAllAnswers(): List<QuestionAndAllAnswers>
```

Right now, these methods are just returning a simple `List` but how do you make them return a LiveData object instead? Well, it's actually very easy! You just need to change your method signatures to this:

```
@Query("SELECT * FROM question ORDER BY question_id")
fun getAllQuestions(): LiveData<List<Question>>

@Transaction
@Query("SELECT * FROM question")
fun getQuestionAndAllAnswers():
LiveData<List<QuestionAndAllAnswers>>
```

> **Note:** Don't forget to import all missing dependencies using **Alt** + **Enter** on Windows or **Option** + **Enter** on Mac.

As previously mentioned, `LiveData` is an observable wrapper around a piece of data. Because of this, you can hold anything within it, like a list, array or a list of lists of lists... you get the point!

So, to use `LiveData`, you need to wrap the object that you want to observe for changes, which in this case are the results of `getAllQuestions()` and `getQuestionsAndAllAnswers()`. Now, every time the data in Room changes, for example by adding a new `Question`, your `LiveData` and its observers will be notified, with the new information. But, if you keep calling to the DAO, you'll always get a new `LiveData`, and this defeats the purpose of Room being observable.

Additionally, you should never talk to the DAOs directly, because it's easier to modify the code for internal database communication if you wrap it around another layer of abstraction. For this reason. you will create a **Repository** that acts as a bridge between your DAOs and the `ViewModels`, which you will define later.

Creating a QuizRepository

Create a new Kotlin interface under the **data** package and name it **QuizRepository**. Add the following code, also importing the missing classes:

```
interface QuizRepository {

  fun getSavedQuestions(): LiveData<List<Question>>

  fun saveQuestion(question: Question)

  fun saveAnswer(answer: Answer)

  fun getQuestionAndAllAnswers():
LiveData<List<QuestionAndAllAnswers>>

  fun deleteQuestions()
}
```

The above interface defines the methods that you will need in your repository. By using an interface you make it much easier to change the implementation of your code if you later decide that you need another database implementation rather than Room.

Now, create a new Kotlin class under the **data** package and name it **Repository**. Make your class implement the **QuizRepository** interface:

```
class Repository : QuizRepository {

}
```

Override all the functions in the interface to implement them. You can press **Ctrl + I** and Android Studio should display a list of all the missing members. Select all of them and press **OK**.

Next, add the the following properties at the top of your class:

```
private val quizDao: QuizDao by lazy
{ QuizApplication.database.questionsDao() }
private val allQuestions by lazy { quizDao.getAllQuestions() }
private val allQuestionsAndAllAnswers by lazy
{ quizDao.getQuestionAndAllAnswers() }
```

You create two `LiveData` values, to observe and react to the data within the database, and all the changes. `allQuestions` will hold a reference to all the questions currently stored in your database.

Once again, since this is `LiveData`, your observers will be notified each time a new record is added or updated in the `questions` table. `allQuestionsAndAllAnswers` holds a `LiveData` list of `QuestionAndAllAnswers`. This property will be useful when displaying a question and its answers to your users.

Now, implement `saveQuestion()` and `saveAnswer()` like this:

```
override fun saveQuestion(question: Question) {
  AsyncTask.execute { quizDao.insert(question) }
}

override fun saveAnswer(answer: Answer) {
  AsyncTask.execute { quizDao.insert(answer) }
}
```

The above code uses `insert()` of your `quizDao` to create new `Question` and `Answer` records in your database. You are using an `AsyncTask` because you don't want to execute long-running write operations on the main thread.

> **Note**: You can also choose different mechanisms to schedule the insert operations in the background, such as **Kotlin Coroutines** or creating your own threads.

Next, change the `deleteQuestions()` to the following code:

```
override fun deleteQuestions() {
  AsyncTask.execute { quizDao.clearQuestions() }
}
```

Just like `saveAnswer()` and `saveQuestion()`, this method uses an `AsyncTask` to execute one of your DAO's methods: `clearQuestions()`. As the name implies, `deleteQuestions()` will delete all the questions in your database.

Finally, implement the remainder of the code like this:

```
override fun getSavedQuestions() = allQuestions

override fun getQuestionAndAllAnswers() =
allQuestionsAndAllAnswers
```

Once again, because you're using `LiveData`, if you ever need to access fresh information from the database, you simply have to observe the preloaded `LiveDatas` in your repository. And that is all you need to create a repository that interacts with your database using your Data Access Objects.

At this point, you might be wondering: *Why do I need to define a repository that interacts with my DAOs? Can't I simply use my DAOs inside my ViewModels?*

Well, you certainly can use your DAOs directly inside your `ViewModels`, but you also need to remember a very important principle in programming: **The Single Responsibility Principle**.

The Single Responsibility Principle states that each class in your code should have a single responsibility or a single reason to change and that it should do it well. Just like in a company, you wouldn't want developers doing accounting stuff and you wouldn't want your accountants touching your code.

Also, by having each class focusing on a single task you will make your code much easier to maintain and test.

All right, that's enough about `LiveData`. Let's talk about `ViewModels`!

Creating ViewModels

The `ViewModel` is a part of the **Google's architecture components** and it's designed to solve two common issues that developers often face when developing Android apps:

- **When an activity or fragment is destroyed, data is lost**:d Most developers can restore simple data by saving it using `onSaveInstanceState()` and retrieving it from the `Bundle` in `onCreate()`. However, this is not always a good approach since `Bundles` are only suitable for small amounts of data that can be serialized and de-serialized. You shouldn't store *all the data* you're displaying and working with.
- **Separation of Concerns**: Activities and fragments usually have to execute different operations such as database transactions, HTTP requests, UI updates and more. It is better to separate `Views` from the business logic by delegating this task to a more appropriate class such as the `ViewModels`.

But how does the ViewModel help solve these issues?

Well, `ViewModel` is specifically designed to hold and manage data related to your user interface. Just like `LiveData` the `ViewModel` is lifecycle aware, which means that it can react to the state of your Android components. Furthermore, using factories, and dependency management, it can survive configuration changes such as screen rotations. Therefore you won't need to manually restore data using methods such as `onSaveInstanceState()`, you can simply retrieve everything you stored within the `ViewModel`.

The `ViewModel` sounds like the perfect choice to manage the questions and answers for your DroidQuiz app, right?

You should find a package under **drodquiz** with the name **viewmodel**. Create a new Kotlin class inside this package and name it **MainViewModel**.

Make `MainViewModel` extend the `ViewModel` by modifying your code like this:

```
class MainViewModel() : ViewModel() {

}
```

Now, since you are going to need your repository to interact with your database from your `ViewModels`, add the following parameter to the primary constructor of your class:

```
class MainViewModel(private val repository: QuizRepository) :
ViewModel() {

}
```

Finally, add the following code:

```
fun prepopulateQuestions() {
  for (question in QuestionInfoProvider.questionList) {
    repository.saveQuestion(question)
  }
  for (answer in QuestionInfoProvider.answerList) {
    repository.saveAnswer(answer)
  }
}

fun clearQuestions() = repository.deleteQuestions()
```

`prepopulateQuestions()` creates new question and answer records in your database by using the sample data included in your `QuestionInfoProvider`, while `clearQuestions()` deletes all the questions in your database using `deleteQuestions()` on your `QuizRepository`.

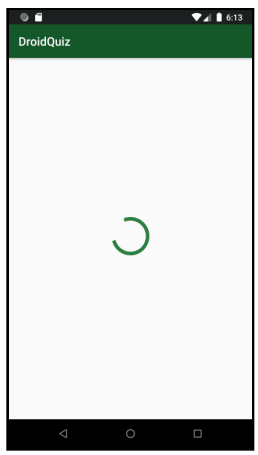
> **Note**: Here you are using a method in your **ViewModel** to prepopulate your database since it is very useful to learn how to perform delete and insert operations at any time. However, if you want to prepopulate your database with some default data, most of the time you will probably use `addCallback()` on your database builder, which gives you a callback, for when the database is ready. Then, within the callback you can call your prepopulated code.

The `ViewModel` for your `MainActivity` is ready! Now, it is time to create the `ViewModel` for your `QuestionActivity`.

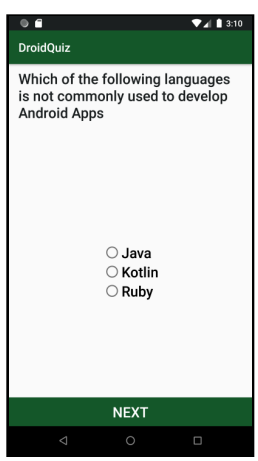
Next, you need to create the **ViewModel** for your `QuestionActivity`, This will be slightly more complex, but don't worry, you'll be guided every step of the way.

The `QuestionActivity` can have three different states at any given point:

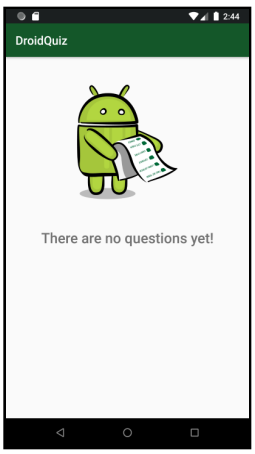
- **Loading State**: Displayed when the list of questions are being loaded from your database and it is represented by a progress bar:



- **Data State**: Displayed when you are ready to display a question to your user. This state is represented by a text and a group of radio buttons for the options:

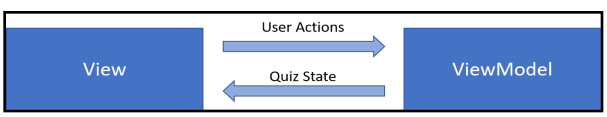


- **Empty State**: Displayed when there are no questions in your database. This state is represented by an image and a text saying that there are no questions:



- **Finish State**: A special state, sent from the `ViewModel` when there are no more questions to be displayed. This state is only used by the `QuestionActivity` to know when to navigate to the `ResultActivity`.

To represent the above states you are going to create a sealed class that your **ViewModel** will update and the `QuestionActivity` will observe using `LiveData`. In the end, you will have an architecture like this:



Your `Views` will only be in charge of communicating the actions from the user to your `ViewModel` and rendering the data received. The ViewModel will be in charge of communicating with the repository, handling the logic and sending UI ready data to your `View`. Interesting huh? :]

Create a new Kotlin class under the **model** package and name it **QuizState**. Modify your class like below:

```
sealed class QuizState {
  object LoadingState : QuizState()
  data class DataState(val data: QuestionAndAllAnswers) :
QuizState()
  object EmptyState : QuizState()
  data class FinishState(val numberOfQuestions: Int, val score:
Int) : QuizState()
}
```

As you can see each of the aforementioned states is represented here. The `Data` has a contains the question that you will display to your users, within `data`. The `Finish` holds the number of questions in the quiz, within `numberOfQuestions` and the number of correct answers from the user within `score`. The other two states - `Loading` and `Empty` are simple `objects`, which represent events for the two cases.

Now, it is time to create your `ViewModel`.

Create a new class under the **viewmodel** package and name it **QuizViewModel**. Modify your class like below:

```
class QuizViewModel(repository: QuizRepository) : ViewModel() {
}
```

Just like before, you are making the `QuizViewModel` class extend from `ViewModel()` and have the repository property in the primary constructor.

Next, add the following properties to the top of your class:

```
private val questionAndAnswers =
MediatorLiveData<QuestionAndAllAnswers>() // 1
private val currentQuestion = MutableLiveData<Int>() // 2
private val currentState = MediatorLiveData<QuizState>() // 3
private val allQuestionAndAllAnswers =
repository.getQuestionAndAllAnswers() // 4
private var score: Int = 0 // 5
```

Step by step:

1. Represents the current `QuestionAndAnswers` that is going to be sent to `QuestionActivity` and displayed to the user.
2. `currentQuestion` is a helper property that helps you keep track of which question has to be displayed from the list of questions retrieved from the repository. For example, if `currentQuestion` is equal to 0 you are going to display the question with `question_id = 0`.
3. `currentState` contains the current `QuizState` that is going to be updated by your ViewModel and observed by your `QuestionActivity`.
4. `allQuestionAndAllAnswers` contains a `LiveData` list of all the questions in your database.
5. `score` is another helper that holds the score of your user which is updated each time your user answers a question correctly.

Next, add the following methods:

```
fun getCurrentState(): LiveData<QuizState> = currentState

private fun changeCurrentQuestion() {
  currentQuestion.postValue(currentQuestion.value?.inc())
}
```

`getCurrentState()` will be used by your `MainActivity` to retrieve and observe the current `QuizState`. `changeCurrentQuestion()` simply adds one to the value of `currentQuestion`.

Next, add the following method:

```
private fun addStateSources() {
  currentState.addSource(currentQuestion)
{ currentQuestionNumber -> // 1
    if (currentQuestionNumber ==
allQuestionAndAllAnswers.value?.size) {

currentState.postValue(QuizState.Finish(currentQuestionNumber,
score))
    }
  }
  currentState.addSource(allQuestionAndAllAnswers)
{ allQuestionsAndAnswers -> // 2
    if (allQuestionsAndAnswers.isEmpty()) {
      currentState.postValue(QuizState.Empty)
    }
  }
  currentState.addSource(questionAndAnswers)
{ questionAndAnswers -> // 3
    currentState.postValue(QuizState.Data(questionAndAnswers))
  }
}
```

You will call `addStateSources()` to add the sources which your `currentState` needs to observe: `currentQuestion`, `allQuestionAndAllAnswers` and `questionAndAnswers`. Taking each commented section in turn:

1. If `currentQuestion` is equal to the number of questions in your database it means that your user has finished answering the questions in your quiz, so you will change the value of `QuizState` to `Finish`.
2. If the list of questions retrieved from the database is empty you will change the value of `QuizState` to `Empty`.
3. This is the `questionAndAnswers` that you will send to the `QuestionActivity` in `Data`.

Now, add the following method:

```
  private fun addQuestionSources() {
    questionAndAnswers.addSource(currentQuestion)
  { currentQuestionNumber ->
      val questions = allQuestionAndAllAnswers.value

      if (questions != null && currentQuestionNumber <
  questions.size) {

  questionAndAnswers.postValue(questions[currentQuestionNumber])
      }
    }

    questionAndAnswers.addSource(allQuestionAndAllAnswers)
  { questionsAndAnswers ->
      val currentQuestionNumber = currentQuestion.value

      if (currentQuestionNumber != null &&
  questionsAndAnswers.isNotEmpty()) {

  questionAndAnswers.postValue(questionsAndAnswers[currentQuestion
  Number])
      }
    }
  }
```

This method adds two different sources to your `questionAndAnswers`: `currentQuestion` and `allQuestionAndAllAnswers`. Observing `currentQuestion` will help you update the current `allQuestionAndAllAnswers` that will be sent to the `QuestionActivity` using a `Data`. Observing `allQuestionAndAllAnswers` will tell your `questionAndAnswers` when the list of questions has been properly retrieved from your database.

Now, add the following code:

```
  fun nextQuestion(choice: Int) { // 1
    verifyAnswer(choice)
    changeCurrentQuestion()
  }

  private fun verifyAnswer(choice: Int) { // 2
    val currentQuestion = questionAndAnswers.value

    if (currentQuestion != null &&
  currentQuestion.answers[choice].isCorrect) {
      score++
    }
  }
```

Step by step:

1. This method will be called when the user presses the **NEXT** button and will call `verifyAnswer()` and `changeCurrentQuestion()`.
2. `verifyAnswer()` checks if the answer selected by the user is correct and will increase the `score` accordingly.

Finally, add the following `init` block, under your class properties, to set up your `ViewModel`:

```
init {
  currentState.postValue(QuizState.Loading)
  addStateSources()
  addQuestionSources()
  currentQuestion.postValue(0)
}
```

Here, you are initializing the `QuizState` as `Loading` and `currentQuestion` with a value of zero (`0`). You are also calling `addStateSources()` and `addQuestionSources()` as soon as your **ViewModel** is created.

And that's it! Your `ViewModels` are ready. Now, you need to create your `Views`.

Defining your Views

As mentioned at the beginning of this chapter, the `ViewModel` is scoped to the lifecycle of an `Activity` or `Fragment` which means that it will live as long as its scope is still alive.

To create a `ViewModel` you usually call the `ViewModelProviders.of(Scope).get(Type)` which contains several utility methods that help you attach a `ViewModel` to a certain lifecycle and keep track of its state. This is how the code would look:

```
viewModel =
ViewModelProviders.of(this).get(MainViewModel::class.java)
```

The only problem with the above approach is that the `ViewModelProviders` is responsible for creating our `ViewModels` and, as such, it can't call their custom constructors. By default, `ViewModelProviders` will always call the empty constructor using `get()`. This is a problem because you need to pass the repository as a parameter.

There are several approaches to solve the above problem but the usual way of doing it is to create a factory for the `ViewModel` and to pass it to `ViewModelProviders`. To keep things short and to the point, a couple of extension functions for the Activity and Fragment classes have already been prepared for you that automatically take care of doing all of this for you. If you want to take a look at the source code just open **Utils.kt** under the root package.

Open **MainActivity.kt** and add the following property at the top of your class:

```
private val viewModel by lazy { getViewModel
{ MainViewModel(Repository()) } }
```

The above code uses lazy initialization to create your `MainViewModel` using `getViewModel()` which automatically takes care of the initialization and creation logic of the `ViewModels` using a `ViewModelFactory`.

Next, you need to set up menu actions for the user:

```
private fun prepopulateQuestions() =
viewModel.prepopulateQuestions() // 1

private fun clearQuestions() = viewModel.clearQuestions() // 2

override fun onOptionsItemSelected(item: MenuItem): Boolean { //
3
  when (item.itemId) {
    R.id.prepopulate -> prepopulateQuestions()
    R.id.clear -> clearQuestions()
    else -> toast("error")
  }
  return super.onOptionsItemSelected(item)
}
```

Step by step:

1. `prepopulateQuestions()` uses your `viewModel` to prepopulate your Room database with sample question and answer records.
2. `clearQuestions()` uses your `viewModel` to clear all the rows in your database.
3. Here, you are adding the appropriate actions to your `Activity`'s action bar. If the user taps on the **prepopulate** button, you're going to call `prepopulateQuestions()`. If the user taps the **clear** button, you will call `clearQuestions()`.

And that is all you need to do in your `MainActivity`! Now, you need to set up the `ViewModel` for the `QuestionActivity`.

Open **QuestionActivity.kt** and add the following property for your `QuizViewModel`:

```
private val viewModel by lazy { getViewModel
{ QuizViewModel(Repository()) } }
```

Just like `MainActivity`, you are using lazy initialization and `getViewModel()` to create an instance of your `QuizViewModel` when the `QuestionActivity` is first created.

Now that your `ViewModel` is set up, you only need to create some methods that handle the different states provided by your `QuizState` and render them to the screen. Since all the logic is handled in your `ViewModel`, this should be pretty easy.

Add the following code:

```
private fun render(state: QuizState) {
  when (state) {
    is QuizState.Empty -> renderEmptyState()
    is QuizState.Data -> renderDataState(state)
    is QuizState.Finish ->
goToResultActivity(state.numberOfQuestions, state.score)
    is QuizState.Loading -> renderLoadingState()
  }
}
```

`render()` will be in charge of calling the appropriate methods depending on `QuizState` using a `when` expression.

Now, add the following code to handle your states:

```
private fun renderDataState(quizState: QuizState.DataState)
{ //. 1
  progressBar.visibility = View.GONE
  displayQuestionsView()
  questionsRadioGroup.clearCheck()
  questionTextView.text = quizState.data.question?.text
  questionsRadioGroup.forEachIndexed { index, view ->
    if (index < quizState.data.answers.size)
      (view as RadioButton).text =
quizState.data.answers[index].text
  }
}

private fun renderLoadingState() { // 2
  progressBar.visibility = View.VISIBLE
}

private fun renderEmptyState() { // 3
  progressBar.visibility = View.GONE
```

```
    emptyDroid.visibility = View.VISIBLE
    emptyTextView.visibility = View.VISIBLE
  }
```

These are all the methods that `render()` will use to display different kinds of screens to the user. Taking each commented section in turn:

1. `renderDataState()` displays a question to your user using`data` of your `QuizState.Data`.
2. `renderLoadingState()` displays a progress bar.
3. `renderEmptyState()` displays an image and text saying that there are no questions in the database.

Now, add the following methods:

```
  fun nextQuestion(view: View) { // 1
    val radioButton =
  findViewById<RadioButton>(questionsRadioGroup.checkedRadioButton
  Id)
    val selectedOption =
  questionsRadioGroup.indexOfChild(radioButton)
    viewModel.nextQuestion(selectedOption)
  }

  private fun displayQuestionsView() { // 2
    questionsRadioGroup.visibility = View.VISIBLE
    questionTextView.visibility = View.VISIBLE
    button.visibility = View.VISIBLE
  }

  private fun goToResultActivity(numberOfQuestions: Int, score:
  Int) { //. 3
    startActivity(
      intentFor<ResultActivity>(
        SCORE to score,
        NUMBER_OF_QUESTIONS to numberOfQuestions
      ).newTask().clearTask()
    )
  }
```

Briefly:

1. `nextQuestion()` calls your `ViewModel`'s `nextQuestion()` passing the index of the selected radio button as a parameter. It will be called every time the user taps the **NEXT** button. The `OnClickListener` is bound within the XML to `nextQuestion()`.

2. `displayQuestionsView()` makes your `questionsRadioGroup`, `questionTextView` and `button` widgets visible, so you can display a question to your user.
3. `goToResultActivity()` creates an `Intent` to start the `ResultActivity` and passes the `score` and `numberOfQuestions` as extras.

Add the following code and import the `androidx.lifecycle.Observer`:

```
private fun getQuestionsAndAnswers() {
  viewModel.getCurrentState().observe(this, Observer {
    render(it)
  })
}
```

This method simply calls the `getCurrentState()` method to get the `QuizState` of your **ViewModel**. Since `QuizState` is a `LiveData` you can observe it using `observe()` and each time its value changes you will call `render()` passing the new QuizState as a parameter.

Finally, add the following line inside `onCreate()`:

```
getQuestionsAndAnswers()
```

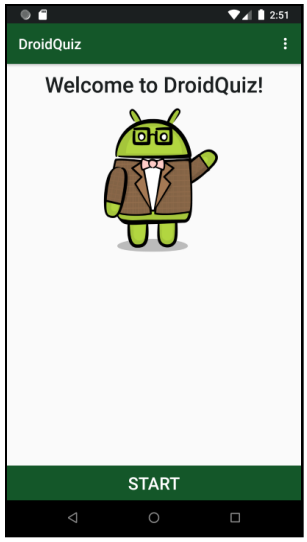
Since you immediately want to start observing the `QuizState`, `onCreate()` is the best place to call this method.

The last step to finish building your app is to display the quiz results to your user.

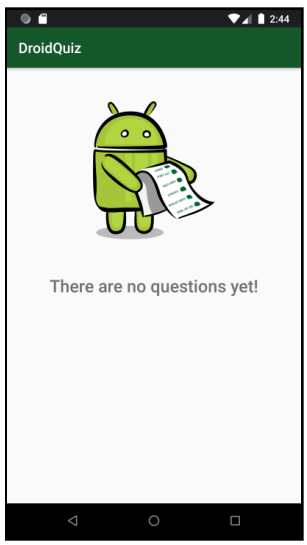
Open the **ResultActivity.kt** file under the **view** package. Add the following code inside `onCreate()`, importing the `scoreTextView` from `activity_result` XML:

```
val score = intent.extras?.getInt(QuestionActivity.SCORE)
val numberOfQuestions =
intent.extras?.getInt(QuestionActivity.NUMBER_OF_QUESTIONS)
scoreTextView.text =
String.format(getString(R.string.score_message), score,
numberOfQuestions)
```

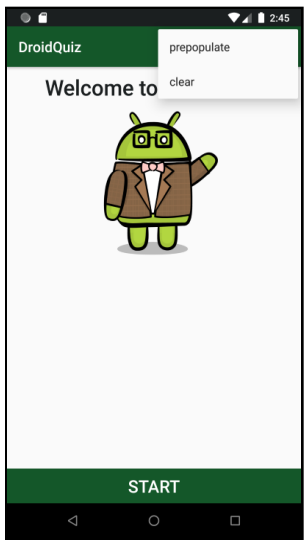
That's it! **build and run** your app to see it in action:



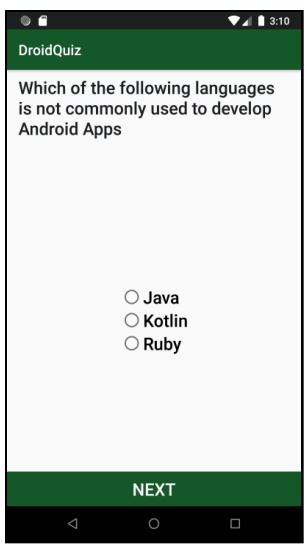
Now, try clicking the **START** button and you should see the empty screen layout:



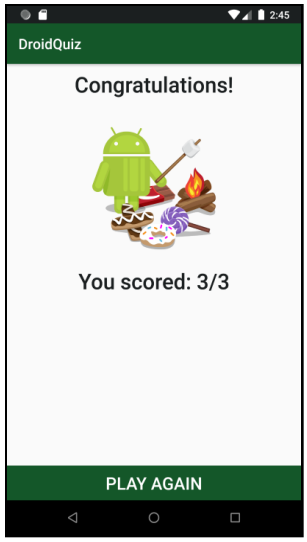
Now, go back to the main screen and click the **prepopulate** button in your action bar:



Click **START** and you should now see your question and answers displayed:



Answer the questions and take a look at the final screen to see your score!



Sweet! Your app is now working and displaying your Question and Answers!

Key points

- `LiveData` is a data holder class, like a `List`, that can be observed for changes by an `Observer`.
- `LiveData` is lifecycle-aware, meaning it can observe the lifecycle of Android components like the `Activity` or `Fragment`. It will only keep updating observers if its component is still active.
- The `ViewModel` is part of the **Google's architecture components** and it's specifically designed to manage data related to your user interface.
- A **Repository** helps you separate concerns to have a single entry point for your app's data.
- You can combine `LiveDatas` and add different `sources`, to take action if something changes.

Where to go from here?

I hope you enjoyed this chapter! If you had troubles following along, you can always download the final project attached to this chapter.

So far, you have only learned about three of the Google architecture components classes: **LiveData**, **ViewModel** and **Room**. However, there are many other classes that Google provides. If you want to learn about them, you can use the following resources:

- This tutorial about MVVM and Databinding with Android Design Patterns: https://www.raywenderlich.com/636803-mvvm-and-databinding-android-design-patterns.
- This tutorial about the Paging Library which helps create Lists on Android: https://www.raywenderlich.com/6948-paging-library-for-android-with-kotlin-creating-infinite-lists.
- This tutorial about the WorkManager architecture component in which you will learn how to create and manage background tasks: https://www.raywenderlich.com/6040-workmanager-tutorial-for-android-getting-started.

See you in the next chapter!

Chapter 10: Migrations with Room

By Aldo Olivares

In the last chapter, you finally learned how to integrate your Room components with other architecture components like LiveData and ViewModel to make your app display a nice set of questions to your users.

But what happens if you want to modify your database schema to organize questions by category or difficulty?

Well, in this chapter you'll learn how Room helps you change your database schema in a predictable way by providing migrations that help you deal with your data.

Along the way you'll learn:

- How to create a migration.
- How to add a migration to your database.
- How to perform SQLite queries.
- How to fall back to a destructive migration.

Ready? It's time to get started.

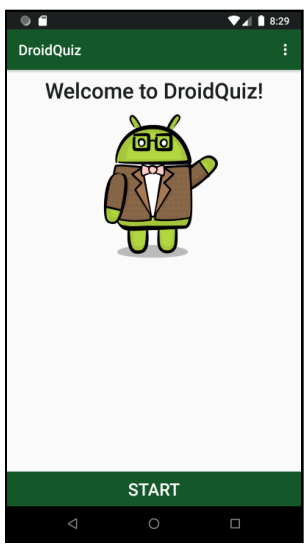
Getting started

To begin, open the starter project, which you can find in this chapter's attachments. Then open the project in Android Studio 3.3 or greater by going to **File ▸ New ▸ Import Project** and selecting the **build.gradle** file in the root package.

If you've been following along up to this point, you should already be familiar with the code. If you're just getting started, here's a quick recap:

- The **data** package contains two packages: **db** and **model**. **db** contains `QuestionDatabase`, which implements your Room database. The **model** package contains your entities, `Question` and `Answer`. It also includes `Repository`, which helps your ViewModels interact with your DAOs.
- The **view** package contains all your activities: `MainActivity`, `QuestionActivity` and `ResultActivity`.
- The **viewmodel** package contains the ViewModels of your class: `MainViewModel` and `QuestionViewModel`.

Once the starter project finishes loading and building, run the app on a device or emulator.



Important: Tap the **START** button to start a quiz, then stop the app running in Android Studio.

Cool! Now, it's time to start working with migrations.

Migrations

Before creating your first migrations with Room, you need to learn what migrations are, right?

Simply put, a database migration or schema migration is the process of moving your data from one database schema to another. There are many reasons why you might want to move your data to another database schema. For example, you might need to add a new table because you want to implement a new feature. Some data are not available and some columns of your database can be removed. Or, the API you're invoking provides different information and you want to add some new columns to an existing table. Or, other table can be removed because part of an A/B test and you need to save space.

The process of migrating your data from one schema to another could be as simple as copying data from one table to another or as complex as reorganizing your entire database. Either way, properly planning your migrations comes with benefits:

- **Reversible**: Sometimes, you might want to roll back your changes and return to an old schema. Without migrations, this process might be a complete nightmare. You'd have to manually apply all the changes, and you might not even remember how your old database looked.
- **No data loss**: With migrations, it's much easier to move your data from one schema to another in a predictable manner without losing data.

Understanding Room migrations

SQLite handles database migrations by specifying a version number for each database schema you create. In other words, each time you modify your database schema by creating, deleting or updating a table, you have to increase the database version number and modify `SQLiteOpenHelper.onUpgrade()`. `onUpGrade()` will tell SQLite what to do when one database version changes to another.

For example, say one of your users still has database version 1 but a new update of your app now uses database version 2. SQLite would realize that the current database version is obsolete and needs an upgrade. Then, SQLite would look for `SQLiteOpenHelper.onUpgrade(db, 1, 2)` and trigger its body to migrate to the new schema. If `SQLiteOpenHelper.onUpgrade(db, 1, 2)` doesn't exist, it will trigger an error.

Room migrations work in a very similar way. The difference is that Room provides an abstraction layer on top of the traditional SQLite methods with a `Migration` class.

`Migration(startVersion, endVersion)` is the base class of a database migration; it can move between *any* two migrations defined by the `startVersion` and `endVersion` parameters. The reason I've emphasized *any* is because you don't necessarily need to specify a sequential migration. For example, say Room opens database version 2 and the latest version is 5. Normally, Room would execute migrations in this order:

```
Migration(2, 3)
Migration(3, 4)
Migration(4, 5)
```

The beauty of Room is that you can also specify a `Migration` that goes directly from version 2 to version 5 like this: `Migration(2, 5)`, which makes the migration process much faster. Of course, there won't always be a direct path from migration X to migration Y, so executing all you migrations one by one might be necessary, but it's usually a good practice to specify a direct migration if possible.

If you don't specify an appropriate migration for the current database version, Room will throw a runtime error and the app will crash.

> **Note**: You can also call `fallbackToDestructiveMigration()` when building your database. This will tell Room to destructively recreate tables if you haven't specified a migration. The advantage is that you won't need to create any migrations and your app won't crash. The disadvantage is that you will delete your data every time you specify a new database version.

Now that you know the theory, you can move on to creating your first Room migrations!

Creating Room migrations

Right now, you have a very nice app that displays a series of random questions to your users. You store these questions in a **question** table, which is represented as a `Question` entity class in your code.

But what happens if you want to add difficulty levels like easy, medium and hard?

Well, right now your question table doesn't have an attribute to classify questions based on their difficulty. So your first step is to add a new column to provide that functionality to your users. Here's how you do that:

Open **Question.kt** under the **data ▸ model** package. Right now, your entity looks like this:

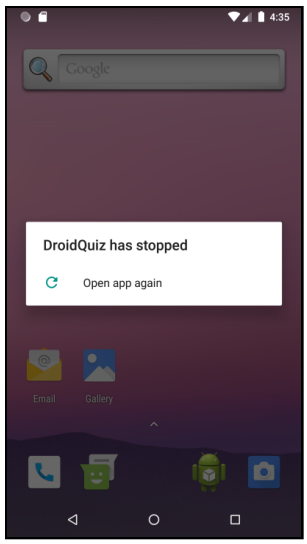
```
@Entity(tableName = "question", indices =
[Index("question_id")])
data class Question(
  @PrimaryKey(autoGenerate = true)
  @ColumnInfo(name = "question_id")
  var questionId: Int,
  val text: String
)
```

You want to represent the difficulty in terms of numbers such as 1, 2 or 3, where 1 is the lowest difficulty and 3 is the highest. To represent this concept, modify your question class to add a `difficulty` property like so:

```
@Entity(tableName = "question", indices =
[Index("question_id")])
data class Question(

  @PrimaryKey(autoGenerate = true)
  @ColumnInfo(name = "question_id")
  var questionId: Int,
  val text: String,
  val difficulty: Int = 0 //Only this lane changes
)
```

This property will represent the difficulty of the question and will have a default value of 0.

Now, build and run the app and press the **Start** button to see if it works.



And the app crashed!

Open the logcat console and take a look at the error displayed:

Room cannot verify the data integrity. Looks like you've changed schema but forgot to update the version number. You can simply fix this by increasing the version number.

> **Note**: If the app didn't crash, you might have forgotten to press the **START** button earlier, when you ran the app before making the modification. If the app crashed but you got a different error message, try uninstalling the app from your device or emulator and repeating the steps above.

Did you expect that crash?

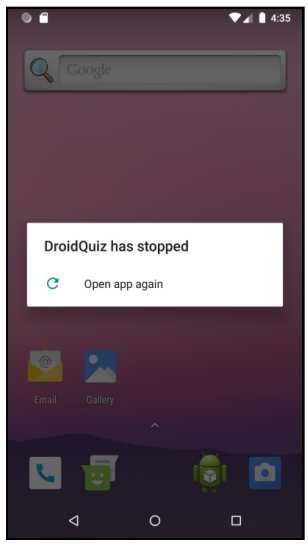
Each time you change the database schema, you need to change the database version. This will help Room know which migrations to run when building the database.

The error seems simple enough to fix, right? According to the logcat console, you just need to increase the version number, so try that now.

Open **QuizDatabase.kt** under the **data ▸ db** package and increase the database version by changing the `version` parameter value to 2 in the `@Database` notation:

```
@Database(entities = [(Question::class), (Answer::class)],
version = 2) //version change
abstract class QuizDatabase : RoomDatabase() {
  abstract fun questionsDao(): QuestionDao
}
```

Build and run the app again and press **START**....



And the app crashes again!

Open the logcat console to see the problem. You should see the message below:

A migration from 1 to 2 was required but not found. Please provide the necessary Migration path via RoomDatabase.Builder.addMigration(Migration ...) or allow for destructive migrations via one of the RoomDatabase.Builder.fallbackToDestructiveMigration methods.*

It looks like you're making some progress, since the error is different now. The error indicates that Room doesn't know how to change the database schema from 1 to 2, so it's giving you two options:

- Create a migration that goes from database schema 1 to 2.
- Call `fallbackToDestructiveMigration()` when building your database.

The second option is the easiest one to implement since you only need to add a single line of code. The only problem with this approach is that you will lose all your data when changing the schema from version 1 to 2. This is fine for your app since you have a handy button to populate your database in the main menu, but it might not be a good idea for other projects where you want to preserve user data.

With the above in mind, you're going to follow the first approach and create a new migration. Create a new package under the **db** package and name it **migrations**.

Inside **migrations**, create a new class and name it **Migration1To2**. Make your class extend `Migration` like this:

```
class Migration1To2 : Migration(1, 2) {
}
```

The first parameter in the constructor represents the start version of the database. The second one represents the end version after you've applied this migration.

Next, press **Control + I** (*implement methods*) so Android Studio displays all missing members. Select all of them and press **OK**. Your class should now have a `migrate()` method:

```
class Migration1To2 : Migration(1, 2) {
  override fun migrate(database: SupportSQLiteDatabase) {
    TODO("not implemented") //To change body of created
functions use File | Settings | File Templates.
  }
}
```

Inside `migrate()`, you should execute all the queries you need to properly change the database schema to the version indicated in the constructor.

Now, since the change is a very simple one, you'll only need to execute a single **ALTER** query to change your **question** table.

Modify `migrate` like this:

```
override fun migrate(database: SupportSQLiteDatabase) {
  database.execSQL("ALTER TABLE question ADD COLUMN difficulty
INTEGER NOT NULL DEFAULT 0")
}
```

`database.execSQL()` executes the query passed as a parameter. Here, you're executing an **ALTER TABLE** query in your **question** table that adds a new **difficulty** column that only accepts integers. It has a default value of 0.

Now that you've defined your migration, you need to tell Room to execute it before building your database.

Open **QuizDatabase.kt** and add the following companion object to the top of your class:

```
companion object {
  val MIGRATION_1_TO_2 = Migration1To2()
}
```

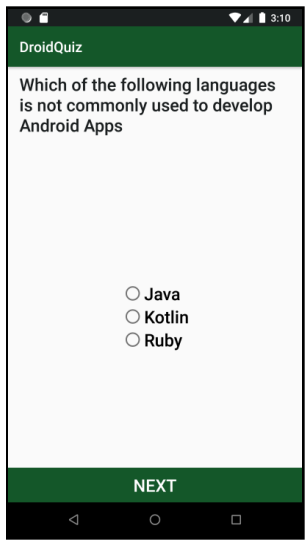
You'll use this companion object to store a reference to all the migrations that you'll define later.

Now, open **QuizAplication.kt** and modify your database builder inside `onCreate()`:

```
database = Room.databaseBuilder(this, QuizDatabase::class.java,
"question_database")
    .addMigrations(QuizDatabase.MIGRATION_1_TO_2) //Only this
line changes
    .build()
```

`addMigrations()` accepts one or more migration objects. Room will use these migrations to bring the database to the latest version.

Build and run your app and press **START** to verify that your migration works properly:



Sweet! It looks like your app works now.

Next, imagine that you want to sort your questions not only by difficulty but also by a category, such as **iOS** or **Android**. This way, you can expand the functionality of your app to display Android questions to Android developers and iOS questions to iOS developers.

Expanding the functionality of your app to support categories requires some changes in your database:

- A new property inside your question entity called **category** of type String.
- A new migration that goes from database version 2 to 3 and handles the new schema change.
- Adding the new migration to your database builder.

Start by opening the **Question.kt** file and adding a new `category` property to your class:

```
@Entity(tableName = "question", indices =
[Index("question_id")])
data class Question(
  @PrimaryKey(autoGenerate = true)
  @ColumnInfo(name = "question_id")
  var questionId: Int,
  val text: String,
  val difficulty: Int = 0,
  val category: String = "android" //Only this line changes
)
```

Now, create a new class under the migrations package and name it **Migration2To3**. Replace everything inside with the following:

```
class Migration2To3 : Migration(2, 3) {
  override fun migrate(database: SupportSQLiteDatabase) {
    database.execSQL("ALTER TABLE question ADD COLUMN category
TEXT NOT NULL DEFAULT 'android'")
  }
}
```

Here, you're creating a new `Migration` object that goes from database version 2 to 3. The query executes an **ALTER TABLE** statement that adds a **category** column of type text with a default value of **android**.

Open the `QuizDatabase` class and modify it like this

```
@Database(entities = [(Question::class), (Answer::class)],
version = 3) //change version to version 3
abstract class QuizDatabase : RoomDatabase() {
```

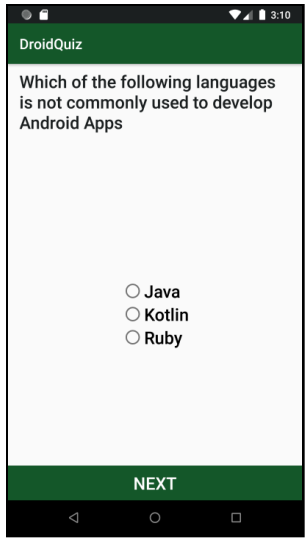
```
    companion object{
      val MIGRATION_1_TO_2 = Migration1To2()
      val MIGRATION_2_TO_3 = Migration2To3() //adds migration
    }
    abstract fun questionsDao(): QuestionDao
}
```

The above code changes the database version to 3 and creates a reference to your new migration.

Now, open the **QuizApplication.kt** file and add the migration you just created to your database builder inside `onCreate()`:

```
database = Room.databaseBuilder(this, QuizDatabase::class.java,
"question_database")
    .addMigrations(QuizDatabase.MIGRATION_1_TO_2,
QuizDatabase.MIGRATION_2_TO_3)
    .build()
```

Build and run your app, then press **START**:



Sweet! It looks like your migration works as expected.

Until now, the changes that you've made to your database schema have been really simple, since you only needed to add a new column to your tables.

But what happens if you need to modify a previously-created column?

Well, it turns out that the **ALTER TABLE** statement is very limited; the only operations that you can perform with it are **RENAME TABLE**, **RENAME COLUMN** and **ADD COLUMN**.

If you want to perform complex schema changes such as changing the type affinity of a column, you'll need to use more than one query. But don't worry, the following steps summarize the process:

1. Create a new temporary table with the new schema.
2. Copy the data from the original table to the temporary table.
3. Drop the original table.
4. Rename the temporary table with the same name as the original table.

To illustrate this process, imagine you want to modify the type affinity of the difficulty column to TEXT instead of INTEGER so that you can store the operating system that the question refers to.

To do this, open **Question.kt** and modify the category property:

```
@Entity(tableName = "question", indices =
[Index("question_id")])
data class Question(
  @PrimaryKey(autoGenerate = true)
  @ColumnInfo(name = "question_id")
  var questionId: Int,
  val text: String,
  val difficulty: String = "0", //Only this line changes
  val category: String = "android"
)
```

Now, create a new class under the migrations package and name it **Migration3To4**. Modify everything like this:

```
class Migration3To4 : Migration(3, 4) {
  override fun migrate(database: SupportSQLiteDatabase) {
    database.execSQL(
      "CREATE TABLE question_new (question_id INTEGER NOT NULL,
" +
          "text TEXT NOT NULL, " +
          "difficulty TEXT NOT NULL, " +
          "category TEXT NOT NULL, " +
          "PRIMARY KEY (question_id))"
    ) //1

    database.execSQL("CREATE INDEX
index_question_new_question_id ON question_new(question_id)") //
```

```
2

    database.execSQL(
      "INSERT INTO question_new (question_id, text, difficulty,
category) " +
          "SELECT question_id, text, difficulty, category FROM
question"
    )//3

    database.execSQL("DROP TABLE question") //4

    database.execSQL("ALTER TABLE question_new RENAME TO
question") //5

  }
}
```

Briefly:

1. Creates a new temporary table with the new schema called **question_new**.
2. Adds an index to the **question_id** column of your **question_new** table.
3. Retrieves all the data from your original **question** table using a **SELECT** statement and adds it to your **question_new** table using an **INSERT INTO** statement.
4. Drops the original question table using a **DROP TABLE** statement.
5. Renames your **question_new** table to **question** using an **ALTER TABLE** with a **RENAME TO** statement.

Open the `QuizDatabase` class and modify it like this:

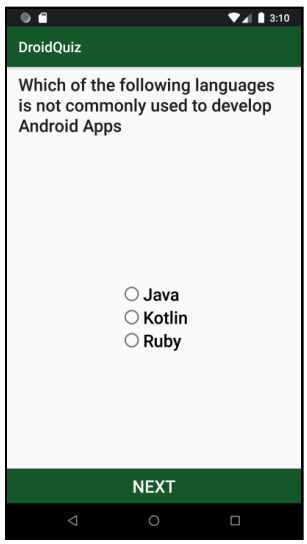
```
@Database(entities = [(Question::class), (Answer::class)],
version = 4)//Changes the db version
abstract class QuizDatabase : RoomDatabase() {
  companion object{
    val MIGRATION_1_TO_2 = Migration1To2()
    val MIGRATION_2_TO_3 = Migration2To3()
    val MIGRATION_3_TO_4 = Migration3To4() //Adds a reference to
your new migration
  }
  abstract fun questionsDao(): QuestionDao
}
```

Just like before, you've changed the database version to 4 and created a reference to your new migration inside the companion object.

Finally, add your new migration to your database by opening the **QuizApplication.kt** file and changing your database builder inside `onCreate()`:

```
database = Room.databaseBuilder(this, QuizDatabase::class.java,
"question_database")
    .addMigrations(QuizDatabase.MIGRATION_1_TO_2,
QuizDatabase.MIGRATION_2_TO_3, QuizDatabase.MIGRATION_3_TO_4)
    .build()
```

Build and run your app, then press **START**:



Cool!

You might have noticed that you now have three different migrations for four different versions of your database. If one of your users had the first version of your database installed and wanted to update the app to the latest version, Room would execute each migration one by one. Since four is still a relatively low number, the process should be quick, but imagine if you had 50 versions of your database! It would be much better to have a shortcut right?

Well, Room allows you to define a migration path that starts from and goes to any version of your database. To illustrate this concept, define a migration that goes from database version 1 to 4.

Create a new class under the migrations package and name it **Migration1To4**. Replace everything inside with the following:

```
class Migration1To4 : Migration(1, 4) {
  override fun migrate(database: SupportSQLiteDatabase) {
    database.execSQL("ALTER TABLE question ADD COLUMN difficulty
TEXT NOT NULL DEFAULT '0'")
    database.execSQL("ALTER TABLE question ADD COLUMN category
TEXT NOT NULL DEFAULT 'android'")
  }
}
```

The above simply executes two **ALTER TABLE** statements to add difficulty and category columns. Since these columns didn't exist in the version 1 database, we don't have to worry about the more complex SQL for the migration in the prior step.

Open the `QuizDatabase` class and add the following line to your companion object to create a reference to your new migration:

```
val MIGRATION_1_TO_4 = Migration1To4()
```

Now go to the **QuizApplication.kt** file and add your new migration to the database builder:

```
database = Room.databaseBuilder(this, QuizDatabase::class.java,
"question_database")
    .addMigrations(
      QuizDatabase.MIGRATION_1_TO_2,
      QuizDatabase.MIGRATION_2_TO_3,
      QuizDatabase.MIGRATION_3_TO_4,
      QuizDatabase.MIGRATION_1_TO_4
    ).build()
```

Cool! You now have a migration that goes directly from database version 1 to 4. If you build the app, the migration won't execute since your app is already on database version 4, but you can now be sure that all your users on database version 1 will properly migrate to the new version when they update the app.

Key points

- Simply put, a database migration or schema migration is the process of moving your data from one database schema to another.
- SQLite handles database migrations by specifying a version number for each database schema that you create.
- Room provides an abstraction layer on top of the traditional SQLite migration methods with `Migration`.
- `Migration(startVersion, endVersion)` is the base class for a database migration. It can move between *any* two migrations defined by the `startVersion` and `endVersion` parameters.
- `fallbackToDestructiveMigration()` tells Room to destructively recreate tables if you haven't specified a migration.

Where to go from here?

By now, you should have a very good idea of how Room migrations work. Of course, the process will differ from project to project, since the queries you'll need to execute will depend on your database schema, but the basic idea is always the same:

- Change the database version.
- Create a migration.
- Add the migration to your database builder.

If you want to learn more about Room migrations the official documentation is always a good resource.

See you in the next *Room*, er, chapter!

Section 3: Using Firebase

Firebase is a mature suite of products that allow you to implement Android applications that persist information in a safe, secure and reliable way. In this section, you'll learn the fundamentals and more advanced concepts of Firebase, including Realtime Database, as well as usage and performance.

- **Chapter 11: Firebase Overview**: In this first chapter, you'll learn what Firebase is and why Google decided to provide a product like. You'll learn about its history and you'll start creating your first project using the Firebase Console. You'll also have the first introduction to all the products of the Firebase suite.
- **Chapter 12: Introduction to Firebase Realtime Database**: In this chapter, you'll learn how to configure a project with the Realtime Database features provided by Firebase. This is a very important chapter because it contains configuration details that are very important also for the following chapters. You'll learn how to download and install into your project the JSON configuration file and how to manage authentication.
- **Chapter 13: Reading to and Writing from Realtime Database**: CRUD means Create Retrieve Update and Delete and it's a way to summarise the main operations you can do on a DB. In this chapter, you'll learn how to execute read and write operations into a Realtime Database from an Android application.

- **Chapter 14: Realtime Database Offline Capabilities**: Mobile applications run on a device with limited resources. In particular, a phone or a tablet is not always connected to the network and some feature hs to be implemented when you need to write and read data from a remote database. In this chapter, you'll learn how to manage data when the device is offline.
- **Chapter 15: Usage & Performance**: Everything has a cost. In this chapter, you'll learn about two important aspects of every application and in particular of every mobile application: cost and performance.
- **Chapter 16: Introduction to Cloud Firestone**: You've already seen how to use a Firebase Realtime Database. In this chapter, you'll learn how to use another similar product which allows you to store and synchronize data from a mobile device into a NoSQL database: Cloud Firestore.
- **Chapter 17: Managing Data with Cloud Firestore**: In this chapter, you'll learn how to set up an application into Cloud Firestore. Implementing the WhatsUp application, you'll learn how to create a DB using the Firebase console and how to set up the main configurations.
- **Chapter 18: Reading Data from Cloud Firestore**: In this chapter, you'll continue working on the WhatsUp application and you'll focus on implementing reading logic. In the process, you'll learn how to read data from the Firestore, how to listen for updates in real-time, and how queries work.
- **Chapter 19: Securing Data in Cloud Firestore**: In this chapter, you'll learn what are security rules in Cloud Firestore and how to add them to your database to make your data safe.
- **Chapter 20: Cloud Storage**: In this last chapter, you'll learn how to store media files using another Firebase feature called Cloud Storage. You'll learn how to store an image to the cloud and how to get a URL to the image to display it in your app.

Chapter 11: Firebase Overview

By Dean Djermanović

Creating a successful mobile app isn't easy. Not only do developers need to focus on writing code and fixing bugs, they often need to manage a variety of tools and build complex infrastructures too. Factor in tight schedules and resource constraints, and you've got your work cut out!

Thankfully, though, Google understood the need for a simpler way to create high-quality apps, and in 2014 they acquired **Firebase**. More recently, Google announced that in October 2019, they will start to sunset their existing **Google Analytics** for mobile apps and is directing its users to use Firebase instead. With Firebase, developers got all of the existing functionality of Google Analytics, plus a lot more.

> **Note**: The Google Analytics referred to hereafter in this book is a new sub-feature of Firebase and not the legacy platform.

Firebase history

Initially, Firebase was a mobile backend service that let you build mobile apps without having to worry about managing your own backend. However, not too long after its release, developers wanted more, so Firebase expanded its initial feature set to include more features. With these new features, you can develop apps faster, increase your user base, make more money and ensure the delivery of high quality apps. On top of all that, there's an analytics product that ties it all together.

> **Note**: Most modern mobile apps require a data access layer for things that can't be done solely on a device, like sharing and processing data from multiple users or storing large files. The remote server, typically known as the backend, is responsible for handling these backend services.

Why Firebase?

Firebase is known for its easy-to-use APIs, great documentation and fantastic developer support. In addition to that, it only takes a few minutes to integrate Firebase with your projects.

Today, apps are rarely developed for a single platform, and most mobile apps are developed for the two biggest: Android and iOS. For that reason, developers often look for cross-platform solutions.

Firebase is a cross-platform service that works on Android, iOS and the web. By using a cross-platform solution, developers are not spending as much time as they would if they needed to use a separate service for each one. Not to mention, there's no need for businesses to invest additional money for different platforms.

Another bonus to using Firebase is that its products are integrated into one set of tools. There's a single SDK, a console and one place to go for the documentation and support. Data between different Firebase products is shared where and when needed, which leads to even faster development.

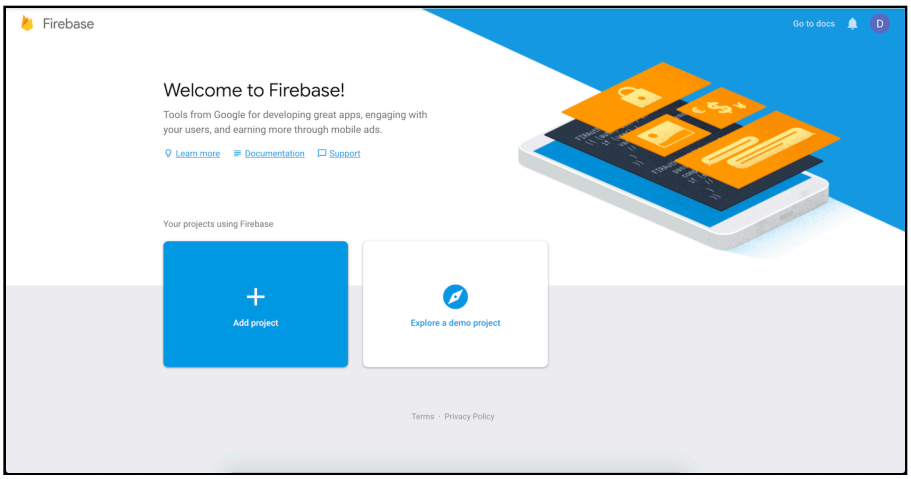
Getting started

Firebase console

The Firebase console is where you set up and manage your apps. From there, you can view all of your projects as well as create new ones.

To get started with Firebase, open your web browser and navigate to console.firebase.google.com.

If you're not already logged in, do so now, and you'll see this screen:

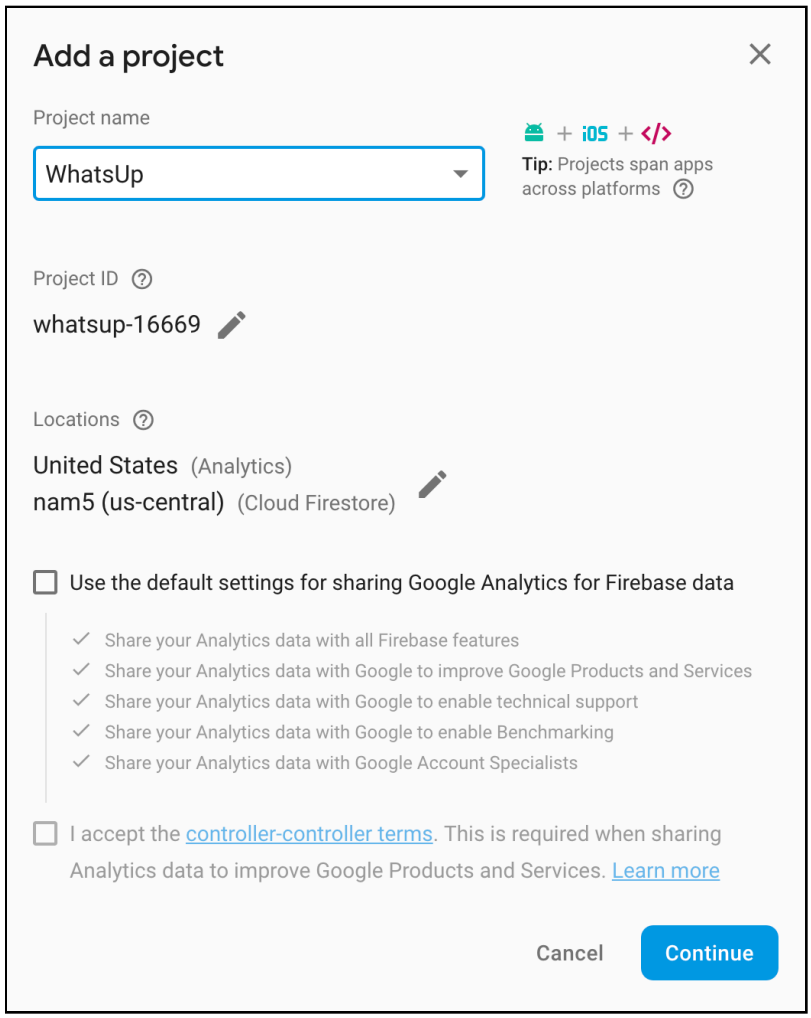


To get started, you'll create a simple social media app that lets you share your thoughts with other app users.

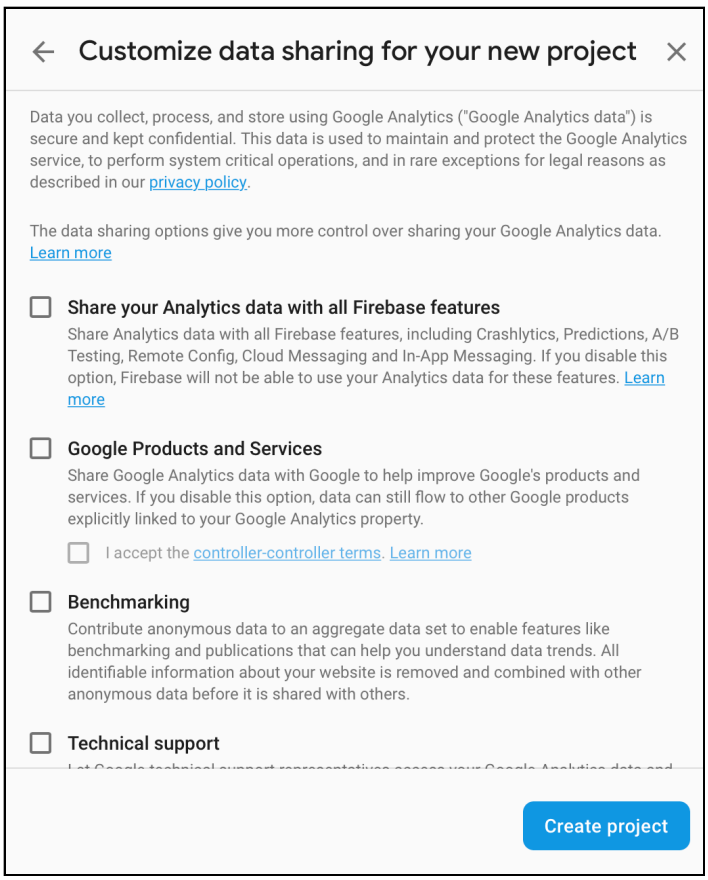
First, you need to add your app to Firebase. Follow the steps:

1. Click **Add project**.
2. For the project name, enter **WhatsUp**.

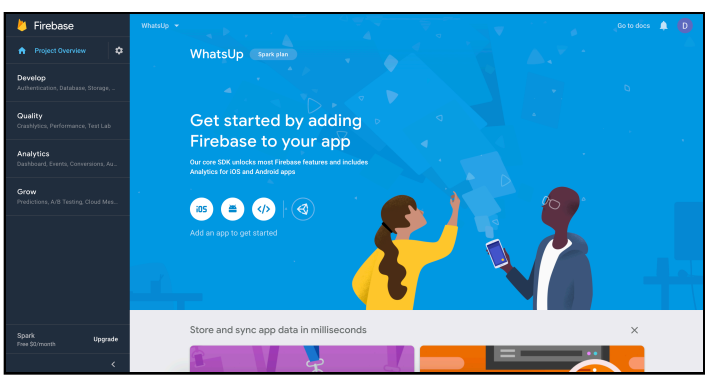
3. Uncheck **Use the default settings for sharing Google analytics for Firebase data**.
4. Click **Continue**.



6. You'll see another screen with additional options to customize data sharing. Leave them all unchecked and click **Create project**.

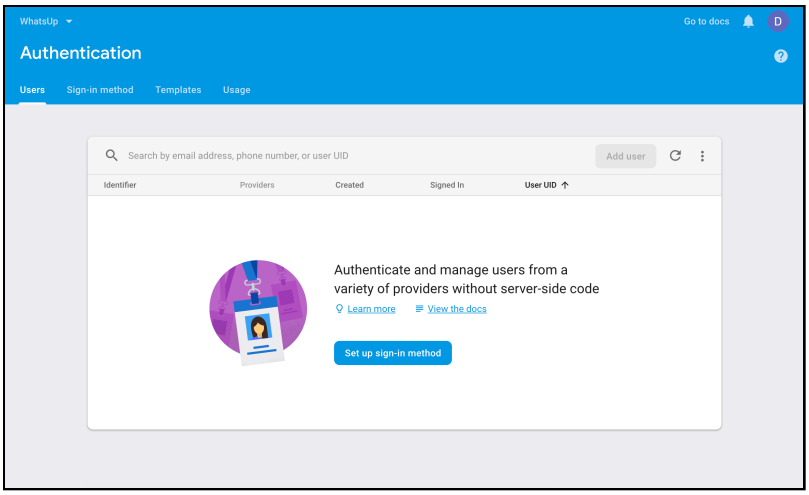


Once your project is created, click **Continue**. You'll see this screen:

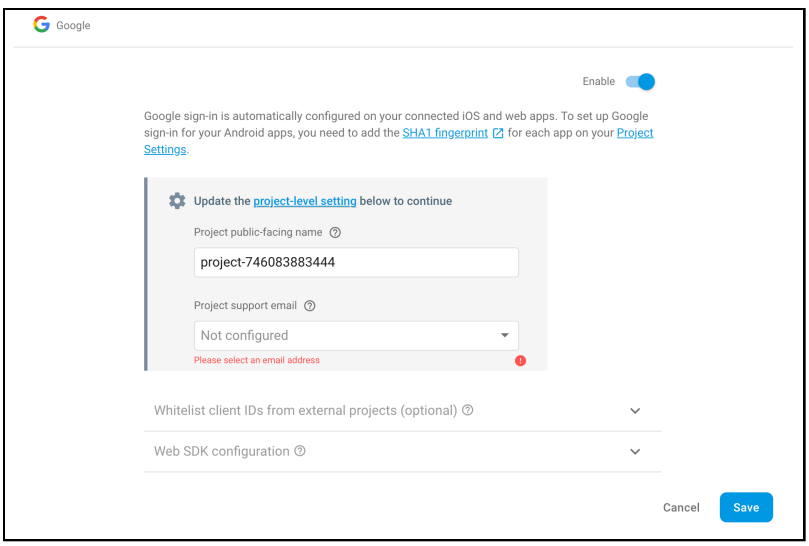


That's it! You've successfully created your first Firebase project.

Now, click on the **Develop** option from the menu on the left and then select **Authentication**. Authentication screen shows up:



Click on the **Sign-in method** and among the sign-in providers click on Google. Enable Google sign-in and click save:



This allows your app users to authenticate with their Google account.

Firebase analytics

To build a successful app, you need to clearly understand how your users behave and how they use your app. This is why analytics are so important.

There are many analytics categories that your app can use. This includes, in-app behavior analytics, which measures who your users are and what they are doing; attribution analytics, which you can use to measure the effectiveness of your advertising and other growth campaigns; push notifications analytics, crash reporting analytics and more.

Without Firebase, you may need to use multiple analytics libraries and tools to collect and save your analytics data. This becomes problematic when you need to share analytics data among those tools. Analytics for Firebase, however, is built to provide all of the data mobile app developers need in one place. Analytics integrates across Firebase features and provides you with two key capabilities: unlimited reporting for up to 500 distinct events and audience segmentation. With audience segmentation, you can create a custom audience that you target with new features or notification messages, for example. You can choose your custom audience base using parameters like device data or user properties.

Once you integrate your app with Firebase, analytics comes standard out-of-the-box.

Developing

Firebase offers many products that help you develop your app. Products that you'll use in this section of the book are Authentication, Realtime Database, Cloud Firestore and Cloud Storage. Let's take a look at each one.

Authentication

Most apps need a way to identify a user so they can customize their experience and keep user data secure, while making authentication easy for both end users and developers.

Firebase supports many different ways for your users to authenticate. **Firebase Auth** has built-in functionality for third-party providers such as Facebook, Twitter, Github or Google. If you want to authenticate users via an email address, you can do that, too.

You can present login functionality to the users in two different ways: using your own interface or taking advantage of Firebase's open source UI, which is also customizable. When the user authenticates, information about that user is returned to the device via a callback. You can then use that information to customize the experience for the specific user.

Firebase also manages user sessions, which means that users will remain logged in after the app restarts.

Realtime Database

Many apps need a way to store and share data from the server. When building your own backend, there are a few things that you need to manage, such as setting up and maintaining the database, real-time data synchronization and offline support. This can be tedious and time-consuming.

Firebase **Realtime Database** does it all for you, including storing and syncing data in real time. This allows users to access the data from any device.

Data is stored on the cloud, and whenever data is updated, all relevant devices get notified simultaneously within milliseconds.

Realtime Database is also optimized for offline use. It uses a local cache to store changes when the user loses network connection and when it comes back online local data gets automatically synchronized.

Realtime Database also takes care of security. You can use security rules to specify who has access to various pieces of data. Security rules are securely stored on the server.

Cloud Firestore

Cloud Firestore, like Realtime Database, is also used for saving the data to the cloud. It comes with the same feature set as Realtime Database, letting you store data in the cloud and sync data among different devices or share it with other users.

Cloud Firestore comes with client libraries, full offline mode support, a comprehensive set of security rules that help manage access to the data and a data browsing tool. It allows you to structure your data in a way that makes sense to you. It also automatically fetches changes from the server as they happen, or if you prefer, you can fetch them manually.

Cloud Firestore also integrates with other Firebase products like Authentication. You'll learn the differences between Realtime Database and Cloud Firestore as you progress through this book.

Cloud Storage

When it comes to storing and sharing pictures and similar files, Cloud Storage is crucial. Cloud Storage lets you upload user files to the cloud so they can be shared with others. If you want to share those files with specific users, you can leverage Firebase Authentication for that.

All network transfers are performed through a secure connection. If the connection breaks during network transfer, the transfer is paused and resumed once the network connection comes back online. This makes Cloud Storage ideal for large files or slow and unreliable network connections.

Other products

Firebase also offers other products for developing your app that aren't covered in this book. These include ML Kit, Cloud Functions and Hosting. You can learn more about them by reading the official Firebase page at https://firebase.google.com/products/.

Improving app quality

Firebase can help you improve the quality of your apps.

Before pushing your app to production, you need to test it. For that, Firebase provides you with **Test Lab**.

With so many different devices out there, you need to ensure that every feature of your app works as expected regardless of screen size or operating system version. Testing on every device is challenging since most developers don't have access to all available device. Firebase Test Lab makes it possible to test your app with a variety of physical devices hosted in the cloud.

Bugs are frustrating for users and can cause them to uninstall the app and negatively impact its success. Many things can go wrong in the app and cause it to crash. **Firebase Crashlytics** collects, analyzes and organizes crash reports. It can also help you prioritize issues so that you can fix the most important ones first.

Your users will use your app in different circumstances — different devices, different networks and different locations. You need to provide the best user experience to all of them. To do that, you need metrics that tell you what's happening during critical moments of your app's use.

The only way to get that information is from the users themselves or by using **Firebase Performance Monitoring**. The Performance Monitoring SDK collects information about your app's performance, such as the app's startup time or details about HTTP transactions. You can also use the provided API to instrument your app to measure critical moments that you want to improve.

Growing a business

Firebase has several products that you can use to methodically grow your app, gain more users and help you earn more money.

In-App Messaging helps you engage users who are actively using your app by sending them targeted and contextual messages that nudge them to complete key in-app actions, like beating a game level or buying an item.

Google Analytics for Firebase gives you the power to build up groups of users, or audiences, out of just about anything you can measure in your app. It provides free, unlimited reporting on up to 500 distinct events.

Key points

- Firebase is Google's mobile platform that helps you quickly develop high-quality apps and grow your business.
- Firebase consists of three main pillars: Develop, Improve and Grow.
- Firebase console is a single place where you need to go to set up and manage your app.

Where to go from here?

There's a lot more to explore in Firebase. You can find out more about different Firebase products and their key features in the official Firebase documentation.

Chapter 12: Introduction to Firebase Realtime Database

By Dean Djermanović

Having a central place for storing application data is a common requirement for mobile applications. Let's say you're building a mobile game and you need to save user progress. You can save it locally on the phone. But what if the user logs in with the same account on a different device? That device doesn't know that the user has already made some progress and the user will need to start the game all over again. That can lead to unhappy users and bad app reviews.

In this case, you would need to save user progress to a remote database so that users can have access to the data from any number of devices they own. That database is usually hosted somewhere, on the Internet, making it accessible through a simple network connection. This concept is known as the **cloud**. You can think of the cloud as someone else's computer, or an entire infrastructure, which you've rented for various services.

Firebase Realtime Database is a solution that stores data in the cloud and provides an easy way to sync your data among various devices. It is powered by the Google Firebase platform, and is just a single piece in an otherwise large puzzle. In this chapter, you'll learn how the Realtime Database works and its key capabilities. Furthermore, you'll add the Realtime Database to an Android project. Along the way you'll learn how the Realtime Database takes care of security with database rules, how data is saved to the database and the best practices for data structure.

Overview

Firebase Realtime Database is a cloud-hosted database that supports iOS, Android, Web, C++ and Unity platforms.

Realtime means that any changes in data are reflected immediately across all platforms and devices within milliseconds. Most traditional databases make you work with a request/response model, but the Realtime Database uses **data synchronization** and **subcriber mechanisms** instead of typical HTTP requests, which allows you to build more flexible real-time apps, easily, with less effort and without the need to worry about networking code.

Many apps become unresponsive when you lose the network connection. Realtime Database provides great **offline** support because it keeps an internal cache of all the data you've queried. When there's no Internet connection, the app uses the data from the cache, allowing apps to remain responsive. When the device connects to the Internet, the Realtime Database synchronizes the local data changes with the remote updates that occurred while the client was offline, resolving any conflicts automatically.

Client devices access the Realtime Database **directly**, without the need for an application server. **Security rules** take care of who has access to what data, and how they can access it. You'll learn more about security rules later in this chapter.

Firebase Realtime Database is not completely free. There are certain pricing plans. If you want your app to scale you'll need to pay for the number of connections, disk usage and network usage. You can check out pricing plans on the firebase pricing plans page here: https://firebase.google.com/pricing/.

Realtime Database is a **NoSQL** database. NoSQL stands for "Not only SQL". The easiest way to think of NoSQL is that it's a database that does not adhere to the traditional relational database management system (RDMS) structure. As such, the Realtime Database has different optimizations and functionality compared to a relational database. It stores the data in the **JSON** format. The entire database is a big JSON tree with multiple nodes. When planning your database you need to keep this in mind to make your database as optimized as possible. You'll also learn more about data structure and best practices later in this chapter.

Setting up Realtime Database

In Chapter 11, "Firebase Overview," you added your app to a Firebase project. Now, you need to connect your app to Firebase, to enable its services.

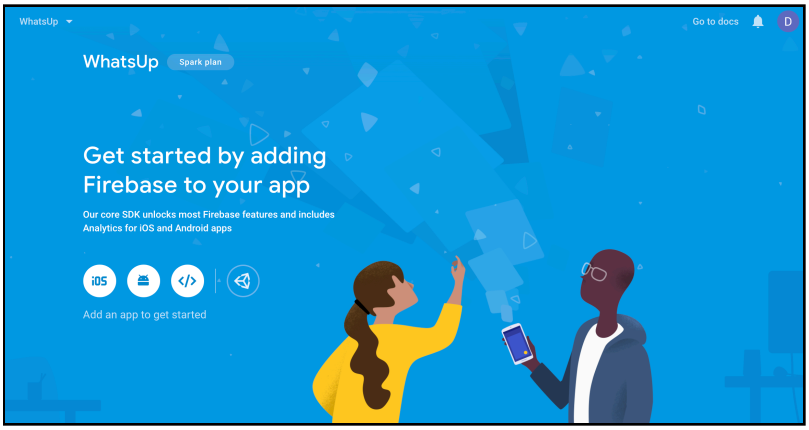
Prerequisites

There are few requirements that you need to fulfill in order to setup Firebase with Android.

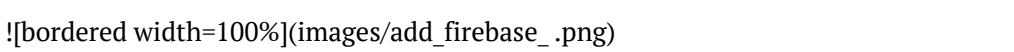
- To run your app on a physical device or an emulator you need to have at least **API level 9**, which is Android 2.3 *Gingerbread*.
- The device must have **Play Services 9.0** or later. You can check your Play Services version in the settings of the device.
- Your app needs to use **Gradle 4.1** or higher.
- Your app needs to target **API level 16** or later.

Connecting the app to the project

Go to the Firebase console and open **WhatsUp** project that you created.



Click on the Android icon to connect your Android app with Firebase. You should see the following :



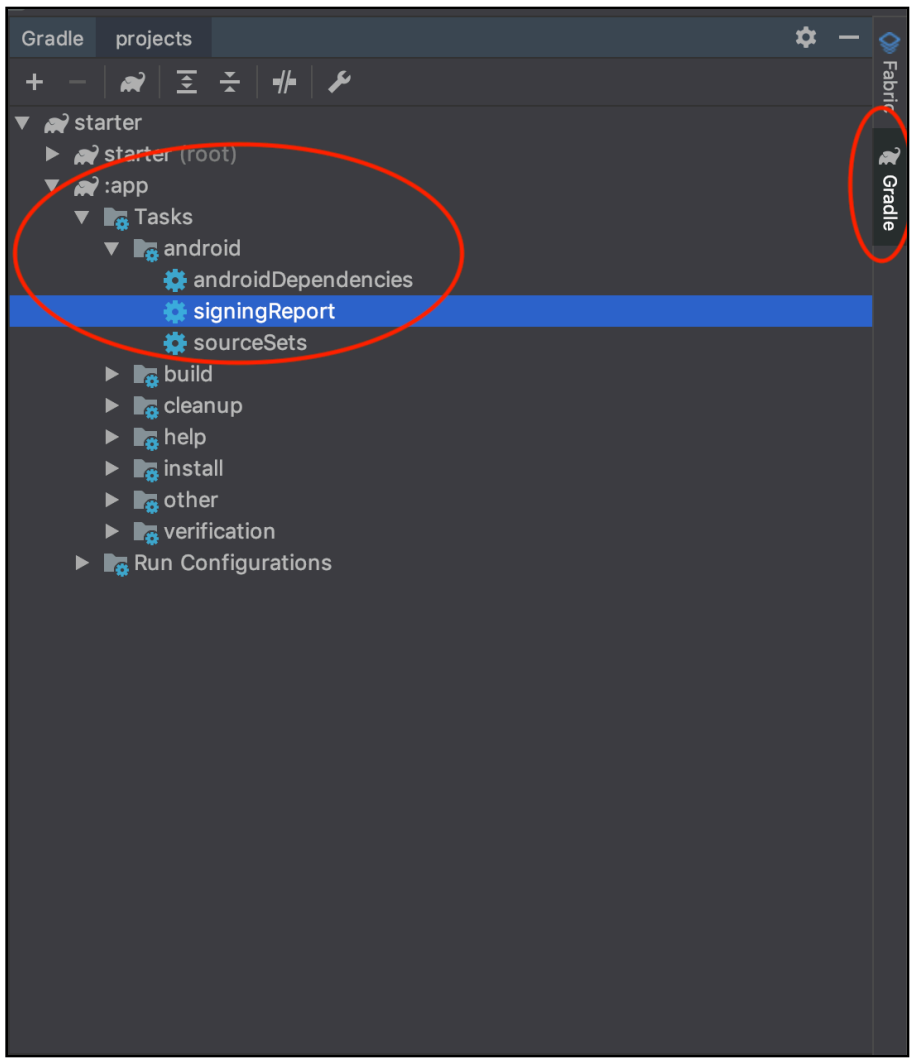
Registering app

The first step is to register your app. For that, you need two pieces of information. The first one is your app's package name which you can find in the app-level **build.gradle** file as **applicationId**. Enter `com.raywenderlich.whatsup` as the package name.

App nickname is optional so you won't add it.

The second thing that you need to provide is the **SHA1** hash of your debug key. This is only required if you'll use specific Firebase features. In this project, it's needed for the **Authentication** feature. You can get your SHA1 hash in two ways, by using Android Studio, and Gradle, or by typing in a terminal command.

For the first option, open up the **Gradle** tab from the right-hand side toolbar, and locate the following task:



Run it, and you should see the output in the terminal. The alternative is running the following command:

```
keytool -list -v -keystore ~/.android/debug.keystore -alias
androiddebugkey -storepass android -keypass android
```

In the Android Studio's **Terminal** panel, for your project.

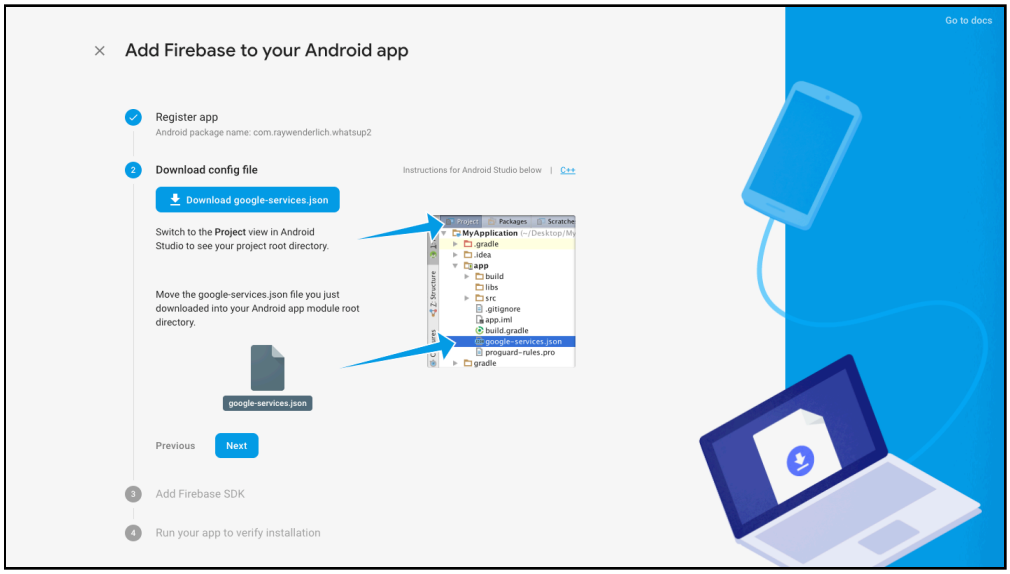
Both of the options command some information about your debug **keystore**. You'll see there a line that starts with **SHA1**.

```
Alias name: androiddebugkey
Creation date: Oct 26, 2018
Entry type: PrivateKeyEntry
Certificate chain length: 1
Certificate[1]:
Owner: C=US, O=Android, CN=Android Debug
Issuer: C=US, O=Android, CN=Android Debug
Serial number: 1
Valid from: Fri Oct 26 13:29:17 CEST 2018 until: Sun Oct 18
13:29:17 CEST 2048
Certificate finger s:
     SHA1: A6:72:CD:92:A6:DD:84:31:FA:
73:83:48:F6:9D:D4:54:C1:94:07:05
     SHA256: E0:67:78:A8:38:18:41:35:3B:
24:C3:87:01:73:29:BC:A8:55:71:E0:08:00:76:CF:
4D:C0:93:38:47:93:FD:54
Signature algorithm name: SHA1withRSA
Subject Public Key Algorithm: 1024-bit RSA key
Version: 1
```

Copy the value after that. That value is just a series of hex values, which represent your application's debug keystore signature. Paste that value into the **Debug signing certificate SHA-1** text box in the console. Click **Register app** button.

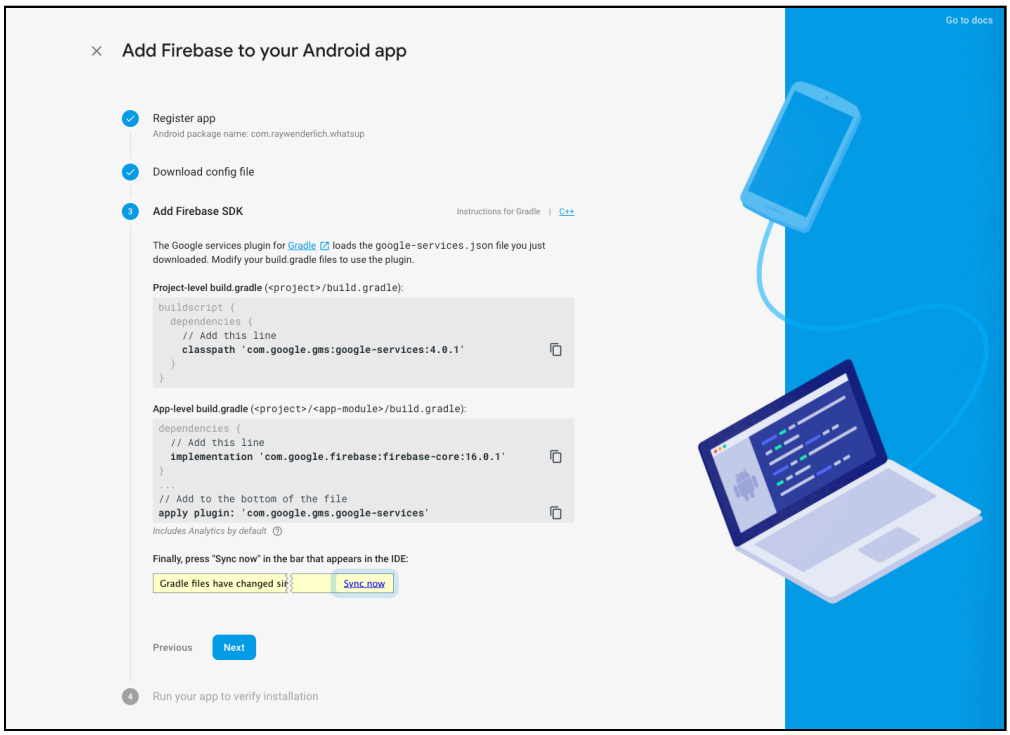
Downloading config file

Next, you need to download the **google-services.json** config file by clicking the blue button, and add it to your Android project. Follow the instructions in the console to do that, so that you paste it to the correct location. This file contains your app configuration. If your Firebase configuration changes later you'll need to download an updated config file and replace the existing one.



Adding Firebase SDK

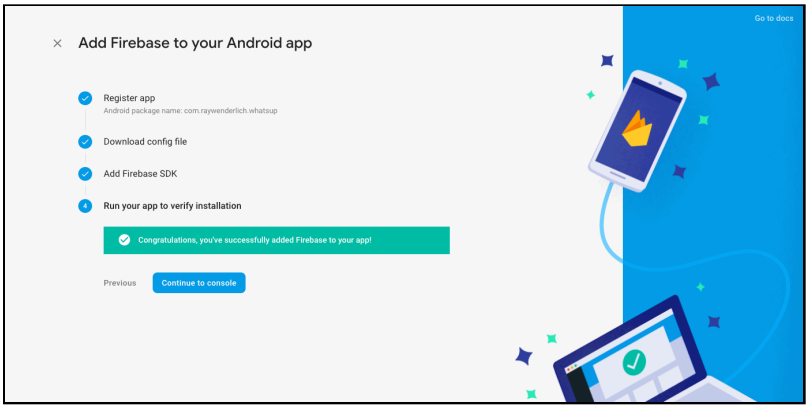
Next, you need to add the Firebase client libraries to your app. Follow the instructions in the console for this, as well.



First, you need to add the Google Services Gradle plugin to your build script configuration. This plugin reads **google-services.json** config file and injects some of its values into your build. Here, you'll also add a dependency to **Firebase core**. Make sure to use the latest version. You can check the documentation — found here https://firebase.google.com/docs/android/setup#available-libraries — to find the latest version. Once you do that click **Next** button.

Verifying installation

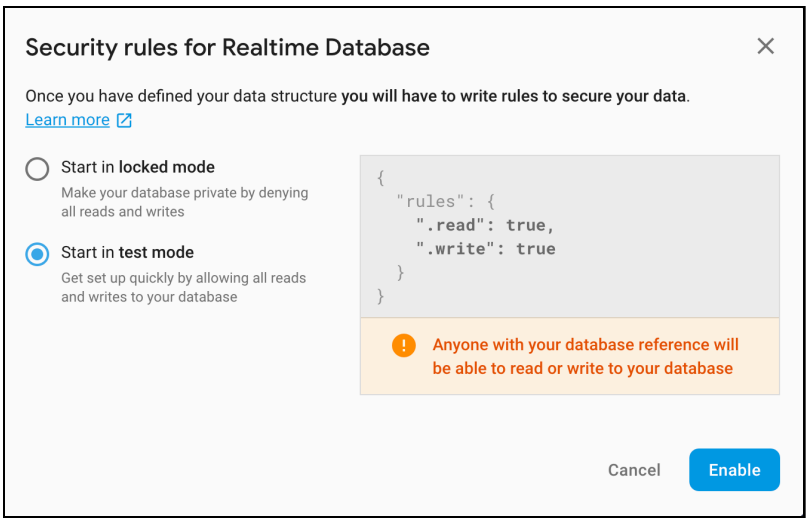
The last step is to verify if everything is set up correctly. For this, you only need to run your app on a device or an emulator. Before you do that, go to the `LoginActivity` class and uncomment the code. Repeat the process for the `HomeActivity` and `AuthenticationManager` classes. Run your app. If everything is set up correctly you'll get verification message in the console.



You can click the **Continue to console** button now.

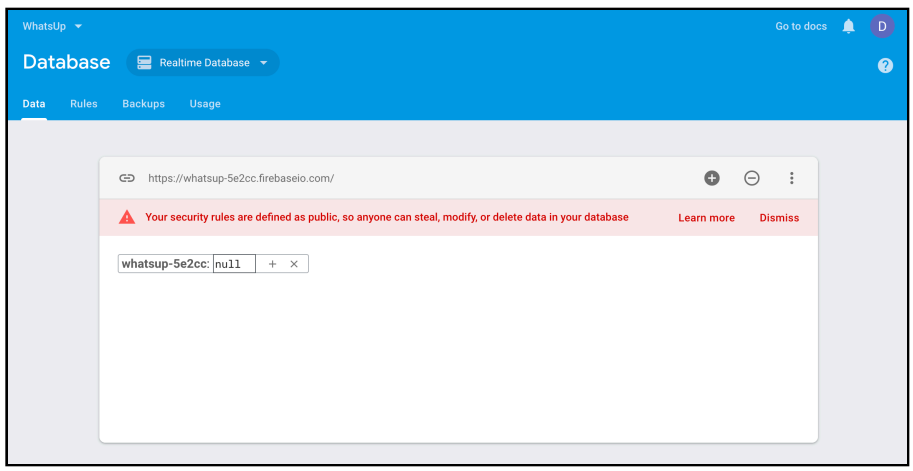
Adding Realtime Database

First, you need to create your database in the console. From the menu on the left select **Database**. Scroll to the Realtime Database section and click the **Create database** button. The security rules dialog will open:



Select the second option, **Start in test mode**, and click the **Enable** button. You'll learn more about security rules in a bit.

Once your database is created you'll get this:



To add the Realtime Database service to your app, you only need to add one more dependency. Open up **build.gradle** file, if you haven't got it open and add the following dependency, making sure you're using the latest version:

```
implementation 'com.google.firebase:firebase-database:16.1.0'
```

Database rules

In this section, you'll be working on **WhatsUp** app which has an authentication feature so the app can know who your users are. **Authentication** is the process of verifying users are who they say they are, and to give them certain security access to your service.

User identity is an important security concept. Different users have different data and different capabilities. In this app, the user will be able to delete posts it created but not the other people's posts. Because of this, you need a way to control who has access to what data in your database. The process of determining who has access to what is called **authorization**.

To implement the various aspects of security, authentication and authorization would require a lot of work. Firebase has the Authentication service which can use for all those sides of security, and the Realtime Database service uses internal **Realtime Database Rules** for authorization. Database rules allow you to control access for each user. They determine who has read and write access to your database,

how your data is structured, and what indexes exist. Every time reading or writing is attempted, a request will only be completed if your rules allow it.

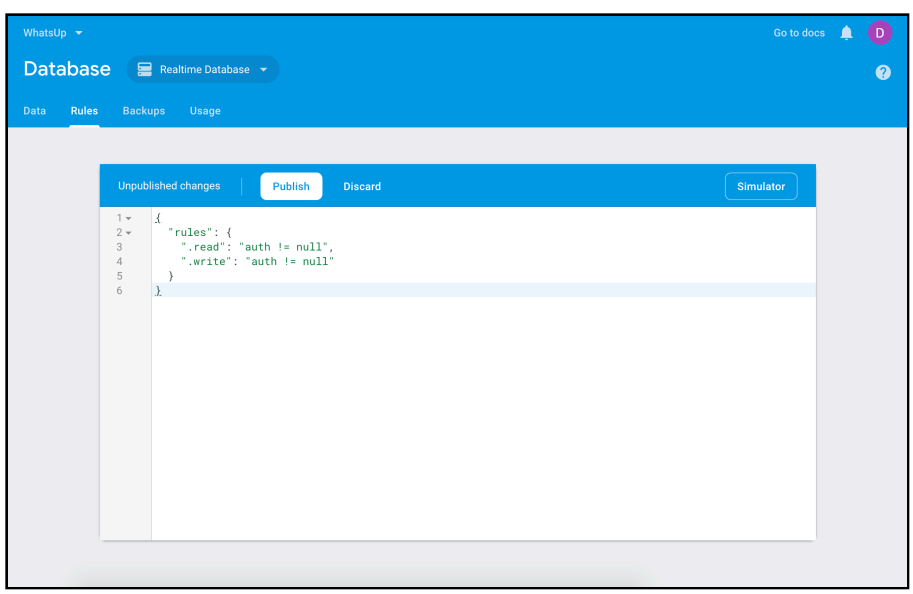
Firebase Database rules are also a **JSON object** which must have a top-level `rules` node. By default, the rules node contains two primitives, `.read` and `.write` and they determine who has read and write access. If `.read` and `.write` are set to **true**, everyone would have complete access to your data, so they can both read and write as they want. To protect your database from the abuse, you need to customize those rules.

The Firebase Database Rules include built-in variables and functions that allow you to refer to other paths, server-side timestamps, authentication information, and much more. For this app, you'll write a rule that grants read and write access only for authenticated users.

This is what this rule looks like:

```
{
  "rules": {
    ".read": "auth != null",
    ".write": "auth != null"
  }
}
```

Navigate to the **Rules** tab, replace the rules with the above snippet and click **Publish**:



Now, only authenticated users are allowed to read from and write to your database.

You can learn more about database rules in the documentation here: https://firebase.google.com/docs/database/security/.

Communication with the Realtime Database

You need a way to talk to the Realtime Database. The first thing you need is a connection. To get a connection you need to create a database reference first. Open `RealtimeDatabaseManager` class and add the `databaseReference` property:

```
private val databaseReference =
FirebaseDatabase.getInstance().reference
```

This gets you a reference to the root of the Firebase JSON tree. You'll learn more about data structure later in this chapter.

For connectivity testing purposes, add a method to the `RealtimeDatabaseManager` that will write some dummy data to the database.

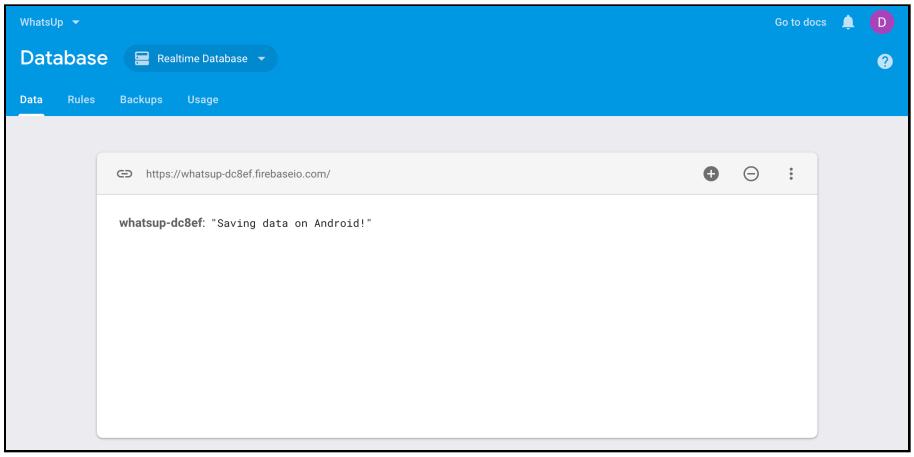
```
fun addDummyData() {
    databaseReference.setValue("Saving data on Android")
}
```

Next, open `HomeActivity` class and add the `realtimeDatabaseManager` property:

```
private val realtimeDatabaseManager by lazy
{ RealtimeDatabaseManager() }
```

Call `realtimeDatabaseManager.addDummyData()` from the `initialize()` method.

Run the app and sign in with your Google account by clicking the **Sign in with Google** button. Next, go to the Firebase console and select **Database** from the menu on the left side. You should see your data in the database.



Congratulations! You have successfully communicated with the Realtime Database. Before you continue, delete the data from the database directly from the console by clicking the **X** button from the right side of the value. You'll learn a lot more about reading and writing to the Realtime Database in the next chapter.

Data structure

JSON format

As mentioned before, the Firebase Realtime Database stores data in the **JSON format**. JSON stands for JavaScript Object Notation and it's a language-independent data format with a minimal number of value types: strings, numbers, booleans, lists, objects, and null. It consists of key/value pairs. The key/value pairs are separated by a colon and each pair is separated by a comma. It is easy for humans to read and write and for machines to parse and generate. This is a sample JSON object:

```
{
  "name": "Dean",
  "lastname": "Djermanovic",
  "age": 23,
  "gender": "male"
}
```

Best practices for data structure

The entire database is a big JSON tree with multiple nodes. When pushing new data to the database you either create a new node with an associated key or update an existing one. Therefore there is the danger of creating a deeply nested structure. Firebase Realtime Database allows nesting data up to 32 levels deep but that doesn't mean that this should be the default structure. When thinking about data structure you need to think about how your data is going to be consumed, you need to make the process of saving and retrieving as easy as possible.

If you have very complex structures with a lot of nesting you fetch all the data every time you read from the database, which is not needed in most of the cases. If you want to get the data from a specific node you get all the data below that node as well. Take a look at this restaurants structure for example:

```
{
  "restaurants": {
    "first_restaurant": {},
    "second_restaurant": {},
    "third_restaurant": {}
  }
}
```

Fetching the restaurant's data would get you all of its child nodes data as well. In addition, when you grant someone access at a node in your database you also grant them access to all of its children's data. You can limit this by specifying how many restaurants you want to fetch or to fetch only restaurants that satisfy some condition but in general, when you're loading data you're loading all of it. Because of this, it's good practice to keep your data structure as flat as possible.

Another good practice would be that you organize your data in a way that you don't fetch the data that you're not rendering on the UI. If you split your data into separate paths you can be more specific about what data you want to fetch. Traditionally, you would have a set of data and you'd build your UI on top of that, but with Firebase, since it's easy to write data, people build their UI and then they start building a data structure from the app. This flat data structure affects the performance in a good way since you don't need to fetch extra data that you won't use, which allows the UI to stay responsive and fast.

Generally, there's no right or wrong approach to structuring your data. Storage is cheap. You can have a million copies of the exact same string field in the Realtime Database and it will cost you almost nothing but the problem appears when fetching this data. With a little bit of practice, you'll be able to judge better what makes sense to nest and what doesn't.

Key points

- To use Firebase Realtime Database in your Android project you need to go through the **configuration** process first.
- The Realtime Database provides **database rules** to control access for each user.
- Firebase Authentication is very much connected to database solutions Firebase offers, since it controls the **access to data**, on a **per-user-basis**.
- Firebase Realtime Database stores data in **JSON format**.
- Because the structure is a JSON, it operates with simple data like numbers, strings, objects, booleans and lists.
- Firebase Realtime Database data structure should be as **flat** as possible and designed with **scaling** in mind.

Where to go from here?

In this chapter, you saw how to configure Realtime Database and what are best practices when it comes to structuring your data. If you want to learn more you can check out official Firebase documentation.

You also wrote your first data to the database. In **Chapter 13: Reading to and writing from Realtime Database** you'll learn a lot more about reading from and writing to Realtime Database and you'll integrate it to the WhatsUp app. You'll be able to write posts from the app and upload it to the Realtime Database and other users will be able to read it.

Chapter 13: Reading to & Writing from Realtime Database

By Dean Djermanović

In the last chapter, you integrated Realtime Database into your app. You added Firebase SDK to your app and connected the app with Firebase project. You also learned about database rules and you set them up to allow only authenticated users the access to the database. You even wrote your first data to the database which was just a sneak peek of what you'll do in this chapter.

This chapter will teach you how to work with Realtime Database data. You'll learn how to read and write data as well as how to do basic manipulation with that data. First, you'll learn about performing **CRUD** operations on to the Realtime Database. CRUD is just an acronym for the four basic types of SQL commands: *Create*, *Read*, *Update*, *Delete*. You'll combine all these concepts together in order to build a fully functional app with Realtime Database as the backend.

> **Note**: You need to set up Firebase in order to follow along. Do the following steps:

1. Create a project in the Firebase console.
2. Enable Google sign-in.
3. Set security rules to the test mode to allow everyone **read** and **write** access.
4. Add **google-service.json** to both **starter** and **final** projects.

> To see how to do this, go back to Chapter 11: Firebase overview and Chapter

12: Introduction to Firebase Realtime Database.

Reading and writing data

Open starter project, and build and run your app. If this is the first time you're running this app you'll need to sign in first in order to use it. To sign in, tap the **Sign in with Google** button and follow the steps on the screen. Next, click on the floating action button. A new screen opens where you can write your post. Write something and click on the **Post** button:

As you can see nothing happens yet. You'll add the logic for saving the post to the database.

Saving data to the database

Open the `RealtimeDatabaseManager` class. Add the `database` field to the class:

```
private val database = FirebaseDatabase.getInstance()
```

`FirebaseDatabase` object is the main entry point to the database. The `getInstance()` method gets you the default `FirebaseDatabase` instance. There are overloads of `getInstance()` methods if you want to get the database for the specific URL or specific app.

Add `POSTS_REFERENCE` constant above the class declaration:

```
private const val POSTS_REFERENCE = "posts"
```

Next, add the function for creation of the `Post` object to the `RealtimeDatabaseManager` class:

```
private fun createPost(key: String, content: String): Post {
    val user = authenticationManager.getCurrentUser()
    val timestamp = getCurrentTime()
    return Post(key, content, user, timestamp)
}
```

This function uses the `AuthenticationManager` class to get the current logged in user name, gets the current time and then returns newly created `Post` instance.

Next, add the function for saving the post to the database:

```
 fun addPost(content: String, onSuccessAction: () -> Unit,
onFailureAction: () -> Unit) {
    //1
    val postsReference = database.getReference(POSTS_REFERENCE)
    //2
    val key = postsReference.push().key ?: ""
    val post = createPost(key, content)

    //3
    postsReference.child(key)
      .setValue(post)
      .addOnSuccessListener { onSuccessAction() }
      .addOnFailureListener { onFailureAction() }
  }
```

Here's what happens here:

1. `DatabaseReference` class represents a particular location in the database and it's used to refer to the location in the database to which you want to write to or read from. `getReference()` method returns a reference to the database root node. You won't save posts to the root node. Instead, you'll create a new node for the posts, which is why you added `POSTS_REFERENCE` constant earlier. You pass that constant to the `getReference()` and this returns a reference for the provided path. Now you can use `postsReference` to read or write data to this location.

2. Posts will be added as a child of the `posts` node. To add a post as a child it needs to have a unique key which will be used as a path to the specific post. The key needs to be unique because setting a value to the existing path would overwrite previous value on that path. You don't want that. You can use the `push()` method

to create an empty node with an auto-generated key. The `push()` method returns a database reference to the newly created node. You can call `getKey()` on the database reference to get the key to that reference. Next, you create a `Post` instance that you'll save to the database and you store the key of that post so you can refer to it later.

3. To access the newly created location you can use the `child()` method that returns a reference to the location relative to the calling reference. Finally, you use the `setValue(post)` method to save the post to this location. The Realtime Database accepts multiple data types to store the data: `String`, `Long`, `Double`, `Boolean`, `Map<String, Object>`, and `List<Object>`. You can also use custom Kotlin or Java objects to store the data model class directly to the database as you're doing here. Finally, you attach `OnSuccessListener` that gets called if the post is saved to the database successfully, and `OnFailureListener` that gets called if the post saving failed.

Now open the `AddPostActivity` class and replace the `TODO` in the `addPostIfNotEmpty()` with the following:

```
val postMessage = postText.text.toString().trim()
    if (postMessage.isNotEmpty()) {
      realtimeDatabaseManager.addPost(postMessage,
        { showToast(getString(R.string.posted_successfully)) },
        { showToast(getString(R.string.posting_failed)) } )
      finish()
    } else {
      showToast(getString(R.string.empty_post_message))
    }
```

Here you get the text from `EditText` and if it's not empty you save the text to the database and you close the current activity.

Build and run your app. Click on the floating action button on the home screen, add some text and tap the *Post* button. Current activity gets closed and the home screen is shown. Posts should be displayed on the home screen. You'll add logic for that in a bit.

Open the database in the Firebase console and confirm that data is saved into the database. You should see your post here along with addiotional data that you added:

Good job! You'll add the logic for displaying posts on the home screen next.

Fetching data from the database

When it comes to reading the data from the database you have two options. You can read the data once or you can be notified whenever data changes. Since you want to see every new post from other users instantly you'll implement the second option.

To get all posts from the database and listen for value changes you need to use `ValueEventListener`. You need to attach this listener to the specific location in the database that you want to listen for changes from.

Open `RealtimeDatabaseManager` class and add `postsValues` field:

```
private val postsValues = MutableLiveData<List<Post>>()
```

You'll use `LiveData` to notify the observers about post changes.

Next, add `postsValueEventListener` field:

```
private lateinit var postsValueEventListener: ValueEventListener
```

This where you'll store your event listener.

Next, add the following function:

```
private fun listenForPostsValueChanges() {
    //1
    postsValueEventListener = object : ValueEventListener {
      //2
      override fun onCancelled(databaseError: DatabaseError) {
        /* No op */
      }

      //3
```

```
        override fun onDataChange(dataSnapshot: DataSnapshot) {
          //4
          if (dataSnapshot.exists()) {
            val posts = dataSnapshot.children.mapNotNull
{ it.getValue(Post::class.java) }.toList()
            postsValues.postValue(posts)
          } else {
            //5
            postsValues.postValue(emptyList())
          }
        }
      }

      //6
      database.getReference(POSTS_REFERENCE)
          .addValueEventListener(postsValueEventListener)
}
```

1. You add `ValueEventListener` as an anonymous inner class and you assign it to `postsValueEventListener` field. There are two methods that you need to implement.

2. The `onCancelled(databaseError: DatabaseError)` method gets triggered if reading from the database is cancelled. Reading can be canceled in case if there are server issues or if you don't have access to the location you're trying to read from due to database rules. `databaseError` parameter contains more information about an error that occurred. In this case, you won't do anything if reading gets canceled.

3. `onDataChange(dataSnapshot: DataSnapshot)` gets triggered whenever data under the reference you attached the listener to gets changed; either new data is added or existing data is updated or deleted. This is the method where you perform desired operations on the new data. You get the data back as `DataSnapshot`. `DataSnapshot` contains all the data from a specific location in the database. `DataSnapshot` is just an immutable copy of your database data so can't use it to modify the data in the database.

4. By calling the `exists()` method on `DataSnapshot` you check if the snapshot contains a non-null value. If there is data in the snapshot you get all of the direct children of the snapshot and you map each one to the `Post` object by calling the `getValue(Post::class.java)` method on a child. `getValue(Post::class.java)` wraps the data to the specified `Post` class and returns an instance of the passed in class or null if there is no data in this location. Then you add `Post` instances to the list and you set this list to the `LiveData` field created earlier which will notify all active observers about new data.

5. If data doesn't exist you set empty list as the new value of `LiveData`. This is needed in the case where all posts get deleted and the database is empty. In that case, `dataSnapshot.exists()` will return `false` and by setting empty list as the new value you'll reflect that.
6. You attach the listener to the `POSTS_REFERENCE` because that is the location from where you want to listen for changes.

Now add `onPostsValuesChange()` function which just calls the function that attaches the listener and returns `LiveData` field:

```
fun onPostsValuesChange(): LiveData<List<Post>> {
    listenForPostsValueChanges()
    return postsValues
}
```

You only want to listen for posts updates when you're on the home screen. Once you navigate away from home screen you don't care about posts updates anymore. To achieve that you need to remove event listener when you're no longer interested in the events. Add `removePostsValuesChangesListener()` function:

```
fun removePostsValuesChangesListener() {

database.getReference(POSTS_REFERENCE).removeEventListener(posts
ValueEventListener)
}
```

This method removes the passed in event listener, by calling `removeEventListener` function, from the specified location.

Open `HomeActivity` and add `onPostsUpdate(posts: List<Post>)` function which will get called every time posts update and it will set new data to the recycler view adapter:

```
private fun onPostsUpdate(posts: List<Post>) {
    feedAdapter.onFeedUpdate(posts)
}
```

Now implement `listenForPostsUpdates()` function which will listen for the changes in the posts and will call `onPostsUpdate()` on every update. Replace the `// TODO` comment with the following :

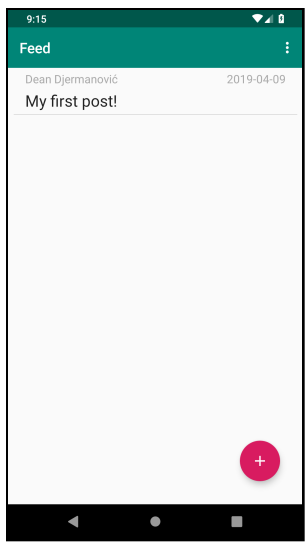
```
realtimeDatabaseManager.onPostsValuesChange()
  .observe(this, Observer(::onPostsUpdate))
```

Finally, override `onStop()` method and call the

`realtimeDatabaseManager.removePostsValuesChangesListener()` to stop listening for the posts updates:

```
override fun onStop() {
    super.onStop()
    realtimeDatabaseManager.removePostsValuesChangesListener()
}
```

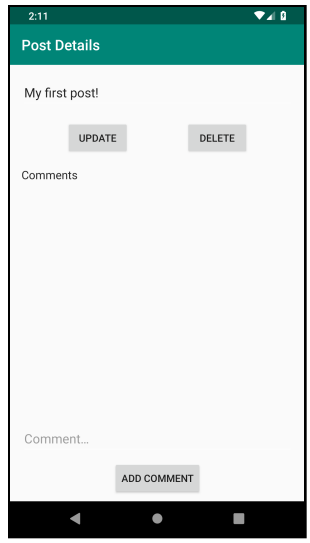
Build and run your app. You should see the post that you previously added on the home screen:



Build and run your app once again on a different device and log in with a different account. Add a new post and observe on your first device how the data is updated in the realtime.

Updating and deleting data

Tap on a post on the home screen to open another screen which shows post details:



On this screen, you can edit your post by taping on it. When you're done you can tap an *Update* button to update the post content. By tapping *Delete* button you can delete the post if you're the author of the post. There's also a *Comments* section here. The app also has the feature of adding a comment to the post which will be displayed here. If you try to tap to any of these buttons you'll see that nothing happens. You'll implement those functionalities next.

Updating

Updating data in Realtime Database is almost the same as writing. You use the same `setValue()` method for updating. Add `POST_CONTENT_PATH` constant above `RealtimeDatabaseManager` class declaration:

```
private const val POST_CONTENT_PATH = "content"
```

You'll use this constant to indicate which field in the database you want to update.

Now add the `updatePostContent` function:

```
fun updatePostContent(key: String, content: String) {
    //1
    database.getReference(POSTS_REFERENCE)
        //2
        .child(key)
        //3
        .child(POST_CONTENT_PATH)
        //4
        .setValue(content)
```

```
}
```

1. First, you get a reference to the location of the posts in the database.
2. Here you use the key to access the location of the post you wan't to update.
3. You can create a new object and write the entire object to this location but that is not needed. You can update a specific field in the post by specifying the path to that field. Here you update only the content of the post.
4. Finally, you call `setValue` method with new content to update the content of the post.

Open `PostDetailsActivity` class and replace `TODO` in `updatePostButton.setOnClickListener` method in the `initializeClickListener` with this:

```
realtimeDatabaseManager.updatePostContent(post.id,
postText.text.toString().trim())
finish()
```

When the user taps on the *Update* button the post content will update and the current activity will close.

Build and run your app. Open any post in the list that was written by you, update the post content, tap the *Update* button and verify both on the home screen and firebase console that post content is updated.

Deleting

Deleting data in Realtime Database is very simple. You have two options. You can delete data by using `setValue` method and specify `null` as an argument or you can use `removeValue()` method which will set the value at the specified location to `null`. You'll use the latter approach. Open `RealtimeDatabaseManager` class and add the `deletePost` function:

```
fun deletePost(key: String) {
    database.getReference(POSTS_REFERENCE)
        .child(key)
        .removeValue()
}
```

Here you get a reference to the location of the posts, then you get the reference to the desired posts and call `removeValue()` to delete it.

Open `PostDetailsActivity` and navigate to the `initializeClickListener()`

function and replace `TODO` in on click listener of the `deletePostButton` with this:

```
realtimeDatabaseManager.deletePost(post.id)
finish()
```

Build and run your app. Open any post in the list that was written by you and click the delete button. Verify on the home screen and firebase console that the post is deleted.

Querying and filtering data

To show how to query data you'll add another feature to the app. You'll enable users to add comments to the post.

Open `RealtimeDatabaseManager` class and add two more constants above class declaration:

```
private const val COMMENTS_REFERENCE = "comments"
private const val COMMENT_POST_ID_PATH = "postId"
```

`COMMENTS_REFERENCE` is used to refer to the location of comments and `COMMENT_POST_ID_PATH` is used when building a query. You'll do that in a bit.

Next, add `commentsValues` and `commentsValueEventListener` fields to the `RealtimeDatabaseManager` class:

```
private val commentsValues = MutableLiveData<List<Comment>>()
private lateinit var commentsValueEventListener:
ValueEventListener
```

Add the `createComment` function which is just a helper function for building a `Comment` instance:

```
private fun createComment(postId: String, content: String):
Comment {
    val user = authenticationManager.getCurrentUser()
    val timestamp = getCurrentTime()
    return Comment(postId, user, timestamp, content)
}
```

Now add the `addComment` function:

```
fun addComment(postId: String, content: String) {
    val commentsReference =
database.getReference(COMMENTS_REFERENCE)
    val key = commentsReference.push().key ?: ""
```

```
    val comment = createComment(postId, content)

    commentsReference.child(key).setValue(comment)
}
```

This function saves the comment to the database. It uses the same logic as the post saving function so you should be familiar with this by now.

Now open the `PostDetailsActivity` class, navigate to the `initializeClickListener` function and replace the `TODO` inside the `addCommentButton` click listener with the following:

```
val comment = commentEditText.text.toString().trim()
  if (comment.isNotEmpty()) {
    realtimeDatabaseManager.addComment(post.id, comment)
    commentEditText.text.clear()
  } else {
    showToast(getString(R.string.empty_comment_message))
}
```

Here you get the text from the edit text and if it is not empty you save the comment to the database.

Build and run your app. Tap on any post from the list, add a comment in the edit text and click *Add comment* button.

Edit text gets cleared but nothing happens on the UI. Go to the Firebase console. You will see there that comment is saved to the database.

You can see there that comment has a `postId` child. This is how you'll know to which post comment belongs.

Now you can add logic for reading the comments from the database.

Open `RealtimeDatabaseManager` class again and add the `listenForPostCommentsValueChanges` function:

```
private fun listenForPostCommentsValueChanges(postId: String) {
    commentsValueEventListener = object : ValueEventListener {
      override fun onCancelled(databaseError: DatabaseError) {
        /* No op */
      }

      override fun onDataChange(dataSnapshot: DataSnapshot) {
        if (dataSnapshot.exists()) {
          val comments = dataSnapshot.children.mapNotNull
{ it.getValue(Comment::class.java) }.toList()
          commentsValues.postValue(comments)
        } else {
          commentsValues.postValue(emptyList())
        }
      }
    }

    database.getReference(COMMENTS_REFERENCE)
          //1
        .orderByChild(COMMENT_POST_ID_PATH)
        //2
        .equalTo(postId)
        .addValueEventListener(commentsValueEventListener)
}
```

This function listens for comments value updates and it is very similar to the `listenForPostsValueChanges`, but there are two differences:

1. The `orderByChild` method returns a `Query` instance where children are ordered by the `postId` value. A query is a request for data or information from a database.

`Query` class is used for reading data and it has many useful methods that allow you to fetch the data in a way you want. You can filter data by some criteria, sort data, limit, etc. Check the official documentation (https://firebase.google.com/docs/reference/android/com/google/firebase/database/Query) for the `Query` class to see what it offers.

2. The `equalTo` method returns a `Query` instance which contains child nodes only where the node value is equal to the specified function argument. In this case, it will return a query with the comments for the specific post.

The rest of the code is the same as the code for listening for post updates.

Next, add a `deletePostComments` function which will delete all of the comments for the specific post:

```
private fun deletePostComments(postId: String) {
    database.getReference(COMMENTS_REFERENCE)
        .orderByChild(COMMENT_POST_ID_PATH)
        .equalTo(postId)
        .addListenerForSingleValueEvent(object :
ValueEventListener {
          override fun onCancelled(databaseError: DatabaseError)
{
            /* No op */
          }

          override fun onDataChange(dataSnapshot: DataSnapshot)
{
            dataSnapshot.children.forEach { it.ref.removeValue()
}
          }
        })
}
```

It uses exactly the same logic for fetching the comments for the specific post as the `listenForPostCommentsValueChanges` function and you're already familiar with how to delete data from the database. Call this function from the `deletePost` function passing in the key of the post. This makes sure that when a post gets deleted, its comments get deleted as well.

Next, add an `onCommentsValuesChange` function which starts listening for comments updates and returns a `LiveData` object:

```
fun onCommentsValuesChange(postId: String):
LiveData<List<Comment>> {
    listenForPostCommentsValueChanges(postId)
    return commentsValues
}
```

Now, open the `PostDetailsActivity` class again, navigate to the `listenForComments` function and replace its TODO comment with the following:

```
realtimeDatabaseManager.onCommentsValuesChange(post.id)
  .observe(this, Observer(::onCommentsUpdate))
```

This just starts listening for the comments update. Note the `Observer` in this case requires you to import `androidx.lifecycle.Observer`.

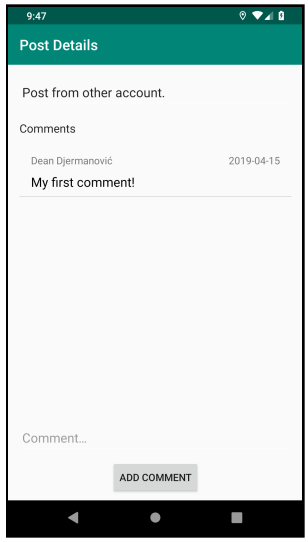
Next, back in the `RealtimeDatabaseManager` class, add a function for removing the comments listener:

```
fun removeCommentsValuesChangesListener() {

database.getReference(COMMENTS_REFERENCE).removeEventListener(co
mmentsValueEventListener)
}
```

In `PostDetailsActivity`, override `onStop` and call `realtimeDatabaseManager.removeCommentsValuesChangesListener()` to remove the comments listener when you no longer want to listen for comment updates.

```
override fun onStop() {
    super.onStop()

realtimeDatabaseManager.removeCommentsValuesChangesListener()
}
```

Build and run your app. Navigate to the same post you added a comment to, earlier.



Now you can see your comment on the UI as well. Add more comments from the same and from the different account to see how comments are updated in real time.

Other features

Transactions

Realtime Database also allows you to write data to the database using a transaction. A database transaction is a unit of work that is independently executed and it must be atomic, consistent, isolated and durable. If the **WhatsUp** app had a feature to allow you to "like" a post you could use transactions to keep track how many *likes* a given post had. Since there is a use case where multiple users could "like" the post at the same time, the transaction would allow you to always have fresh and correct data about *likes*.

Check the official documentation https://firebase.google.com/docs/database/android/read-and-write#save_data_as_transactions to see how to work with transactions.

Listening for child events

Previously you saw how to use value event listener. Often you'll also need to know about changes in children of a specific node. In that case, you'll need to use a child event listener. Child event listeners notifiy the app when child nodes are added, deleted or moved within a parent node. To add a child event listener you'll need to call `addChildEventListener()` on a database reference instance, and there are four methods that you'll need to implement. Check the official documentation https://firebase.google.com/docs/database/android/lists-of-data#child-events to learn more about child events.

Indexing

There can be a performance issue if your app frequently queries the database. To improve query performance you should consider defining indexing rules. A database index is a data structure which is used to quickly locate and access the data in a database.

You can learn more about indexing data in the official documentation https://firebase.google.com/docs/database/security/indexing-data.

Key points

- `FirebaseDatabase` object is the main entry point to the database
- `DatabaseReference` class represents a particular location in the database and it is used to refer to the location in the database to which you want to write to or read from.
- `push()` method is used to create an empty node with an auto-generated key.
- Firebase Realtime Database has several types of listeners, and each listener type has a different kind of callback.
- `ValueEventListener` listens for data changes to a specific database reference.
- `ChildEventListener` listens for changes to the children of a specific database reference.
- You need to decide how to handle listeners when the user is not actively interacting with the app. In most cases, you want to stop listening for updates. To do that you need to remove the listener.
- For updating data in Realtime Database, the `setValue()` method is used.
- You can delete data by using the `setValue` method and specify `null` as an argument or you can use `removeValue()` method which will set the value at the specified location to `null`.
- A query is a request for data or information from a database. `Query` class is used for reading data and it has many useful methods that allow you to fetch the data in a way you want.
- A database transaction is a unit of work that is independently executed and it must be atomic, consistent, isolated and durable.
- To improve query performance you should consider defining indexing rules.

Where to go from here?

You covered a lot in this chapter. You have seen how to write data to the Realtime Database, how to listen for changes in the database and how to update and delete data. It takes a little bit of practice to get used to working with Realtime Database so feel free to play a bit with the current app. To see specifics about each method, what

it does and how it does it, you can visit the official Firebase documentation to find out.

WhatsUp app works great for now, but what if you were using it in a place where the Internet connection is bad? What if you started uploading data and you lost internet connection in the process? Can you write data to the database if you're offline? The good news is that Realtime Database provides great offline support. In Chapter 14, "Realtime Database offline capabilities" you'll learn how Firebase handles all of the mentioned cases. You'll make your *WhatsUp* app to work seamlessly offline and you'll learn what happens under the hood that makes that possible.

Chapter 14: Realtime Database Offline Capabilities

By Dean Djermanović

So far, you've created an app that enables you to save posts to the database and read the posts from the database. The next step is to implement offline support. If you turn off your internet connection now and run your app, you'd see an empty screen. That is because your app can't fetch the data from the database without an internet connection.

One of the most important features of Realtime database is its offline capabilities. If you were creating your own backend system, you would need to persist the data by yourself. Firebase handles that for you, and it enables your app to work properly even when the user loses network connection. In this chapter, you'll learn how exactly it does that, and you'll add offline support to your app so that you could see posts on the screen and even add posts while you are offline.

> **Note**: If you skipped previous chapters, you need to setup Firebase in order to follow along. Do the following steps:

1. Create a project in the Firebase console.
2. Enable Google sign-in.
3. Set security rules to the test mode to allow everyone **read** and **write** access.
4. Add **google-service.json** to both **starter** and **final** projects.

> **Note**: If you need a reminder of how to do this, go back to "Chapter 11: Firebase Overview" and "Chapter 12: Introduction to Firebase Realtime Database."
>
> Be sure to use the starter project from **this chapter**, by opening the **realtime-database-offline-capabilities** folder and its **starter** project from the **projects** folder, rather than continuing with the final project you previously worked on. It has a few things added to it, including placeholders for the code to add in this chapter.

Enabling disk persistence

Before you start, build and run the **starter** project, located in the **projects** folder into **realtime-database-offline-capabilities**. Make sure you device is connected to the internet. You'll see your posts on the home screen. Open any post. Now, disconnect your mobile device from the network and navigate back to the home screen. Your posts are still there. By default, Firebase stores your data **in-memory**. Now, close the app and kill the app process from the **Recent apps** menu. Run your app again. Now, you'll see an empty screen.

Caching data locally

To enable disk persistence, you only need one line of code. Open `WhatsUpApplication` class and enable persistence on the `FirebaseDatabase` instance in the `onCreate` method:

```
override fun onCreate() {
    super.onCreate()
    FirebaseDatabase.getInstance().setPersistenceEnabled(true)
}
```

Turn on the network connection on your device. Build and run your app. Your posts will appear on the home screen. Now, disconnect your mobile phone from the network, close the app and kill the app process from the **Recent apps** menu. Run your app again. You'll see the posts appearing on the home screen.

Setting the `setPersistenceEnabled` method argument to `true` enables the app to store the data to the devices local storage — the disk. That is what makes the data available even after you kill the app.

The reason you had to enable disk persistence in the `Application` class, instead of the `RealtimeDatabaseManager`, is that `setPersistenceEnabled` method needs to be called once per app and before creating the first database reference.

Writing data when offline

Disconnect your mobile device from the network and run your app. Add a new post. You'll see that the post appears on the home screen like it was added to the database. But how is that possible if you are offline?

Open the Firebase console and check if your post is there. You'll notice that it's not. Now, connect your mobile phone to the network and observe the database data in the console. You'll see that a few moments after you connect your app back to the internet your post appears in the database.

Setting the `setPersistenceEnabled` method argument to `true` also keeps track of all the writes you initiated while you were offline and then, when network connection comes back, it resends all the write operations. This makes the user experience optimal even if the user loses the network connection for a moment, because your app works as if it's connected to the internet because it uses local data from the disk for synchronization.

Keeping data in sync

Realtime database stores a copy of the data, locally, only for active listeners. To understand this, first, delete your app's data by going to your device's **Settings ▶ Apps & notifications ▶ WhatsUp ▶ Stor**age and finally tap on t**he Clear Stor**age butt**on**.

Next, build and run your app while making sure you're connected to the internet. When the home screen opens and posts show up disconnect the device from the Internet, once again. Next, open any post that you know has comments. You'll notice that there are no comments displayed even if you instructed the app to store data locally by setting `setPersistenceEnabled(true)`. Since Realtime database stores data locally only for active listeners your comments weren't saved, because you haven't accessed them yet.

If you want to save data locally for the location that has no active listeners attached, you can use the `keepSynced` method on a database reference, which you'll do in a moment.

First, open `RealtimeDatabaseManager` class and remove `private` modifier from the `COMMENTS_REFERENCE` constant.

Now, open `WhatsUpApplication` class and call `keepSynced` on comments reference passing in the `true` as an argument:

```
FirebaseDatabase.getInstance().apply {
      setPersistenceEnabled(true)
      getReference(COMMENTS_REFERENCE).keepSynced(true)
}
```

Now, the Realtime database will download the comments and keep them in sync, even if there are no active listeners at that location. Whatever happens at this location — either data gets deleted or updated, you'll receive an update locally, as well.

Connect your mobile device to the network, and build and run your app. When posts appear on the home screen disconnect your app from the network. Now open any post that you know has comments. You'll see your comments there, this time.

Default cache size is **10MB**, which allows you to store a substantial amount of data locally, and, in most cases, this should be enough. If you exceed that limit, any data that hasn't been used for a long time will be deleted. So it's basically an LRU-cache-kind-of mechanism.

In a multi-user app, if there are two users that are not connected to the internet, and both write a post, one later than the other, when they finally connect to the internet, they will end up in a race-condition. Whichever user has a better and a faster connection will write to the database first. This is important to know because, in some cases, this may not be the desired behavior.

Other offline scenarios and network connectivity features

Firebase has many features that can help you when offline mode and connectivity are an important part of your app. The features you're about to learn apply to your app regardless if the local offline persistence is enabled, or not, in your app.

Real-time presence system

The **real-time presence** system allows your app to know the status of your users — are they **online**, **offline**, **away**, or some other status. This feature is inevitable for chat applications for example, because you want to know if the person you are texting is online. This feature may seem simple, but to build an entire app infrastructure or a mechanism, which handles this for you, can be quite troublesome.

Firebase has this infrastructure implemented and it allows you to use it out of the box. Firebase saves the user presence status info to the `<database>/.info/connected` location that you can observe just like any other location in the database. The `.info/connected` reference just contains a `boolean` which indicates if the client is connected or not. The problem appears if you want to write something to the database when the user status changes to the offline status. For this case, you can use the special `onDisconnect()` method which Firebase provides, that tells the Firebase server to do something when it notices that the client isn't online anymore. The `onDisconnect()` method works properly, even in cases when the app crashes, or the connection is lost, or any other nasty edge case.

On Android, Firebase automatically manages connection state to **optimize battery usage** and **reduce bandwidth**. If the client app doesn't have any connection to the database, no active listeners, no pending requests, or similar, Firebase will automatically close the connection after **60 seconds** of inactivity. Alternatively, you can explicitly close the connection by using the `goOffline` method.

Visit the official documentation to learn more about the presence feature.

Latency

Generally speaking, **latency** is the time delay between the cause and the effect of some change. In Realtime database that would, for example, be when a user triggers the action to disconnect from the server until the user is actually disconnected, or the delay between requesting a login entry, to actual authorization response.

Firebase handles latency in a way that it stores a timestamp, that is generated on the server, as data, when the client disconnects, and lets you use that data to reliably know the exact time when the user disconnected. You can combine this feature with the `onDisconnect()` method, that you learned about earlier, to store the exact time when the user disconnected from the database. The timestamp is a static field in the `ServerValue` class and you access it by calling `ServerValue.TIMESTAMP`.

Key points

- Realtime database allows you to enable **disk persistence** to make your data available when you're **offline**.
- Enabling disk persistence also tracks of **all the writes you initiated** while you were offline and then when network connection comes back it **synchronizes** all the write operations.
- Realtime database stores a copy of the data, locally, only for active listeners. You can use the `keepSynced` method on a database reference to save data locally for the location that has no active listeners attached.
- Firebase provides you with the **real-time presence** system, which allows your app to know the status of your users, are they **online** or **offline**.
- Firebase handles **latency** in a way that stores a **timestamp**, that is generated on the server, as data when the client disconnects and lets you use that data to reliably know the exact time when the user disconnected.

Where to go from here?

In this chapter, you learned how Firebase works offline and what features it provides to help you handle offline mode and connectivity issues. You also improved your apps **user experience** in a way that you enabled your app to work as expected even if the user is not connected to the internet.

Visit the official documentation here https://firebase.google.com/docs/database/android/offline-capabilities for more info and examples on enabling offline capabilities. You can play around with the app a bit and try to add more cool features, that Firebase provides, to the app.

Chapter 15, "Usage and Performances," is the last chapter about Realtime database and it will teach you more about Realtime database performance and its limits.

Chapter 15: Usage & Performance

By Dean Djermanović

In the previous chapters, you learned how to work with the Firebase Realtime Database. Realtime Database is built to handle high-traffic apps. To work effectively with Realtime Database, you have to be aware of its usage and performance limits. This chapter covers just that. In this chapter, you'll cover Realtime Database pricing model, general Realtime Database limits, reading and writing limitations, and performance. You'll learn how to measure and optimize performance and how to profile your database.

Pricing model

The Realtime Database is free — but that's only true up to a certain point. If you visit the Firebase pricing page, which you can access at https://firebase.google.com/pricing, you'll see, "Start for free, then pay as you go." Firebase is designed to work for free for smaller startups or experimental projects, like the one you will build in this section. You can see that Firebase offers additional pricing plans.

The Spark Plan is also free and exists so that everyone can experiment and get their hands on Firebase, integrate it into their apps and see how it performs. The majority of the money that Firebase makes comes from big apps with lots of users. All of the products that Firebase has are included in all the plans that they offer. This means that you can try out any product you want for free.

When it comes to Realtime Database, the metrics that Firebase uses to decide how much to bill you for their services are the following:

1. Simultaneous connections: You can to have up to 100 simultaneous connections for free.
2. Data storage: You can store 1GB of data for free. Data in this context is text data and 1GB of text data is an enormous amount.
3. Downloaded data: You can download 10GB of data per month for free from the Realtime Database.
4. Databases per project: You are not allowed to have multiple databases per project for free.

To understand better Firebase billing and how to optimize Realtime Database usage you can check out official Firebase billing guidelines at https://firebase.google.com/docs/database/usage/billing.

Limitations

As mentioned earlier in this chapter, Realtime Database is built to handle high-traffic apps, but it still has some limits. You'll examine some of those limits next. All of the limits that will be mentioned apply for the Realtime Database in general, not for the free plans.

Realtime Database allows you to have 100 simultaneous connections for free, but 100,000 simultaneous connections in a paid plan. This doesn't mean that your app can have 100,000 maximum users because not all of your users are connected at once. Simultaneous connections are devices currently connected to the database.

A single database can approximately send 100,000 responses per second. Responses are anything that comes from the database, like read operations, for example.

When writing to the Realtime Database, the maximum size of a single write event is 1MB. That write event includes already existing data at the location that you're writing to plus the new data.

When it comes to the data in the Realtime Database, the data is stored as a JSON tree, as you learned previously. The maximum number of child nodes must be less than 32 levels deep, the maximum length of the key is 768 bytes and the maximum size of the string is 10MB.

Reading and writing operations are also limited. The size of the data at a single location in the Realtime Database should be less than 256MB for a single-read operation. To perform a read operation at a larger location you should consider using pagination with a query or some other method. The maximum time to run a query is 15 minutes. The total number of cumulative nodes in a path that you want to listen to or query needs to be less than 75 million.

The Realtime Database can handle 64MB per minute through simultaneous write operations on the database. The maximum size of a single write request is 16MB if you're writing through the SDK and 256MB if you're writing from a REST API.

To avoid those limits and scale your Realtime Database data, you can have your data divided across multiple Realtime Database instances. Since the limits mentioned above only apply to a single Realtime Database instance, this is a way to avoid them. Having multiple database instances also allows you to balance server load and improve performance. This concept is known as **database sharding**.

To learn more about Realtime Database limitations, visit the official Firebase documentation on it, which you can access here: https://firebase.google.com/docs/database/usage/limits. Learn more about scaling as well, here: https://firebase.google.com/docs/database/usage/sharding.

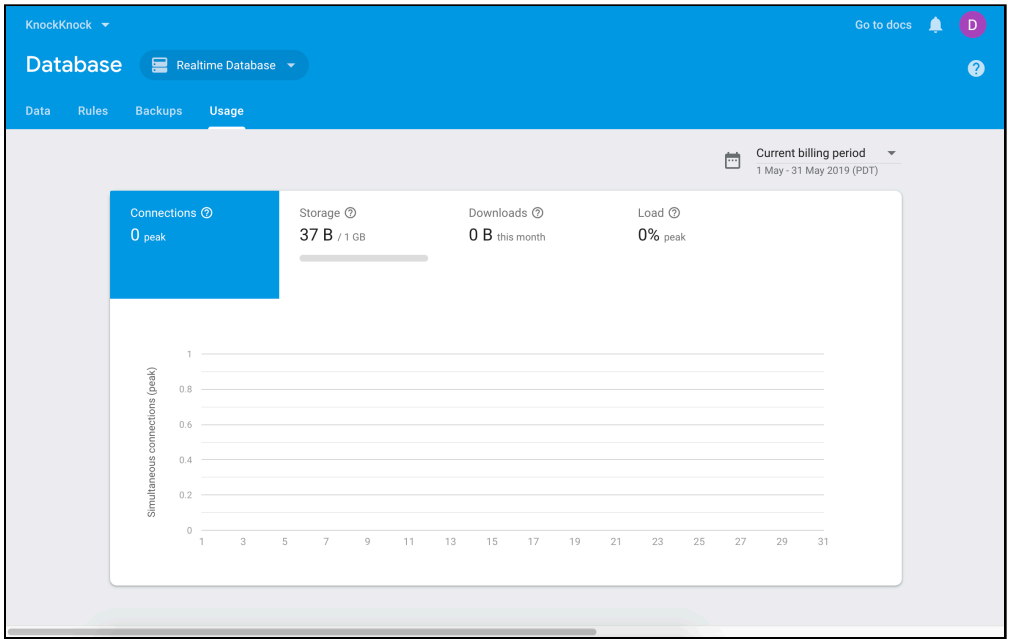
Performance

Monitoring

Realtime Database offers several ways to monitor database performance and find the source of potential problems in your app. It offers different tools that provide insight into performance data. You'll look into those tools next.

One of the tools that Firebase provides is the Realtime Database profiler tool. This tool gives you an overview of reading and writing operations on the database in real-time, which includes information about the speed and payload size of operations.

Firebase console can also be a helpful debugging tool. The **usage** tab in the console gives you data about storage, bandwidth and simultaneous connections. Here's an example of the **usage** tab:



Stackdriver monitoring is also offered by Firebase. Stackdriver monitoring is the most granular approach to performance monitoring because it allows you to combine individual performance metrics to create dashboards with charts. Stackdriver monitoring provides you with metrics that you can use to monitor your billed usage if you're on the paid plan and also contains useful metrics to monitor performance.

To learn more about performance monitoring tools, check out the official page, "Monistor Database Performance," found here: https://firebase.google.com/docs/database/usage/monitor-performance.

Profiling

Database profiling is critical for finding bottlenecks or other issues that might be degrading the user experience. The Firebase command-line interface offers a variety of tools. One of these, the **Database Profiling** tool, analyzes the activity in the database over a specific period of time and generates a detailed report that you can use to troubleshoot the database performance.

The profiling results are split into three main categories: **speed**, **bandwidth** and **unindexed queries**:

- The speed category contains data about reading speed, write speed and broadcast speed.
- The bandwidth category profiles database data consumption across incoming and outgoing operations.
- Finally, the unindexed queries category contains data about unindexed queries since those queries can be expensive.

Optimizing

The best way to optimize performance is to gather all of the data from the tools mentioned above. After you have gathered the data find out about best practices in the area that you want to improve and make changes accordingly.

Other ways of optimizing performance that were already mentioned in this section are sharing data across multiple database instances, building efficient data structures, query indexing, etc.

To learn more about optimizing database performance check out the official documentation on optimization, here: https://firebase.google.com/docs/database/usage/optimize.

Key points

- Realtime Database is free up to a certain point.
- Realtime Database is built to handle high-traffic apps but it has some limits.
- Firebase provides you with tools that allow you to monitor, profile and optimize Realtime Database performance.

Where to go from here?

In this chapter, you covered the usage and performance aspects of the Realtime Database, which are critical to know for large scale apps.

This chapter wraps up the Realtime Database part of this section. This is a good place to pause and revisit what you learned so far and to try to play with Realtime Database and check the official documentation to continue learning about what it can offer you as you build your apps.

In the coming chapters, you'll learn about **Cloud Firestore**, which is another Firebase product that's similar to Realtime Database.

Chapter 16: Introduction to Cloud Firestore

By Dean Djermanović

In the previous chapters, you learned how to use Realtime Database for storing data in the cloud. Firebase offers another product that you can use for storing data in the cloud: **Cloud Firestore**.

Cloud Firestore has a similar feature set as Realtime Database. It allows you store data in the cloud and sync data across devices, but it's designed to overcome all of the drawbacks of the Realtime database — and it also stores data within a single JSON document. This chapter introduces you to the Cloud Firestore and discusses the differences between Realtime Database and Cloud Firestore. More importantly, it also helps you determine when it's appropriate to use one over the other.

What is Cloud Firestore?

Cloud Firestore is a NoSQL database similar to the Realtime Database. It stores data in a structure that looks like a tree, but where data is stored as documents.

Documents and **collections** are the primary building blocks of the Cloud Firestore. It's helpful to think of documents as files, and that these files consist of key-value pairs known as **fields** — this is similar to how models work. The values can be anything, strings, numbers, binary data, or even nested objects in a map format that resembles a JSON object. Collections, on the other hand, are simply groups of documents.

When working with Cloud Firestore, there are a few rules to keep in mind:

- **First Rule**: Collections can only contain documents. For example, you cannot add a `String` to the collection.
- **Second Rule**: Documents cannot contain other documents; however, they can point to subcollections. For example, your collections can contain many documents, and those documents can point to other collections. This is how things are formatted in a tree-like structure.
- **Third Rule**: The root of the Cloud Firestore database can only contain collections.

For example, in the **WhatsUp** app you created earlier, you could have a *Posts* collection that contains a document for each post. Each document would point to a *Comments* collection that contains comments for that post, and the document that contains the comments would point to another collection, and so on.

When you worked with the Realtime Database, you learned that you should avoid these deeply nested hierarchy structures. In Cloud Firestore, however, these deeply nested structures are typical because the queries are shallow, meaning that querying data from a document will get you *only that document*; you don't have to query the entire collection or the subcollections within the document. This also means that queries are more efficient and flexible than in a Realtime Database, especially when it comes to filtering and sorting the data.

With **WhatsUp** app running with Cloud Firestore, you could have a collection of posts and any other collections you need to represent the data.

Cloud Firestore vs. Realtime database

Due to the similarity between the Realtime Database and the Firestore, you may be wondering how they're different. Both of these products offer a cloud-based database solution with real-time data syncing for mobile clients, so what gives?

You can think of the Cloud Firestore as an **improved** version of the Realtime Database because it's designed to overcome the drawbacks of the Realtime Database with things like **scaling**, **data structuring** and **querying**. Since the Realtime Database stores data as one big JSON tree, it's challenging to organize and scale complex data.

Firestore has a new and intuitive data model, and it handles complex data using subcollections within documents. Because of how documents and data are stored, the Firestore has faster queries than the Realtime Database, and it supports indexed

queries with **compound sorting and filtering**. Additionally, in the Realtime Database, you cannot sort and filter the data in the same query, and when you query the data, the result is the whole subtree. Firestore allows all kinds of query chaining that NoSQL databases allow, and instead of querying entire collections or a document, you can query subcollections within a document. Furthermore, in the Realtime Database, you need to perform write operations in a single query; in the Firestore, you can collect all of your data and write it as a batch operation. This means that one large job is executed in small parts to improve efficiency.

Firestore has a lot of advanced features too. Both the Realtime Database and the Firestore offer offline support; however, the Realtime Database offers it only for the mobile clients, while the Firestore offers it for **web apps** as well.

In the Realtime Database, you need callbacks for transactions. In the Firestore, you don't. Transactions are completed automatically until all of them are finished.

Scalability in the Realtime database isn't that big of a problem, but when the data exceeds the limits you learned about in Chapter 15, "Usage and performance", you needed to shred your data across multiple database instances. In the Firestore, you won't need to do that regardless of how big your database will be — the **database scaling** is handled for you. This is a considerable improvement for large scale projects.

Like the Realtime Database, Firestore is free, up to a certain point; you need to pay for your database to scale. Firestore charges based on the read and write operations that you're performing on the database.

Because of the improvements that the Firestore offers compared to the Realtime Database, Firebase recommends using the Firestore for all new projects.

Cloud Firestore data structure

In this chapter, you learned that the Firestore is a **NoSQL database**, meaning there is no SQL. But if there's no SQL, you can't build queries that will take one piece of data from one part of the database, and another piece of data from another part of the database, and merge them. In the Firestore, to get data from two different parts of the database, you must make two different requests. If you run into that scenario, it's likely that you need to re-structure your data in a way that you'll always be able to get what you need in **one request**.

You also learned that the Firestore database consists of collections and documents. Take the **WhatsUp** app, for example. While it's possible to have a *Posts* collection that contains individual posts as documents, **WhatsUp** has the feature where every post can contain comments. Maybe you can make it so that every post document contains a *Comments* subcollection, and that that collection contains comments for that post. With that setup, you could easily fetch the post and the comments in a single call. However, that's not how you want to do that.

When you think about it, you don't need to know about the post comments until the user opens the post by tapping on it. It's only when the post details screen appears that you need the comments. In this case, a better approach is to have a *Comments* collection stored as a separate collection rather than as a subcollection. You can then put the **post id** to the individual comment, so you'll know to which post the comment belongs. Finally, when fetching comments, you can filter them by the post id and get all of the comments that belong to a specific post.

There is one drawback to this approach, however, and that is data duplication. Every comment has an author so you'll likely want to know who wrote the comment. In **WhatsUp** this is not the case, but in other apps, you could have another collection of users, and then the comment would need to contain the user data.

By doing that, not only do you fill the database with duplicate user data objects in each of the comments but also if the user chooses to change the data, you'll need to update all of the comments, as well. So, perhaps a better approach is to store the author id in the comment; then, when you need to get the user data, you can filter out the independent *Users* collection using the available id.

One significant advantage of the NoSQL database is that it can distribute data across multiple machines easily. In relational databases, when you have an app that's becoming more popular and needs more storage space, you'd need a more powerful and bigger machine. This is known as **vertical scaling**.

In many NoSQL databases, including Firestore, when you need more storage, Firestore spreads your data across many servers. This is known as **horizontal scaling**, and it's much easier to scale horizontally than vertically. Why? Because it's much easier to get many moderately powerful machines than to continually upgrade a single machine to handle everything. Machines have their limits too, you know!

Collections and documents

You learned that the Realtime Database stores data as one large JSON tree that contains keys and values. You also learned that these values can be objects containing other key-value pairs. The Firestore is a collection of objects that are stored in a hierarchical structure that resembles a tree. Every object in a collection is represented as a document. The document consists of key-value pairs known as **fields** in the Firestore. These values can be strings, numbers, binary data, or nested objects in a map format. The limitation, however, is that the document size must be less than 1MB.

In simple terms, collections are nothing more than a group of documents. A document cannot contain other documents, but it can contain another collection known as **subcollection**.

Cloud Firestore supports many data types. To learn more about them, visit the official documentation at https://firebase.google.com/docs/firestore/manage-data/data-types.

Key points

- Cloud Firestore is a NoSQL database similar to the Realtime Database.
- Firestore stores data as a collection of objects which are stored in a hierarchical structure that resemble a tree.
- Documents and collections are the main building blocks of Cloud Firestore.
- Documents consist of key-value pairs known as fields.
- Collections are a group of documents.
- Collections can only contain documents.
- The root of the Cloud Firestore database can only consist of collections.
- A document cannot contain other documents, but it can contain another collection; these are known as subcollections.

- It's easier to query, filter and sort data using the Firestore since it can all be done within a single request.
- It's best to use foreign-key-like fields in objects, as you don't want to duplicate data and clutter the database.
- The Firestore scales horizontally; this is easier than the Realtime Database which scales vertically.

Where to go from here?

In this chapter, you learned the basics of Cloud Firestore. You learned what the Firestore is, the differences between the Firestore and the Realtime Database, and how the Firestore structures the data. You still have a lot to cover, so be sure to visit the official documentation here: https://firebase.google.com/docs/firestore to understand the specifics of the Cloud Firestore better. You can find it here: https://firebase.google.com/docs/firestore.

In the next chapter, you'll learn how to manage the Firestore data using the Firebase console and how to add and delete data from the database.

Chapter 17: Managing Data with Cloud Firestore

By Dean Djermanović

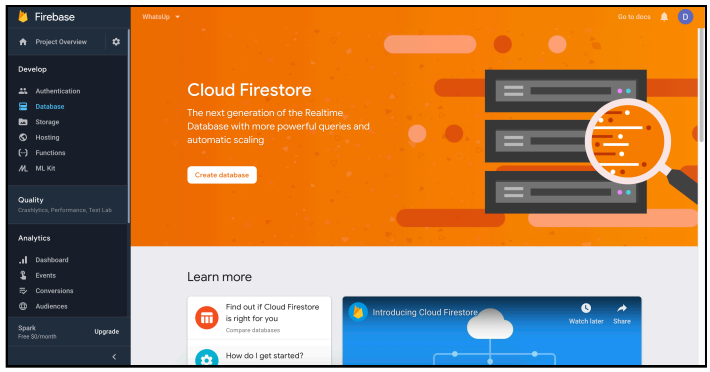
In the previous chapter, you learned the basics of Cloud Firestore. You learned what Firestore is, how it differs from Realtime database, and how it structures its data. In this chapter, you'll integrate Firestore into the app. You'll refactor the current **WhatsUp** app to use the Firestore as the backend. All of the functionality of **WhatsUp** app will remain the same. In the process, you'll learn how to add data to the Firestore, how to update and delete data, and how to use Firebase console to manage Firestore data.

Getting started

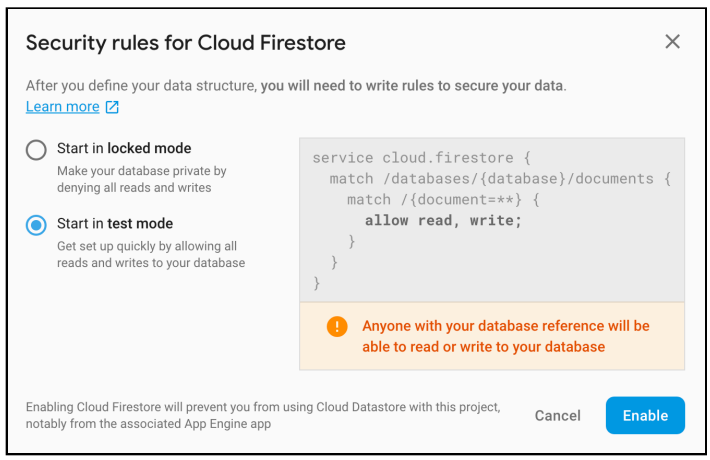
You need to set up Firestore before you can start using it. If you followed along with Realtime database chapters, you have already created the project in the Firebase console. If you didn't, go back to the "Chapter 11: Firebase overview" and "Chapter 12: Introduction toFirebase Realtime Database" to see how to create the project in the console and how to connect your app with Firebase.

Creating the database

Open your **WhatsUp** project in the Firebase console. Select **Database** from the menu on the left. You'll see this screen:



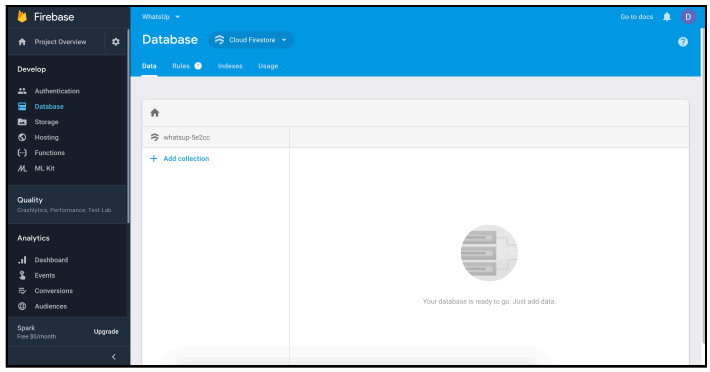
Click the **Create database** button in the Cloud Firestore section at the top of the page. Security rules dialog will open:



Two security modes are offered to you. **Test** mode will allow anyone to have read and write access to the database while the **locked** mode will deny all reads and writes to the database. Choose the test mode for now. You'll learn more about the security of the Cloud Firestore in the "Chapter 19: Securing data in Cloud Firestore".

Click the **enable** button.

Your database will open after Firebase finishes creating it. This what you'll see:



Configuring application

You have created the database in the console. Now you need to configure your app so it can communicate with the database.

> **NOTE:** This chapter provides **starter** and **final** projects that you can use to follow along. In order to use those projects, you need to configure them first by creating a project in the Firebase and by adding **google-services.json** configuration file to the project. Take a look at "Chapter 11: Firebase overview" and "Chapter 12: Introduction to Firebase Realtime database" to see how to do that.

Open the **starter** project for this chapter.

First, you need to add a Firestore client library for Android to the project. Open the apps level **build.gradle** file and add the following dependency:

```
implementation 'com.google.firebase:firebase-firestore:20.1.0'
```

The second thing you need to do is to initialize the Firestore instance. Open the `CloudFirestoreManager` class and add `database` field:

```
private val database = FirebaseFirestore.getInstance()
```

`FirebaseFirestore` represents the Firestore instance and it is used for all the communication with the Firestore database from the application.

Writing data

The first part of the app that you'll refactor to use Firestore is writing. Instead of writing data to Realtime Database you'll write the data to the Cloud Firestore.

In the `CloudFirestoreManager` class replace the `TODO` inside the `addPost` function with the following:

```
val documentReference =
database.collection(POSTS_COLLECTION).document() //1

val post = HashMap<String, Any>() //2
//3
post[AUTHOR_KEY] = authenticationManager.getCurrentUser()
post[CONTENT_KEY] = content
post[TIMESTAMP_KEY] = getCurrentTime()
post[ID_KEY] = documentReference.id
//4
documentReference
  .set(post)
  .addOnSuccessListener { onSuccessAction() }
  .addOnFailureListener { onFailureAction() }
```

1. First, you call the `collection` method passing in the posts collection path. The `collection` method returns a reference to the collection at the specified path in the database. You use that collection reference to get the document reference by calling the `document` method, which points to the new document within that collection with an auto-generated ID. You'll use that document reference to get the document ID that you'll store in the database with the post object.

2. Here, you create data that you want to save to the document. This data is represented as a map of `String, Any` type where `String` is the type of the key and `Any` is the type of the value.

3. You need to populate the map with the values that you want to write to the database. You add author, post content, timestamp and the ID of the document to the map.

4. This where you actually save the data. First, you call the `set` method on the document reference that will replace the data in the document if it already exists or it will create it if it doesn't. You pass in the `post` map that contains the data that you want to write to that document. The `set` method returns a `Task` which represent an asynchronous operation. Since the operation is asynchronous, you attach two listeners, `OnSuccessListener` that is called if the `Task` completes successfully, and `OnFailureListener` that is called if the `Task` fails. You pass in

the actions that you receive as the function parameters.

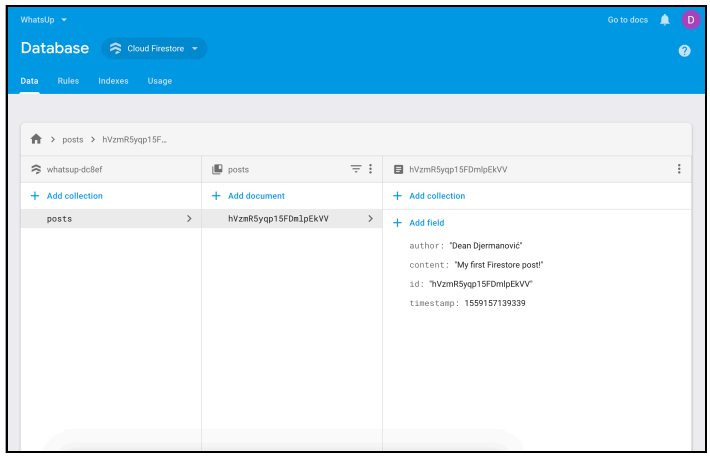
Open the `AddPostActivity` class and replace the `TODO` inside the `addPostIfNotEmpty` function with the call to the `cloudFirestoreManager.addPost`:

```
cloudFirestoreManager.addPost(postMessage, ::onPostAddSuccess, :
:onPostAddFailed)
```

Build and run your app. Click on the floating action button at the bottom right corner. Add some text and click the **Post** button:

You should get a toast message that says that the post save is successful. Nothing is displayed on the home screen. That is because you haven't implemented the logic for reading yet.

Open the database in the console. You should see your post there. If you don't see it try to refresh the page:



Congratulations, you saved your first post to the Firestore database!

Transactions

Firestore supports another way of writing data, **transactions**. Transactions are used in cases when you want to write a bunch of data to the database at once. While the transaction is executing, the user won't be able to read that partially changed state. If one of the operations that are executed in a transaction fails, none of them will be applied because that could potentially leave the database in an inconsistent and undesired state. Either all are applied or none. One transaction operation can write to 500 documents maximally.

There is another type of transaction called **batched write**. Batched write allows you to perform a bunch of writes all at once, in other words, in a batch. It works in a way that you specify what you want to change and tell the SDK to change it. You don't have to worry about what happens if the operation fails halfway through. None of the changes will be applied in that case. Also, another user won't be able to change that same data that you are currently changing because those write operations are **atomic** which means that the operation is guaranteed to be isolated from other operations that may be happening at the same time. Batch operation is also much more efficient than doing many individual write operations. A good use case for batch write is when you want to change many related documents and your new value does not depend on the old value.

To learn more about transactions and batched writes check out the official documentation: https://firebase.google.com/docs/firestore/manage-data/transactions.

Updating data

Next, you'll add an update feature to your app. You'll see that it's very similiar to what you did when adding new data. Open the `CloudFirestoreManager` class and replace the `TODO` inside the `updatePostContent`with the following:

```
//1
 val updatedPost = HashMap<String, Any>()

 //2
 updatedPost[CONTENT_KEY] = content

//3
database.collection(POSTS_COLLECTION)
  .document(key)
  .update(updatedPost)
  .addOnSuccessListener { onSuccessAction() }
  .addOnFailureListener { onFailureAction() }
```

1. You start the same way as when adding a new post, by creating a map of data that you want to save to the database.
2. When updating an existing document you only need to specify the data that you are updating. In this case, this is only the post content.
3. Finally, you get the reference to the posts collection and from there you get the reference to the document that you're updating by specifying a key. Then you call `update` method on a document reference which updates fields in the document. The listener logic stays the same as in the case of writing new data.

Open the `PostDetailsActivity` class and inside the `initializeClickListener` function replace the `TODO` in the on-click listener, so the *update post* button will update the database with the update content when clicked:

```
cloudFirestoreManager.updatePostContent(
  post.id,
  postText.text.toString().trim(),
  ::onPostSuccessfullyUpdated,
  ::onPostUpdateFailed
)
```

Now you can update posts in the database as well. You'll be able to test this functionality when you implement reading logic in the "Chapter 18: Read data from Cloud Firestore".

Deleting data

One last bit of functionality that you'll add in this chapter is post deleting. Open the `CloudFirestoreManager` class and replace the `TODO` inside `deletePost` function with the following:

```
database.collection(POSTS_COLLECTION)
  .document(key)
  .delete()
  .addOnSuccessListener { onSuccessAction() }
  .addOnFailureListener { onFailureAction() }
```

To delete a post you first get a reference to the collection of the post by calling the `collection` method on a database instance and passing in the path to the posts collection. Then you get a reference to the specific post document that you want to delete by passing in the key which is the ID of the post. Finally, you call `delete` method on a document reference which deletes the document referred to by the reference. The `delete` method deletes data asynchronously, so you also attach the listeners that get triggered when the deleting succeeds or fails.

Now, open the `PostDetailsActivity` class and inside the `initializeClickListener` function replace the `TODO` inside the delete button click listener with the following:

```
cloudFirestoreManager.deletePost(post.id, ::onPostSuccessfullyDe
leted, ::onPostDeleteFailed)
```

Now when you open post details you can delete post by tapping the delete button. You'll also test this functionality when you implement reading logic in the "Chapter 18: Read data from Cloud Firestore".

One important thing to mention here is when you delete a post document, if that document contained a subcollection, that subcollection would not have been deleted. When you delete a document only that document is deleted; Firestore does not delete the documents inside the subcollections.

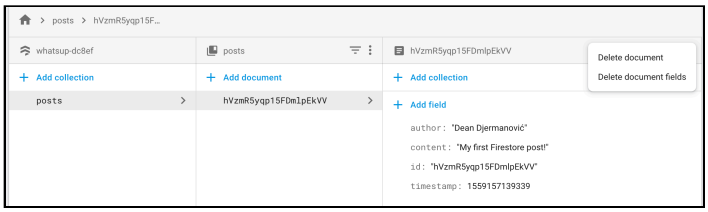
Firebase console

You can do all of these operations that you implemented in this chapter, like adding data, updating and deleting, manually in the Firebase console.

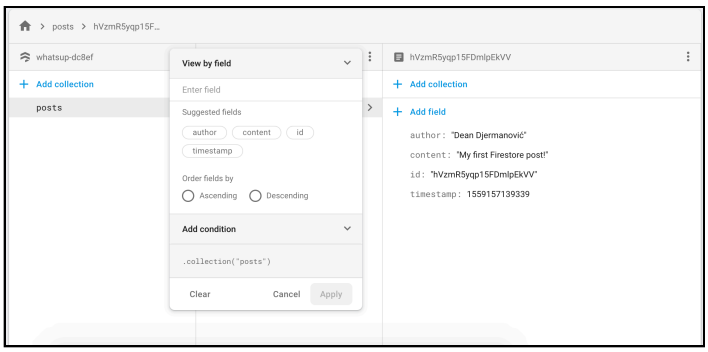
Open firebase console in the browser and navigate to the Firestore database.

From here, you can view your database data. You can click on any collection to see the documents within that collection, and you can click on any document to see the details of that document.

You'll also notice these menu icons. Click on the in the last column for example. There you'll see the options to delete a document or a specific field of the document:



You can also filter the documents inside the collection by clicking the filter button:



Visit the official documentation https://firebase.google.com/docs/firestore/using-console to explore more possibilities of the console.

Key points

- Firestore database is created in the Firebase console.
- You need to add a Firestore client library for Android to the project in order to use Firestore APIs.
- You need to initialize a Firestore instance in order to communicate with the database.
- You call the `collection` method passing in the collection path to get a reference to the collection at the specified path in the database.
- You need to create and populate the map of data that you wan't to save to the

database.

- You call the `set` method on the document reference that will replace the data in the document if it already exists or it will create it if it doesn't to save the data to the database. You pass in the map that contains the data that you want to write to that document.
- Firebase supports transactions which are used in cases when you want to write a bunch of data to the database at once.
- You call the `update` method on a document reference to update fields in the document.
- You call the `delete` method on a document reference which deletes the document referred to by the reference.
- Adding, updating and deleting operations are asynchronous.
- You can use the Firebase console to manage data in the Firestore database.

Where to go from here?

You implemented adding, updating, and deleting functionalities in this chapter and you saw how you can use the Firebase console to achieve that. You can visit the official documentation https://firebase.google.com/docs/firestore/manage-data/add-data to learn more about these operations.

You still don't have a way to test these functionalities. In "Chapter 18: Reading data from Cloud Firestore" you'll add the ability to listen for data updates in real time. You'll learn how to read data from the database and to do other data manipulation operations.

Chapter 18: Reading Data from Cloud Firestore

By Dean Djermanović

In the previous chapter, you learned how to write data to the Firestore, and how to update or delete data from Firestore by implementing that functionality in the **WhatsUp** app. You also became familiar with the Firebase console and learned how to use it for managing data.

In this chapter, you'll continue working on your app. Since now you still don't have any data on the home screen when you run the app, you'll focus on implementing reading logic. In the process, you'll learn how to read data from the Firestore, how to listen for updates in real-time, and how queries work.

> **Note**: If you skipped previous chapters, you need to setup Firebase in order to follow along. Do the following steps:

1. Create a project in the Firebase console.
2. Enable Google sign-in.
3. Set security rules to the test mode to allow everyone **read** and **write** access.
4. Add **google-service.json** to both **starter** and **final** projects.

> To see how to do this, go back to *"Chapter 11: Firebase Overview"* and _"Chapter 12: Introduction to Firebase Realtime Database"_.
>
> Be sure to use the starter project from **this chapter**, by opening the **reading-data-from-cloud-firestore** folder and its **starter** project from the **projects**

folder, rather than continuing with the final project you previously worked on. It has a few things added to it, including placeholders for the code to add in this chapter.

Reading data

Like the Realtime Database, Firestore allows to read data once, or to listen for data changes in real-time.

To get the data once, you need to call `get()` on the collection reference from which you want to read the data or you can also use `get()` on the document reference, if you need to read data from a specific document. For example, this is how you'd read the data from the `posts` collection:

```
database.collection("posts")
    .get()
    .addOnSuccessListener { result ->
      ...
    }
    .addOnFailureListener { exception ->
      ...
    }
```

Since getting the data is asynchronous, you need to attach a listener that will notify you when the data fetching is complete. It returns the data as a `QuerySnapshot`. `QuerySnapshot` is a class that contains the results of a query and can contain `QueryDocumentSnapshot` objects if they are available. A `QueryDocumentSnapshot` contains data read from a document in your Firestore database. You'll see an example of this shortly.

Since you want that your app always has the latest data you won't fetch the data only once. Instead, you'll implement a listener, so you can receive events when the data changes.

Listening for data changes

If you don't have the project open by now, make sure to open it, and head over to **CloudFirestoreManager.kt**. Add a `postsRegistration` field like this:

```
private lateinit var postsRegistration: ListenerRegistration
```

`ListenerRegistration` represents a subscription of sorts, for a database reference, when you attach a listener to the reference. You'll use it to assign a `posts` listener to it and to remove it when needed, to clean up your code, and to stop receiving changes.

Next, navigate to `listenForPostsValueChanges()`. Replace the `TODO` inside the fuction with the following implementation:

```
private fun listenForPostsValueChanges() {
  // 1
  postsRegistration = database.collection(POSTS_COLLECTION) // 2
    // 3
    .addSnapshotListener(EventListener<QuerySnapshot> { value,
error ->
      // 4
      if (error != null || value == null) {
        return@EventListener
      }

      // 5
      if (value.isEmpty) {
        // 6
        postsValues.postValue(emptyList())
      } else {
        // 7
        val posts = ArrayList<Post>()
        // 8
        for (doc in value) {
          // 9
          val post = doc.toObject(Post::class.java)
          posts.add(post)
        }
        // 10
        postsValues.postValue(posts)
      }
    })
}
```

1. You assign the listener to `postsRegistration`, by attaching an `EventListener` to the database collection.
2. You receive the database collection by calling `database.collection(POSTS_COLLECTION)`.
3. You call `addSnapshotListener()` on the collection reference which starts listening for the data changes at its location.
4. When `onEvent()` is called you first check if an error occurred by checking if the error argument *is not* `null`, or if the value *is* `null`. If it is you'll just return from

the function, since you cannot consume the event.

5. Check if the received data actually contains documents - it isn't empty.
6. If the value is empty, it means no posts are available, and you simply communicate it by updating the `postsValues` with an `emptyList()`.
7. If there are values, instantiate an `ArrayList` to store them.
8. Iterate through each document in the value snapshot.
9. Parse each document as a `Post`, and add it to `posts`.
10. Update the `postsValues` with parsed posts.

To read the data, you pass in the listener of type `EventListener` that will be called whenever data changes or if an error occurs. `EventListener` is a generic interface that is used for any type of event listening, and contains only the `onEvent(T value, FirebaseFirestoreException error)` function that you're required to implement. `onEvent()` will be called with the new value or the error if an error occurred. You get the result data as a `QuerySnapshot` object. This is the easiest way to communicate data changes or errors, and since it's **generic**, it can work for any collection.

Open `HomeActivity` and navigate to the `listenForPostsUpdates` function. Replace the `TODO` inside the function with the following:

```
private fun listenForPostsUpdates() {
  cloudFirestoreManager.onPostsValuesChange()
      .observe(this, Observer(::onPostsUpdate))
}
```

When new data is received you'll reflect that, by displaying it on the screen.

You also need to remove the listener when you no longer want to receive data change events. To do that, open **CloudFirestoreManager.kt** and navigate to `stopListeningForPostChanges()` and replace the function code with the following:

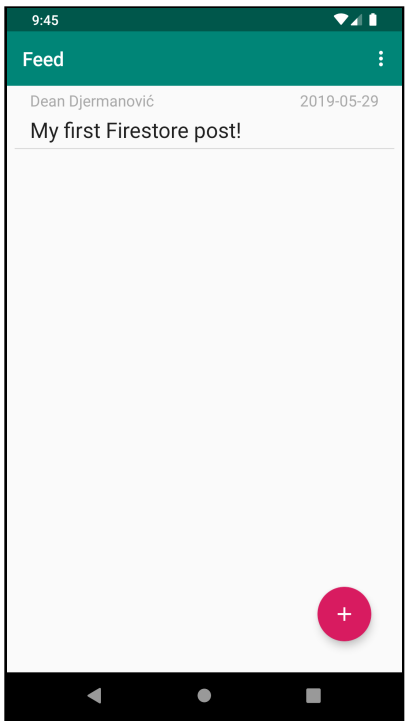
```
fun stopListeningForPostChanges() = postsRegistration.remove()
```

By calling `remove` method on a `ListenerRegistration` object you remove the listener from the locatin that this listener is assigned to.

Now go back to the `HomeActivity` and override `onStop` method and call `stopListeningForPostChanges` from there, like this:

```
override fun onStop() {
    super.onStop()
    cloudFirestoreManager.stopListeningForPostChanges()
}
```

Build and run your app. You should see the posts now on the home screen:



You can test the real-time updates by deleting the post directly from the console. You should see how the change is reflected in the app almost instantly.

Performing queries

Sometimes, you don't want to read just the documents of certain collections. Sometimes you need to filter out, match by values, or simply skip a certain amount of documents. To do this, you use database **queries**. Since you don't have any nested documents in the `posts` collection, let's add something to make it a bit more complex.

Adding comments

There's one more feature that you have in the Realtime Database version of the **WhatsUp** app that's you didn't add, and that is the ability to add a comment to the post. You'll add that now and you'll use that feature to see how the queries are performed.

Open **CloudFirestoreManager.kt**, once again, and navigate to `addComment()`. Replace the `TODO`, inside the function, with the following code:

```
// 1
val commentReference =
database.collection(COMMENTS_COLLECTION).document()

// 2
val comment = HashMap<String, Any>()

// 3
comment[AUTHOR_KEY] = authenticationManager.getCurrentUser()
comment[CONTENT_KEY] = content
comment[POST_ID] = postId
comment[TIMESTAMP_KEY] = getCurrentTime()

// 4
commentReference
    .set(comment) // 5
    .addOnSuccessListener { onSuccessAction() } // 6
    .addOnFailureListener { onFailureAction() } // 7
```

The logic for adding the comment to the database is exactly the same as with adding posts so you should understand what happens in the code above by now, but to sum it up, here's what happens:

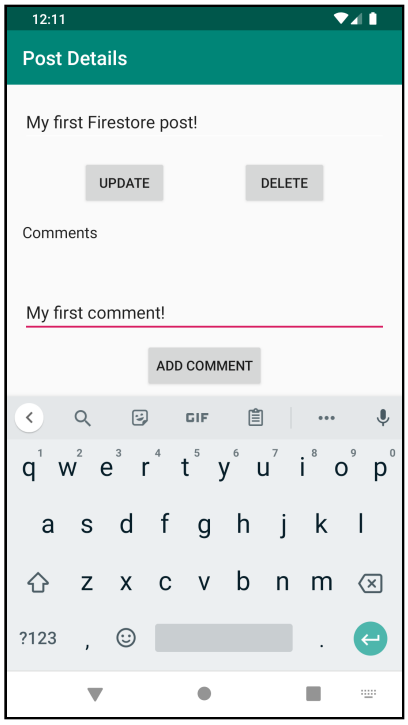
1. Create a new document in Firestore, and store its reference.
2. Create a `HashMap<String, Any>`, to store the comment data.
3. Store the data in `comment`.
4. Use the commentReference to communicate the save operation.
5. Set the reference value to the new comment.
6. In case of a **Success**, call the `onSuccessAction`.
7. In case something goes wrong - a **Failure** occured, call the `onFailureAction`.

Open **PostDetailsActivity.kt**, navigate to `initializeClickListener()`, and replace the `TODO` inside `addCommentButton` click listener with a call to `addComment()`:

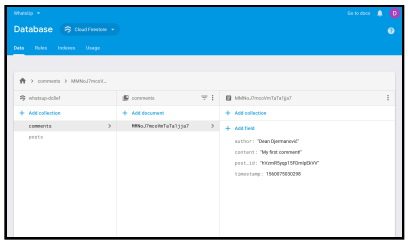
```
...
addCommentButton.setOnClickListener {
  val comment = commentEditText.text.toString().trim()
  if (comment.isNotEmpty()) {
    cloudFirestoreManager.addComment(
      post.id,
      comment,
      ::onCommentSuccessfullyAdded,
      ::onCommentAddFailed
      )
  } else {
    showToast(getString(R.string.empty_comment_message))
  }
}
```

This will save the comment to the database on **Add Comment** button click.

Build and run your app. Tap on any post in the list. Enter some text into the comments `EditText` and tap the **Add Comment** button:



Your comment is now saved to the database. Open the database in the console to confirm that. You should see your comment there:



Listening for comments

You can add comments to the database now, but you still can't read them. Since comments are stored in a separate collection from posts, to read them you'll need to write a query that returns comments for the specific post. Every comment document has a `post_id` property that indicates to which post the comment belongs to.

Open **CloudFirestoreManager.kt**. Add a `commentsRegistration` field:

```
private lateinit var commentsRegistration: ListenerRegistration
```

You'll use this field to assign the comments listener to it and to remove the listener when needed, just like before.

Next, navigate to `listenForPostCommentsValueChanges()`. Replace the `TODO` inside the function with the following:

```
// 1
commentsRegistration = database.collection(COMMENTS_COLLECTION)
    // 2
    .whereEqualTo(POST_ID, postId) // 3
    // 4
    .addSnapshotListener(EventListener<QuerySnapshot> { value,
error ->
      if (error != null || value == null) {
        return@EventListener
      }

      if (value.isEmpty) {
        postsValues.postValue(emptyList())
      } else {
        val comments = ArrayList<Comment>()
        for (doc in value) {
          val comment = doc.toObject(Comment::class.java)
          comments.add(comment)
        }
        commentsValues.postValue(comments)
      }
    })
```

1. As before, you assing a listener to the `comments` reference.
2. You use `whereEqualTo` method to create the query that filters the documents in the collection that contain the specified field and value in that field.
3. Pass in the `POST_ID` that represents the `post_id` property and the `postId` that represents the value for comparison. This query will only return the documents that belong to the specified post. `whereEqualTo` method returns a `Query` that you can read or listen to.
4. Once again, attach an `EventListener` and parse the `Comments`, if there are any, updating the UI when you're done.

Next, open **PostDetailsActivity.kt** and navigate to `listenForComments()`. Replace the `TODO` inside the function with the following:

```
cloudFirestoreManager.onCommentsValuesChange(post.id)
    .observe(this, Observer(::onCommentsUpdate))
```

Here, you start listening for the comments changes for that particular post and when the data changes you update the UI.

Go back to the **CloudFirestoreManager.kt** class and navigate to `stopListeningForCommentsChanges()`. Replace the function with the following:

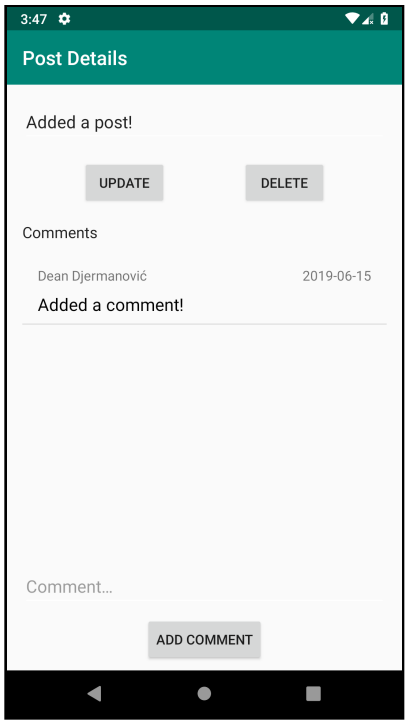
```
fun stopListeningForCommentsChanges() =
commentsRegistration.remove()
```

Here, you remove the listener from the location that you assigned to the `commentsRegistration`.

Open **PostDetailsActivity.kt** class and override `onStop()`. Remove the comments listener from this method because this is the point where you're no longer interested in the comments changes:

```
override fun onStop() {
    super.onStop()
    cloudFirestoreManager.stopListeningForCommentsChanges()
}
```

If you build and run the code now, you should see the comment appear, in the post details section of the app.



Deleting comments

One last thing that you need to add is the ability to delete the comments. You'll delete the comments for the particular posts when that post is deleted.

Open **CloudFirestoreManager.kt** and navigate to `deletePostComments()`. Replace the `TODO` inside the function with the following:

```
// 1
database.collection(COMMENTS_COLLECTION)
    .whereEqualTo(POST_ID, postId)
    //2
    .get()
    //3
    .continueWith { task -> task.result?.documents?.forEach
{ it.reference.delete() } }
```

1. First, get a reference to the comments collection and filter the comments that belong to the specific post.
2. Call `get()` to retrieve the filtered-by-post comments, **asynchronously**.

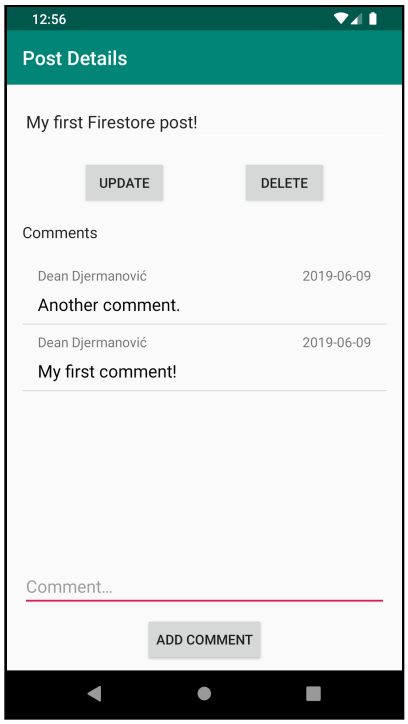
3. After comments are loaded, delete them from the database, one by one.

`continueWith()` on a `Task` instance returns a new `Task` that will be completed with the `result` of applying the specified `Continuation` to this `Task`. A `Continuation` is a function that is called to continue execution after completion of a `Task`. When the comments for the specific posts are fetched, you delete them by traversing the result documents and calling `delete` method on each document reference. // TODO FPE - Should we try to separate and clarify this more? And how?

Finally, call `deletePostComments()` from `deletePost()`, to delete the comments tied to that post, when thte post is deleted:

```
fun deletePost(key: String, onSuccessAction: () -> Unit,
onFailureAction: () -> Unit) {
    ...
    deletePostComments(key)
}
```

Build and run your app. Open the post that you added a comment to before. You'll now see that your comment is displayed, like before. Add another comment and you'll see that it's displayed on the screen immediately.



Open the database console. Now, delete the posts that you added comments to and observe the database in the console. You'll notice that comments for that post are deleted, as well.

Working offline

Like Realtime Database, Firestore can also work **offline**. Cloud Firestore stores a copy of data that your app is using, locally, so that you can have access to the data if the device goes offline. You can perform operations like reading, writing and querying on the local copy. When your device goes back online, Firestore automatically syncs the data with the data that is stored remotely!

Firestores offline persistence is enabled by default for mobile clients. You can test this in your **WhatsUp** app.

Build and run your app. Add some posts if you don't have already. You can add some comment to that post as well if you like. Now disconnect the device from the network and kill the process of your app. Start your app again and you'll notice that your data is still displayed on the screen.

Now add another post. Tap on the floating action button on the home screen and enter some content for the post and tap the **Post** button. Nothing happens because you only consider post saved when it is saved to the remote database.

Go back to the home screen by tapping the system back button. You'll see your post that you added while offline is displayed on the home screen. This is because it was saved to the local cache. If you open the console and look into the database you won't see that post in the database.

Now connect your device back to the network. You'll get a toast message on the device that the post is saved an now you can see your post in the remote database.

If you don't want to have the offline feature enabled, you can disable it when initializing Cloud Firestore.

Check the official documentation to learn more about offline support.

Other features

Cloud Firestore has many other features. You'll go through some of them next.

Ordering and limiting

You've already seen how you can specify which documents you want to fetch from the collection by using `whereEqualTo()`. But there's much more you can do, on top of the `whereEqualTo()`:

- You can use `orderBy()` on the collection reference to sort the data by the specified field. By default, the documents are sorted in ascending order by document ID.
- You can use `limit()` on the collection reference to only return up to the specified number of documents.
- You can also combine all of the `where` methods for filtering with `limit()` and `orderBy()`.

Pagination

You can have a lot of data stored in your database, but you probably don't need all of the data all the time. Pagination allows you to split your database data into chunks so that you don't need to fetch all of it at once.

Firestore provides you with the **pagination** feature, that works in a way where you don't need to execute one large query, but instead multiple smaller queries **sequentially**. Firestores library has some useful methods that you can use to divide your query into smaller queries, like `startAt()`, `startAfter()`, `endAt()` or `endBefore()`.

Check the official documentation to learn more about pagination.

Indexing

To ensure good performance for every query, Firestore requires an index. Firestore automatically creates indices for the basic queries for you.

Check the official documentation to learn more about how to add indexing manually and how it works.

Key points

- Firestore allows to **read data once** or to **listen for data changes** in real-time.
- To get the data once, you would need to use `get` method on the collection

reference.

- `ListenerRegistration` interface represents a Firestore subscription listener.
- You can call `addSnapshotListener()` on a collection reference to start listening for data changes at a specific location.
- **Queries** are used to get only a **subset** of the documents within a collection.
- Cloud Firestore stores a copy of data that your app is using, locally, so that you can access the data, if the device goes offline.
- You can also use `orderBy()` and `limit()`, on the collection reference, to get only specific documents from a collection.
- **Pagination** allows you to split your database data into **chunks** so that you don't need to fetch all your data at once.
- To ensure good performance for every query, Firestore requires an index, when creating them.

Where to go from here?

You covered a lot in this chapter. You learned how to read data from Firestore and listen for data changes in real-time. You also learned what queries are and how to use them only to fetch specific documents from a collection.

To learn more about those features, you can check out the official documentation.

WhatsUp app is now complete, but it has one big flaw. Anyone can read and write the data to the database. In "*Chapter 19: Securing data in Cloud Firestore*" you'll learn how to secure the data in the database and to restrict access to the data.

Chapter 19: Securing Data in Cloud Firestore

By Dean Djermanović

In the previous chapters, you implemented all of the features to the **WhatsUp** app except the most important one. You haven't implemented any security rules, which means anyone has access to your data.

In this chapter, you'll learn what security rules in Cloud Firestore are and how to add them to your database to make your data safe.

What are security rules?

To set up your own security system you'd need to set up your own server that acts as a proxy between your mobile clients and the remote database. That server would need to process all of the requests that are sent to the database and make sure that the client is accessing only the data that it is allowed to see.

Security rules handle security for you. You don't need to set up your own security system.

How security rules work?

Security rules check the requests that are coming to the database and lets through those that satisfy the criteria and reject the ones that don't. So for example, if your database only allows writing data to the authenticated client and an unauthenticated user tries to write something to the database, then that request would be rejected.

Any request that comes to the database involves the document. You're either trying to write the document to the database, read the document from the database, update

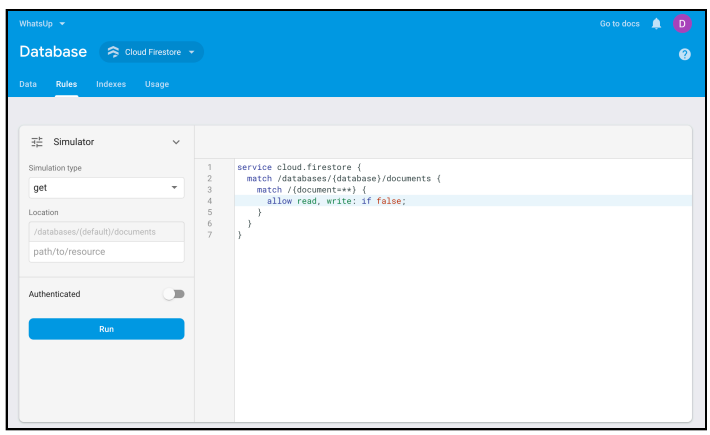
an existing document, or something similar. Cloud Firestore will take a look at the security rules that apply to the document that you request contains. It will then run a set of tests that you wrote to determine if the request is allowed or not.

In a nutshell, security rules consist of two things:

1. Specifying which documents you are securing.
2. What logic you're using to secure them.

Getting started

To see how the security rules look like open your Firestore database in the console. You'll see **Rules** tab at the top. Click on it. Then click on the **Simulator** icon to expand the simulator window:



This is where you can see your current logic for the security rules.

You'll take a deeper look into these rules next.

```
match /databases/{database}/documents
```

This line indicates the path that all the documents belong to. By default, all the documents belong to the `/databases/{database}/documents` path.

```
match /{document=**} {
      ...
}
```

This is where you set the rules for the specific document by specifying the path to

that document. `match` statement specifies the path to the document. `document=**` is a recursive wildcard which matches any document in the entire database. As of May 2019, there is version 2 of the Cloud Firestore security rules which changes the behavior of the recursive wildcards. Check the official documentation https://firebase.google.com/docs/firestore/security/get-started#security_rules_version_2 to see the differences in the behavior.

In your current database, you have a posts collection that contains a specific post. The path to the specific post looks like this:

```
/databases/{database}/documents/posts/{postId}
```

If you only want to write a security rule that applies to that specific path you'd do it like this:

```
match /databases/{database}/documents {
    match posts/{postId} {
      ...
    }
}
```

As you can see, Firestore lets you nest the paths.

The first *match* you see will almost always look like this:

```
match /databases/{database}/documents
```

`{database}` in curly brackets is a wildcard that matches any database name. You'll learn more about wildcards later.

Now, your **posts** collection could have a subcollection. You could add a separate rule for that subcollection like this:

```
match /databases/{database}/documents {
    match posts/{postId} {
      match subcollection/{documentId} {
          ...
      }
    }
}
```

There is one important thing to notice when looking at these nested rules. The rules you add to the top level `match posts/{postId}` **do not** apply to the inner *match* statements. Security rules in Cloud Firestore do not cascade.

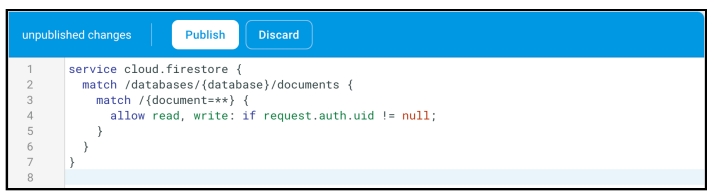
Adding security rules

Your **WhatsUp** app is still not safe. You'll add security rules next to restrict the access to data. Open Firestore database in the Firebase console and click on the **Rules** tab. Add the following rule:

```
service cloud.firestore {
  match /databases/{database}/documents {
    match /{document=**} {
      allow read, write: if request.auth.uid != null;
    }
  }
}
```

This rule allows *read* and *write* access on all documents for any signed in user. The *allow* expression specifies when the writing or reading the data is allowed.

When you're done with writing the rules to the editor click **Publish**:



Usually, it takes a minute for the security rules to make an effect, but sometimes it can take up to 10 minutes. Before you start testing make sure you wait a couple of minutes.

Testing the security rules

You have already seen a **Simulator** window in the Firebase console. This is a nice feature that Firestore provides that you can use to test your rules.

Click on the **Data** tab, open *posts* collection and copy the ID of one post. Go back to the **Rules** tab and click on the **Simulator** to open simulator window.

1. Under the *Simulation type* field leave it set to *get*.
2. Under the *Location* field enter the path to the specific post. In my case the path looks like this:

```
posts/0gbGvf23YT2xhRpcMxqt
```

The `0gbGvf23YT2xhRpcMxqt` is the ID of the post. Replace that value with the ID you

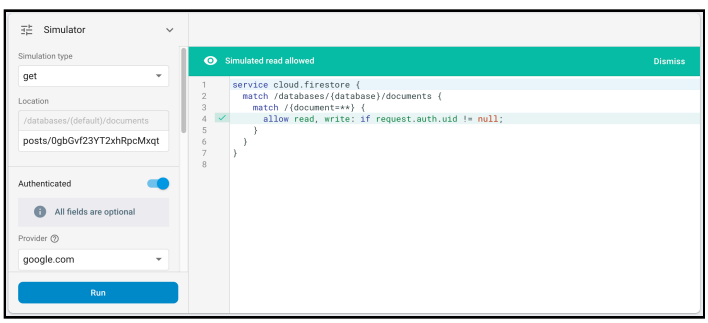
copied earlier.

Leave the *Authenticated* switch in the inactive state.

Now, click the **Run** button. You should see an error message:

Your request didn't succeed because you simulated unauthenticated request.

Now change the *Authenticated* switch to active state, leaving the authentication fields that appear with their default values, and click **Run** again:



Your request is now successful.

Key points

- **Security rules** check the requests that are coming to the database and lets through those that satisfy the criteria and reject the ones that don't.
- Security rules consist of two things: 1. Specifying which documents you are securing; 2. What logic you're using to secure them.
- In the *Rules* tab in the Firebase console, you can see your current security configuration.

- `match` statement specifies the path to the document.
- `allow` expression specifies when the writing or reading the data is allowed.
- Security rules in Cloud Firestore **do not** cascade.
- Cloud Firestore provides **Simulator** feature that you can use to test your rules.

Where to go from here?

In this chapter, you learned the basics of the Cloud Firestore's **Security rules**. Your **WhatsUp** app now only allows authenticated users to access the data.

To learn more about writing conditions, structuring and testing Security rules check out the official guidelines https://firebase.google.com/docs/firestore/security/rules-structure

Chapter 20: Cloud Storage

By Dean Djermanović

With Realtime Database and Cloud Firestore you saved data to the database. But what about files like photos, for example? While small pieces of data like posts, comments or users tend to be just a few kilobytes of text, photos are much larger. You don't want to store photos in a database because it should be fast; storing and retrieving photos would extend both the startup time and loading time when reading the database.

In this chapter, you'll learn how to store media files using another Firebase feature — **Cloud Storage**. You'll learn how to store an image to the cloud and how to get a URL to the image to display it in your app.

> **Note**: If you skipped previous chapters, you need to setup Firebase to follow along. Do the following steps:

1. Create a project in the Firebase console.
2. Enable Google sign-in.
3. Set security rules to the test mode to allow everyone **read** and **write** access.
4. Add **google-service.json** to both **starter** and **final** projects.

> **Note**: To see how to do the steps above, go back to "**Chapter 11: Firebase Overview**" and "**Chapter 12: Introduction to Firebase Realtime Database**".
>
> Be sure to use the starter project from **this chapter** by opening the **cloud-storage** folder and its **starter** project from the **projects** folder, rather than continuing with the final project you previously worked on. This chapter's starter project has a few things added to it, including placeholders for the code to add in this chapter.

Cloud Storage overview

Cloud Storage is another Firebase product used for saving files associated with your app. You can use it to store large documents or media files like images or videos.

Since Cloud Storage operates with large files, it's fundamental to provide robust network connection mechanisms and fallbacks. Cloud Storage handles all of the potential network problems for you. Depending on your connection, upload or download can take a while. If you lose the network connection in the middle of an upload or a download, the transfer will continue where it left off, after you reconnect to the network. This makes transferring your data very efficient.

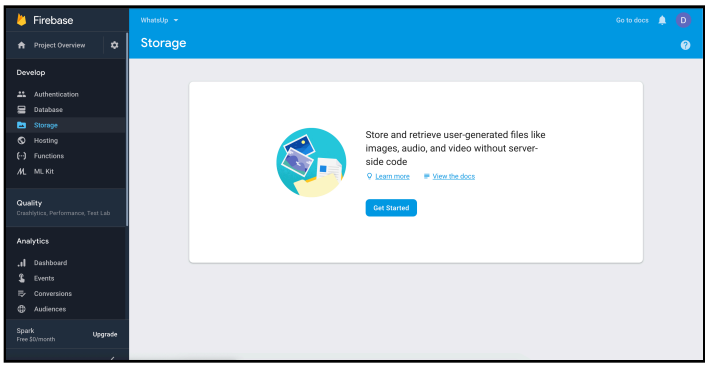
Cloud Storage also has security features that will safely store your files away from the public. You can decide who can write data to and read data from the storage.

The foundations of Cloud Storage are the folders that you create to organize your data. You can then decide which users can access which folders.

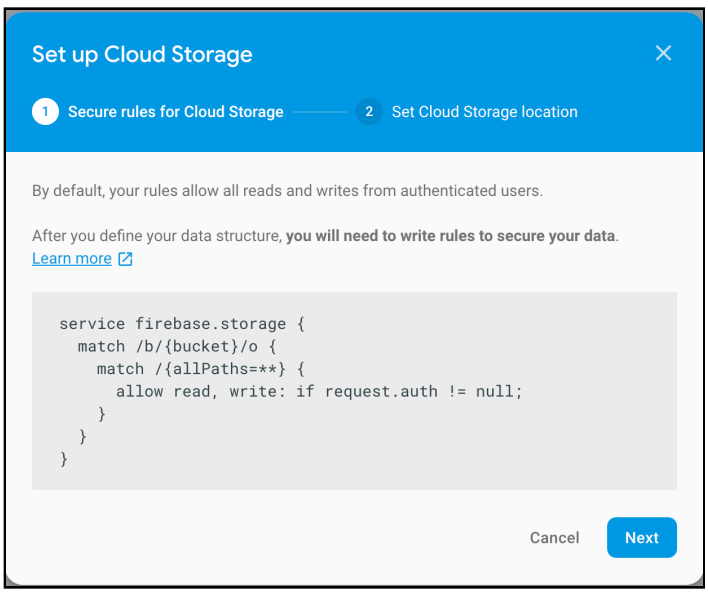
There's more theory you could learn, but for now, you'll use the Firebase console to set up Cloud Storage and you'll use the **WhatsUp** app to store images and to download and display them to users on the app screen.

Getting started

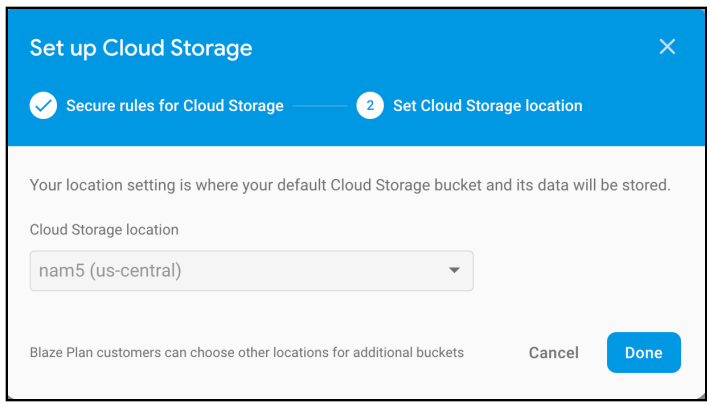
Open your **WhatsUp** app in the Firebase console. Select **Storage** from the **Develop** menu on the left. You'll see the following screen:



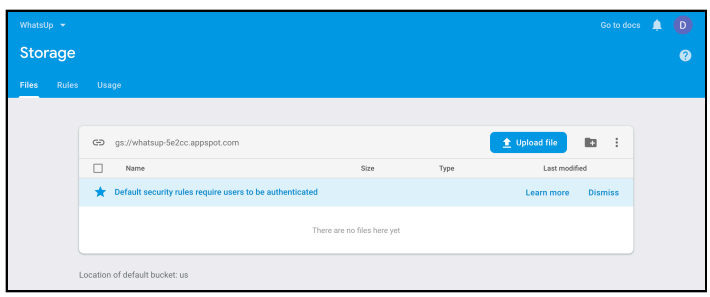
Click on the **Get Started** button to set up Cloud Storage. The setup window will pop up:



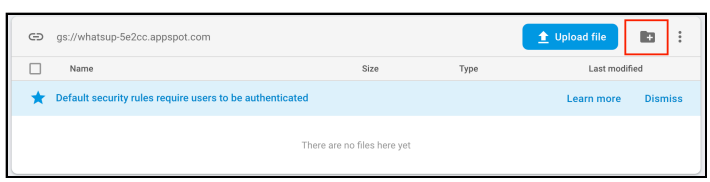
For your first step, you need to set up security rules for your storage. Leave the default rules that allow reads and writes from **authenticated users**. Click **Next**.



In the second step, you need to choose the location for your Cloud Storage. Since you're on the free **Spark** plan, you're not allowed to change this, so just click **Done**. Your Cloud Storage is now ready for use:



You can see that your storage is empty; you haven't added any files yet. Next, you're going to change this. Click on the little folder icon in the top-right corner to create a new folder.

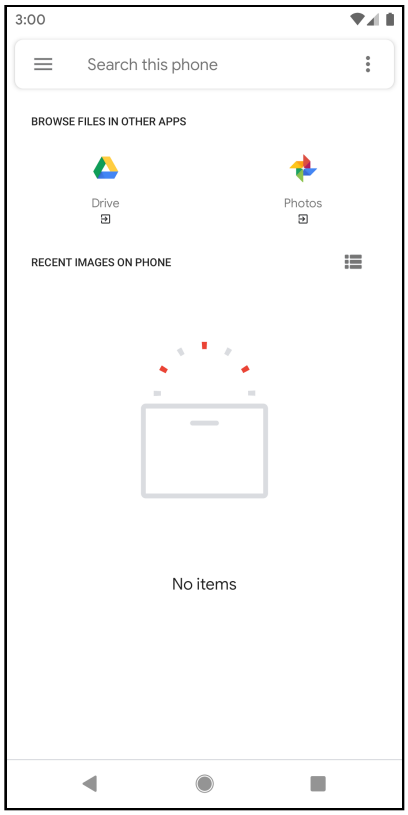


Name your folder **photos** and click **Add folder**. You'll use this folder to store the photos.

Cloud storage is now set up and ready for use. Next, you'll integrate it with your app.

Integrating Cloud Storage with your app

Open the **starter** project for this chapter then **build and run** the app. You'll see an empty screen with a floating action button in the bottom-right corner. When you click on the button, a File Explorer on your device will open:



This is where you'll choose the image that you want to store to the Cloud Storage. If you select an image now, nothing will happen, but you'll change that soon.

> **Note**: File Explorers may vary in appearance depending on your Android version, phone manufacturer and whether you've installed third-party file manager applications.

Next, you'll implement the logic for uploading the image. When a user selects an image, you'll upload it to Cloud Storage. Then you'll get a URL of that image which you'll use to display the image on the home screen.

Open **CloudStorageManager.kt** and replace `uploadPhoto()` with the following:

```
fun uploadPhoto(selectedImageUri: Uri, onSuccessAction: (String)
-> Unit) {
  // 1
  val photosReference =
firebaseStorage.getReference(PHOTOS_REFERENCE)

  // 2
  selectedImageUri.lastPathSegment?.let { segment ->
    // 3
    val photoReference = photosReference.child(segment)

    // 4
    photoReference.putFile(selectedImageUri)
        // 5
        .continueWithTask(Continuation<UploadTask.TaskSnapshot,
Task<Uri>> { task ->
          val exception = task.exception
            // 6
          if (!task.isSuccessful && exception != null) {
            throw exception
          }
          return@Continuation photoReference.downloadUrl
        })
        // 7
        .addOnCompleteListener { task ->
            // 8
          if (task.isSuccessful) {
            val downloadUri = task.result
            onSuccessAction(downloadUri.toString())
          }
        }
  }
}
```

1. First, you get a reference to the **photos** folder that you created earlier, by calling `getReference` on `firebaseStorage`. This is where you'll upload your photo.
2. You'll use `lastPathSegment` of the image URI as the name of the file that you're going to save.
3. Get a reference that points to the location to which you'll store the image.
4. To store the image to the reference, call `putFile()` on it and pass in the content URI of the image. This method stores the image asynchronously and returns an instance of `UploadTask` that you'll use to track the upload progress.

5. Next, call `continueWithTask()` on `UploadTask` to get the download URL of the image you're uploading when the image upload finishes.
6. If the `Task` is successful, you return `photoReference.downloadUrl` which returns the `Task<Uri>`. Otherwise, you throw an exception.
7. Finally, attach an `OnCompleteListener` so you'll receive a notification when the upload finishes.
8. If the task is successful, you get the download URL by calling `task.result`. You pass that result to `onSuccessAction()`.

Now, open **HomeActivity.kt**, navigate to `onActivityResult()` and replace it with following code:

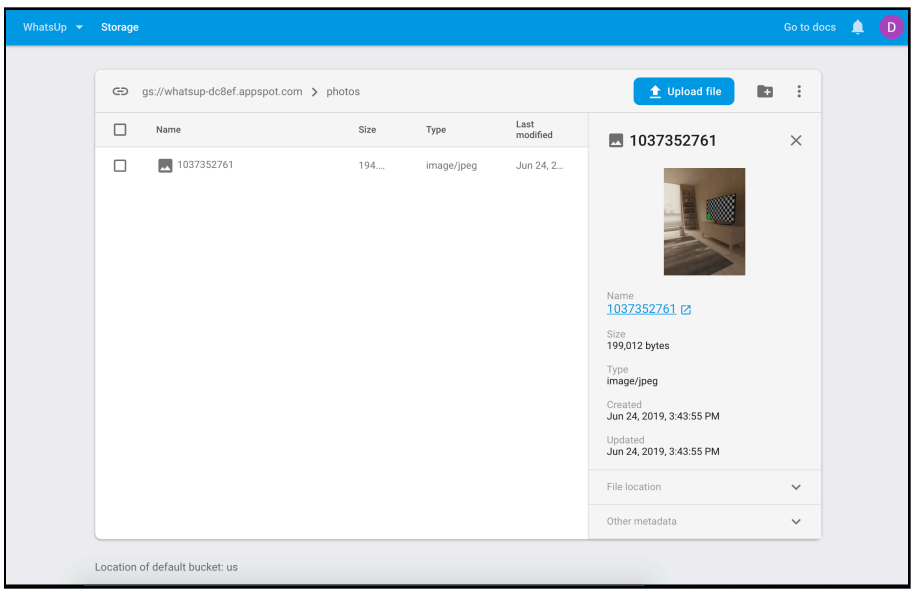
```
override fun onActivityResult(requestCode: Int, resultCode: Int,
data: Intent?) {
  super.onActivityResult(requestCode, resultCode, data)
  if (requestCode == CHOOSE_IMAGE_REQUEST_CODE && resultCode ==
Activity.RESULT_OK) {
    val selectedImageUri = data?.data ?: return

cloudStorageManager.uploadPhoto(selectedImageUri, ::onPhotoUploa
dSuccess)
  }
}
```

Here, you get the URI of the selected image and pass it to `uploadPhoto()` in the `cloudStorageManager`.

Build and run your app. Now, when you select an image from the File Explorer, it will upload to Cloud Storage.

When the upload finishes, you'll display the image on the home screen:

Go to Firebase console and open your app's storage. You'll see the photo you uploaded in the **photos** folder:



Awesome! You've successfully connected your app to Firebase Cloud Storage!

Key points

- **Cloud Storage** is a Firebase product used for saving files associated with your app.
- If you lose a network connection in the middle of the upload or a download, the transfer will continue where it left off after you reconnect to the network.
- Cloud Storage also has **security features** that will make your files secure.
- The foundations of the Cloud Storage are **folders** that you can create to organize your data.

Where to go from here?

This chapter was just an introduction to Cloud Storage to show you how to store media files to the cloud. You learned how to set up Cloud Storage and how to upload and download files from it. Cloud Storage has many other features. To learn more about them visit the official guidelines.

Conclusion

Congratulations! After a long journey, you have learned a lot of concepts about persistence in Android. You can use the API and tools provided by the Android SDK or the Room library provided with the Google Architecture Components. If your app needs to manage persistence, along with security and offline capability, you can now have the fundamentals of using the Firebase suite.

And, remember, if you want to further your understanding of Kotlin and Android app development after working through *Saving Data on Android*, we suggest you read the *Android Apprentice* and *Kotlin Apprentice* available on our online store:

- https://store.raywenderlich.com/products/android-apprentice
- https://store.raywenderlich.com/products/kotlin-apprentice

If you have any questions or comments as you work through this book, please stop by our forums at http://forums.raywenderlich.com and look for the particular forum category for this book.

Thank you again for purchasing this book. Your continued support is what makes the tutorials, books, videos, conferences and other things we do at raywenderlich.com possible, and we truly appreciate it!

Wishing you all the best in your continued Kotlin and saving data on Android.

–The *Saving Data on Android* book team

Saving Data on Android!

The persistence of data is always been a fundamental part of any application. Saving data locally or remotely along with the modern technics for synchronization, allow your app to be always up to date reactively presenting fresh data.

Who This Book Is For

This book is for intermediate Kotlin or Android developers who want to know how to persist data using the standard Android APIs, the Room architecture component or what Google Firebase can offer.

Topics Covered in Saving Data on Android:

- **Persistence with Android SDK:** Learn how to manage files, SharedPreferences or SQLite databases using the APIs the Android platform has to offer by default.
- **Using Room:** Room is one of the most important Google Architecture Component. It allows managing entities and relations using classic Object-Oriented principles. In this book, you'll learn everything you need to store data and run queries on top of it.
- **Manage relations with Room:** A database has entities and relations. With this book, you'll learn how to design your DB and how to manage relations eagerly and lazily.
- **Managing and testing Migrations:** Every application evolves in time. Here you'll learn how to manage migrations with Room and how to test them properly.
- **Firebase Realtime Database:** If you want to manage data locally and in remote, you can use the tools provided by Google through the Firebase platform. With Firebase Realtime Database you can manage and keep in sync data in a very simple and efficient way.
- **Cloud Storage:** Another option provided by Google is the Cloud Storage which allows you to leverage all the power of Google infrastructure to manage your data and run expensive queries.

One thing you can count on: after reading this book, you'll be prepared to use the right solution to manage persistence in your Android application.

About the Tutorial Team

The Tutorial Team is a group of app developers and authors who write tutorials at the popular website **raywenderlich.com.** We take pride in making sure each tutorial we write holds to the highest standards of quality. We want our tutorials to be well written, easy to follow, and fun.

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