LEARNING CORE DATA FOR iOS WITH SWIFT

A Hands-On Guide to Building Core Data Applications

TIM ROADLEY

Learning Core Data for iOS with Swift

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Tim Roadley

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❖

The more I learn, the more I learn I need to learn more.

I dedicate this book to my wonderful wife, Tracey, who has given up many nights and weekends with me to help make this book a reality. Finally, we can sit back and relax together again! I'm sure Tyler & Taliah will let us....

❖

Contents at a Glance

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Acknowledgments

A resounding thank-you first goes out to Trina MacDonald for giving me the opportunity to write this book originally and again for Swift. Her guidance throughout the whole process has been invaluable, as has the assistance of Michael Thurston and the technical reviews from Ash Furrow, Carl Brown, and Niklas Saers. You guys saved this book from a few bugs that crept through on those late nights and also provided some great insight and coding technique suggestions with Swift.

About the Author

Tim Roadley is a family man with strong technical focus in career and personal goals. From managing IT infrastructure to developing apps and writing books, if it's complex, he's in his element. He currently works for TKH Group, primarily focused on system integration software used by large clients such as Westfield. Prior roles include implementations of various IT systems at government departments and major banks, most notably the implementation of a payments switch that drives the RediATM network in Australia. In his downtime, he enjoys spending time with his wonderful wife, Tracey (when he can pull her away from her Thermomix), and two lovely children, Tyler and Taliah.

Preface

Every day, millions of Apple devices run applications, or apps, that rely on Core Data. This has led to a mature, stable, and incredibly fast platform for apps to access their data. Core Data itself is not a database. In fact, Core Data is a framework that, among other things, automates how you interact with a database. Instead of writing SQL code, you work with managed objects. All the associated SQL you would otherwise have to write yourself is generated automatically. This leaves you with all the benefits of a relational database without the headache of writing, testing, and optimizing SQL queries within your code. The SQL code generated automatically "under the hood" is the product of years of refinement and optimization by Apple's masterful engineers. Using Core Data not only speeds up your own application development time, it also significantly reduces the amount of code you have to write.

Here are some notable features of Core Data:

- Change management (undo and redo)
- Relationships
- Data model versioning and migration
- Efficient fetching (through batching and faulting)
- Efficient filtering (through predicates)
- Data consistency and validation

With this book, you are introduced to Core Data features and best practices. As you progress through the chapters, you also build a fully functional Core Data iPhone app from scratch. Each key piece of information is explained in succinct detail so you can apply what you've learned straight away. The sample application built throughout this book has been especially designed to demonstrate as many aspects of Core Data as possible. At the same time it is a completely real-world application available on the App Store today. This should make it easier to absorb concepts as you relate them to real-life scenarios.

The arrival of iOS 9 offers major improvements in the speed, reliability, and simplicity of Core Data integration with iCloud and introduction of CloudKit. I encourage anyone who has previously given up on this technology to give it another go, because you will be pleasantly surprised.

If you have feedback, bug fixes, corrections, or anything else you would like to contribute to a future edition, please contact me at timroadley@icloud.com. Finally, thank you for taking an interest in this book. If you like it, please tweet or post to Facebook about it! I have put a lot of effort into meticulously crafting it, so I truly hope it helps you on your way to mastering this brilliant technology.

—Tim Roadley (*@TimRoadley*), September 2015

Who Is This Book For?

This book is aimed at Swift programmers who want to learn how to efficiently manage data in their iOS apps. Prior experience with databases may help you pick up some topics faster, yet is not essential knowledge. As old habits die hard, some SQL programmers may find it more difficult to wrap their heads around some topics.

Beyond the basics, the closing chapters explain how to build a CloudKit solution for sharing data with multiple users. This is something previously impossible with old iCloud technology.

Whatever your scenario, don't worry. Every step is explained and demonstrated clearly.

What You'll Need

As a Swift programmer, it is expected that you already have a reasonably modern Mac or MacBook running Xcode 7 or above. You should also be familiar with Xcode and have an iOS device to test with. This is particularly true once you reach Chapter 10, "Performance," which is all about device performance.

Swift is new to everyone, so it's likely you'll encounter code and techniques you haven't seen before. Fortunately, you'll be guided step-by-step through the entire process of creating a real-world Swift Core Data application for iOS, so your experience with Swift will grow throughout.

The following resources are suggested as an accompaniment to this book:

- *Swift,* by Apple (search iBooks Store within the iBooks App)
- *Learning Swift Programming*, by Jacob Schatz (search amazon.com)

How This Book Is Organized

This book takes you through the entire process of building the **Groceries** application, which is available from the App Store today. The Groceries implementation throughout the book demonstrates Core Data integration with iCloud and CloudKit. Each chapter in this book builds on the last, so you're introduced to topics in the order you need to implement them. Along the way you build helper classes that simplify redeployment of what you've learned into your own applications. In fact, the exercises at the end of the iCloud and CloudKit chapters guide you through this redeployment of the helper classes into a brand new app. Using this as an example you can integrate Core Data, iCloud, and CloudKit into your own applications in no time!

Here's a brief summary of what you find in each chapter:

- **Chapter 1, "Your First Core Data Application"**—The groundwork is laid as the fundamental concepts of Core Data are introduced. You learn what Core Data is, and just as importantly, what it isn't. In addition, Core Data integration with an existing application is demonstrated as the `CDHelper` class is implemented.
- **Chapter 2, "Managed Object Model Basics"**—Data models are introduced as parallels are drawn between traditional database schema design and Core Data. You learn how to configure a basic managed object model as entities and attributes are discussed, along with accompanying advice on choosing the right data types. Inserting, fetching, filtering, sorting, and deleting managed objects are also covered and followed up with an introduction to fetch request templates.
- **Chapter 3, "Managed Object Model Migration"**—Experience lightweight migration, default migration, and using a migration manager to display migration progress. You learn how to make an informed decision when deciding between migration options for your own applications and become comfortable with the model-versioning capabilities of Core Data.
- **Chapter 4, "Managed Object Model Expansion"**—The true power of a relational data model is unlocked as different types of relationships are explained and added to Groceries. Other model features such as abstract and parent entities are also covered, along with techniques for dealing with data validation errors.
- **Chapter 5, "Table Views"**—The application really comes to life as Core Data is used to drive memory-efficient and highly performing table views with a fetched results controller. Of course, most of the generic legwork is put into a reusable table view controller subclass called `CDTableViewController`. By dropping this class into your own applications, you can easily deploy Core Data–driven table views yourself.
- **Chapter 6, "Views"**—Working with managed objects takes a front seat as you're shown how to pass them around the application. Objects selected on a table view are passed to a second view, ready for editing. The editing interface is added to Groceries, demonstrating how to work with objects and then save them back to the persistent store.
- **Chapter 7, "Picker Views"**—As a nice touch, Core Data–driven picker views are added to the editing views. Picker views allow the user to quickly assign existing items to a unit of measurement, home location, or shop location. A special reusable text field subclass called `CDPickerTextField` is introduced, which replaces the keyboard with a Core Data picker view whenever an associated text field is tapped.
- **Chapter 8, "Preloading Data"**—Techniques for generating a persistent store full of default data from XML are explained and demonstrated in this chapter as the generic `CDImporter` helper class is introduced. Once you have a persistent store to include with a shipping application, you then see how to determine whether a default data import is required or even desired by the user.

- **Chapter 9, "Deep Copy"**—A highly flexible and fine-grained alternative to `migratePersistentStore`, deep copy enables you to copy objects and relationships from selected entities between persistent stores. In this chapter, the `CDImporter` helper class is enhanced with the deep copy capability.
- **Chapter 10, "Performance"**—Gain experience with Instruments as you identify and eliminate performance issues caused by the common pitfalls of a Core Data application. The camera functionality is introduced to highlight these issues and demonstrates just how important good model design is to a well-performing application.
- **Chapter 11, "Background Processing"**—Top-notch performance requires intensive tasks be offloaded to a background thread. You learn just how easy it is to run processes in the background as the example of photo thumbnail generation is added with a generic helper class called `CDThumbnailer`. You also learn how to keep memory usage low with another helper class, called `CDFaulter`.
- **Chapter 12, "Search"**—This chapter shows you how to integrate a `UISearchController` with Core Data as you implement efficient search in `CDTableViewController`.
- **Chapter 13, "iCloud"**—Enjoy the easiest, most reliable Core Data integration with iCloud yet. You learn how to handle multiple accounts and varying preferences on using iCloud without missing a beat.
- **Chapter 14, "Taming iCloud"**—Take iCloud integration to the next level with entity-level seeding and unique object de-duplication. This chapter shows you how to emulate first-time iCloud use by resetting ubiquitous content globally, the right way.
- **Chapter 15, "CloudKit Sync: Uploading Objects"**—This chapter shows you how to leverage a public CloudKit database to keep a small data set synchronized across the devices of a group of iCloud users. Part 1 lays the foundation for synchronization as the capability to automatically upload new `NSManagedObjects` is added.
- **Chapter 16, "CloudKit Sync: Downloading Changes and Handling Deletions"**—The synchronization implementation is finalized as deletion support and the capability to download changed CloudKit records are added.
- **Appendix A, "Preparing the Groceries Application"**—Every (non–Core Data) step involved in preparing the starting-point application for Chapter 1 is documented here for completeness.
- **Appendix B, "Finalizing the Groceries Application"**—Every (non–Core Data) step involved in finalizing the application for the App Store is documented here for completeness.

Getting the Sample Code

The sample code built throughout this book is available for download from timroadley.com. Links are given in each chapter, or you can use Table P.1 as a reference, which is arranged in the order of implementation.

Table P.1 **Groceries Code**

Final Code	Link
Appendix A	http://timroadley.com/LCDwS/Groceries-AfterAppendixA.zip
Chapter 1	http://timroadley.com/LCDwS/Groceries-AfterChapter01.zip
Chapter 2	http://timroadley.com/LCDwS/Groceries-AfterChapter02.zip
Chapter 3	http://timroadley.com/LCDwS/Groceries-AfterChapter03.zip
Chapter 4	http://timroadley.com/LCDwS/Groceries-AfterChapter04.zip
Chapter 5	http://timroadley.com/LCDwS/Groceries-AfterChapter05.zip
Chapter 6	http://timroadley.com/LCDwS/Groceries-AfterChapter06.zip
Chapter 7	http://timroadley.com/LCDwS/Groceries-AfterChapter07.zip
Chapter 8	http://timroadley.com/LCDwS/Groceries-AfterChapter08.zip
Chapter 9	http://timroadley.com/LCDwS/Groceries-AfterChapter09.zip
Chapter 10	http://timroadley.com/LCDwS/Groceries-AfterChapter10.zip
Chapter 11	http://timroadley.com/LCDwS/Groceries-AfterChapter11.zip
Chapter 12	http://timroadley.com/LCDwS/Groceries-AfterChapter12.zip
Chapter 13	http://timroadley.com/LCDwS/Groceries-AfterChapter13.zip
Chapter 14	http://timroadley.com/LCDwS/Groceries-AfterChapter14.zip
Chapter 14 “Mini-project”	http://timroadley.com/LCDwS/EZiCloud.zip
Chapter 15	http://timroadley.com/LCDwS/Groceries-AfterChapter15.zip
Chapter 16	http://timroadley.com/LCDwS/Groceries-AfterChapter16.zip
Chapter 16 “Mini-project”	http://timroadley.com/LCDwS/EZCloudKit.zip
Appendix B “Final Project”	http://timroadley.com/LCDwS/Groceries-AfterAppendixB.zip
Helper classes, for your own projects, with CloudKit support	http://timroadley.com/LCDwS/Generic%20Core%20Data%20 Classes.zip

Conventions Used in This Book

Code Breaks

Occasionally lines of code in the chapters are too long to fit on the printed page. Where that occurs, a code-continuation arrow (➥) has been used to mark the continuation. For example:

```
let _localStore = self.coordinator.addPersistentStoreWithType(NSSQLiteStoreType,
➥configuration: nil, URL: self.localStoreURL, options: options, error: &error)
```

Sample Code Updates

When it's time to apply what you've learned to the sample application, the instructions are preceded by the words "Update Groceries as follows". You should apply the subsequent steps to the sample application as instructed. The instructions make heavy use of bold formatting to clarify the interface elements you can expect to interact with. For example:

Update Groceries as follows to link to the Core Data Framework:

1. Select the **Groceries Target**, as shown in Figure 1.2.
2. Click the + found in the **Linked Frameworks and Libraries** section of the **General** tab and then link to the **CoreData.framework**, as shown in Figure 1.2.

We Want to Hear from You!

As the reader of this book, you are our most important critic and commentator. We value your opinion and want to know what we're doing right, what we could do better, what areas you'd like to see us publish in, and any other words of wisdom you're willing to pass our way.

You can email or write me directly to let me know what you did or didn't like about this book—as well as what we can do to make our books stronger.

Please note that I cannot help you with technical problems related to the topic of this book, and that due to the high volume of mail I receive, I might not be able to reply to every message.

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Managed Object Model Migration

Anyone who has never made a mistake has never tried anything new.

Albert Einstein

In Chapter 2, "Managed Object Model Basics," the fundamentals of managed object models were introduced, yet you were constrained to just one entity and a few attributes. The next logical step is to add to the model; however, this requires a number of preliminary steps to prevent errors caused by these changes. This chapter shows how to add model versions and model mappings, and it demonstrates different migration techniques you can choose when upgrading a model.

Changing a Managed Object Model

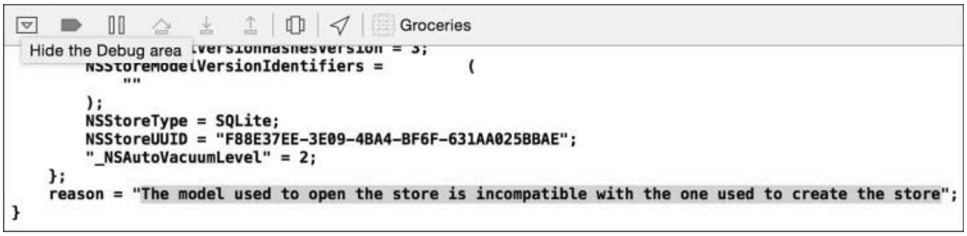
As an application evolves, its managed object model probably needs to change, too. Simple changes, such as attribute defaults, validation rules, and fetch request templates can be modified without consequence. Other more structural changes require that persistent stores be migrated to new model versions. If a persistent store doesn't have the appropriate mappings and settings required to migrate data from one version to the next, the application throws a "store is incompatible" error.

Note

To continue building the sample application, you need to have added the previous chapter's code to Groceries. Alternatively, you may download, unzip, and use the project up to this point from http://www.timroadley.com/LCDwS/Groceries-AfterChapter02.zip. Any time you start using an Xcode project from a ZIP file, it's good practice to hold down **option** and click **Product** > **Clean Build Folder**. This practice ensures there's no residual cache from previous projects using the same name. It is recommended that you use the iOS Simulator when following this chapter so you can inspect the contents of the SQLite database files easily.

Update Groceries as follows to generate a "store is incompatible" error:

1. Run Groceries once to ensure the existing model has been used to create the persistent store. You should see the file system location of the store printed to the console log.
2. Select **Model.xcdatamodeld** in Xcode.
3. Add a new entity and rename it to **Measurement**.
4. Select the **Measurement** entity and add an attribute called **abc**. Set its type to **String**.
5. Rerun the application and examine the console log. You should now have generated arguably one of the most common Core Data errors, as shown in Figure 3.1. If this error has not appeared, delete the application and then click **Product** > **Clean** and retry from step 1.



```
        NSStoreModelVersionIdentifiers =         (
            ""
        );
        NSStoreType = SQLite;
        NSStoreUUID = "F88E37EE-3E09-4BA4-BF6F-631AA025BBAE";
        "_NSAutoVacuumLevel" = 2;
    };
    reason = "The model used to open the store is incompatible with the one used to create the store";
}
```

Figure 3.1 Store incompatibility

This error isn't an issue when an application is in its initial development phase. To get past it, you can just delete the application from the device and run it again from Xcode. When the application is run for the first time after being deleted, the persistent store is created based on the latest model. This makes the store compatible with the model, so the application won't throw the error anymore. *However,* it won't have any old data in it. As such, this scenario is unacceptable for any application already available on the App Store. There are a few approaches to migrating existing persistent stores, and the migration path you choose is driven by the complexity of the changes and whether you're using iCloud. Whatever you do, you first need to become familiar with model versioning.

Update Groceries as follows to revert to the original model:

1. Select **Model.xcdatamodeld**.
2. Delete the **Measurement** entity.
3. Rerun the application, which now should not throw an error.

Adding a Model Version

To avoid the error shown in Figure 3.1, you need to create a new model version *before* making changes to the model. Ongoing, you should not remove old versions of a model. Old model versions are needed to help migrate incompatible persistent stores to the current model version. If there are no existing persistent stores on customer devices, you can ignore model versioning until your application is on the App Store.

Update Groceries as follows to add a model version:

1. Select **Model.xcdatamodeld**.
2. Click **Editor** > **Add Model Version...**.
3. Click **Finish** to accept **Model 2** as the version name.

You should now have two model versions, as shown in Figure 3.2.

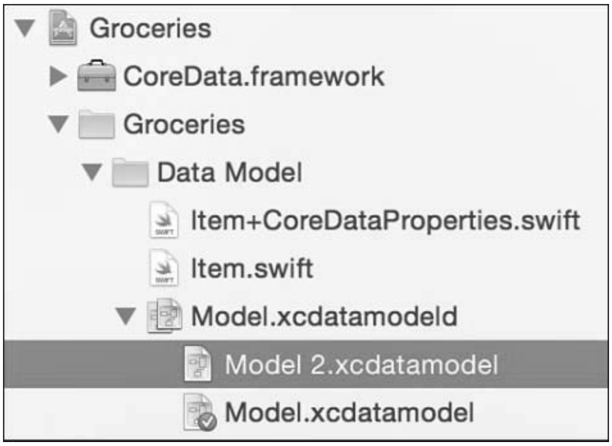


Figure 3.2 Multiple model versions

The new model **Model 2.xcdatamodel** starts out as a replica of **Model.xcdatamodel**. This unfortunately makes it easy to modify the wrong version unintentionally. Before you edit a model, you should triple-check you have selected the correct one. You may want to get into the habit of taking a snapshot, committing to source control, or even backing up the whole project prior to editing a model. Note that the check mark in the green circle represents the current model, which is the model version used at runtime.

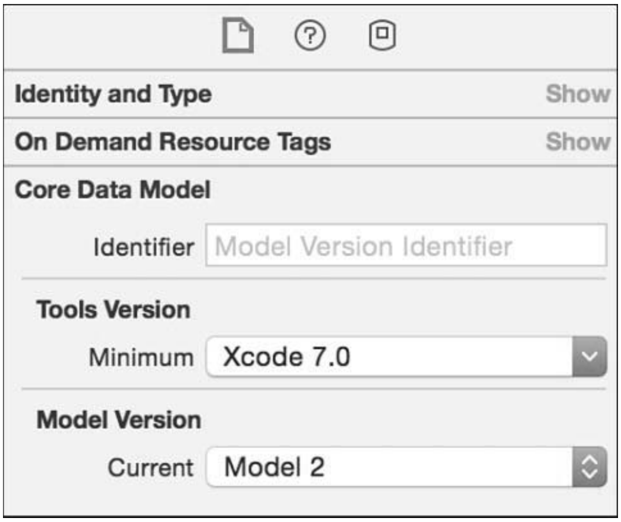
Update Groceries as follows to reintroduce the **Measurement** entity:

1. Optionally take a snapshot or back up the Groceries project.
2. Select **Model 2.xcdatamodel**.
3. Add a new entity and rename it to **Measurement**.
4. Select the **Measurement** entity and add an attribute called **abc**. Set its type to **String**.

After you add the new model version, you still need to set it as the current version before it is used by the application.

Update Groceries as follows to change the current model version:

1. Select **Model.xcdatamodeld** (not Model.xcdatamodel).
2. Click **View** > **Utilities** > **Show File Inspector** (or press **Option**+⌘+**1**).
3. Set the **Current Model Version** to **Model 2**, as shown at the bottom of Figure 3.3.



Identity and Type — Show
On Demand Resource Tags — Show
Core Data Model
Identifier: Model Version Identifier
Tools Version
Minimum: Xcode 7.0
Model Version
Current: Model 2

Figure 3.3 Setting the current model

Before you can successfully launch the application, you need to configure migration options to tell Core Data how to migrate. Feel free to launch it again to generate the incompatible store error in the meantime.

Lightweight Migration

Whenever a new model is set as the current version, existing persistent stores must be migrated to use them. This is because the persistent store coordinator tries to use the current model to open the existing store, which fails if the store was created using a previous version of the model. The process of store migration can be handled automatically by passing an options dictionary to a persistent store coordinator when a store is added:

- When the `NSMigratePersistentStoresAutomaticallyOption` is true (`1`) and passed to a persistent store coordinator, Core Data automatically attempts to migrate incompatible persistent stores to the current model.
- When the `NSInferMappingModelAutomaticallyOption` is true (`1`) and passed to a persistent store coordinator, Core Data automatically attempts to infer a best guess at what attributes from the *source* model entities should end up as attributes in the *destination* model entities.

Using those persistent store coordinator options together is called **lightweight migration** and is demonstrated in bold in Listing 3.1. These options are set in an updated `localStore` variable of `CDHelper.swift`. Note that if you're using iCloud, this is your only choice for migration.

Listing 3.1 **The Local Store (`CDHelper.swift localStore`)**

```
// MARK: - STORE
lazy var localStore: NSPersistentStore? = {
    let options:[NSObject:AnyObject] = [NSSQLitePragmasOption:["journal_
➥ mode":"DELETE"],
                                         NSMigratePersistentStoresAutomaticallyOption:1,
                                         NSInferMappingModelAutomaticallyOption:1]
    var _localStore:NSPersistentStore?
    do {
        _localStore = try self.coordinator.addPersistentStoreWithType
➥ (NSSQLiteStoreType, configuration: nil, URL: self.localStoreURL, options: options)
        return _localStore
    } catch {
        return nil
    }
}()
```

Update Groceries as follows to enable lightweight migration:

1. Replace the existing `localStore` variable code in `CDHelper.swift` with the code from Listing 3.1. The key change to be aware of is the introduction of the bold code.
2. Rerun the application, which should not throw an error.

From now on, any time you set a new model as the current version and lightweight migration is enabled, the migration should occur transparently.

Before other migration types can be demonstrated, some test data needs to be generated. Listing 3.2 contains code that generates managed objects based on the **Measurement** entity. You may notice that this code blocks the user interface until it finishes because the context runs on the main thread. More appropriate ways to insert test data in the background are demonstrated later in the book.

Listing 3.2 **Inserting Test Measurement Data (`AppDelegate.swift demo`)**

```
func demo () {
    let context = CDHelper.shared.context
    for i in 0...50000 {
        if let newMeasurement = NSEntityDescription.insertNewObjectForEntityForName
➥ ("Measurement", inManagedObjectContext: context) as? Measurement {

            newMeasurement.abc = "-->> LOTS OF TEST DATA x\(i)"
            print("Inserted \(newMeasurement.abc!)")
        }
    }
    CDHelper.saveSharedContext()
}
```

Update Groceries as follows to generate test data:

1. Create an `NSManagedObject` subclass of the **Measurement** entity. As discussed in Chapter 2, this is achieved by first selecting the entity and then clicking **Editor** > **Create NSManagedObject Subclass...** and following the prompts. When it comes time to save the class file, don't forget to save the file in the **Data Model** group and check the **Groceries** target.
2. Replace the `demo` function in `AppDelegate.swift` with the code from Listing 3.2.
3. Run the application once. This inserts a lot of test data into the persistent store, which you can monitor by examining the console log. This may take a little while, depending on the speed of your machine. It's important to have a fair amount of data in the persistent store to demonstrate the speed of migrations later. Note that the table view still remains blank because it has not yet been configured to display anything.

The next step is to reconfigure the `demo` function to show some of what's in the persistent store. The code shown in Listing 3.3 fetches a small sample of `Measurement` data. Notice that a new option is included that limits fetched results to 50. This is great for limiting how many results are fetched from large data sets, and it is even more powerful when mixed with sorting to generate a Top-50, for example.

Listing 3.3 **Fetching Test Measurement Data (`AppDelegate.swift demo`)**

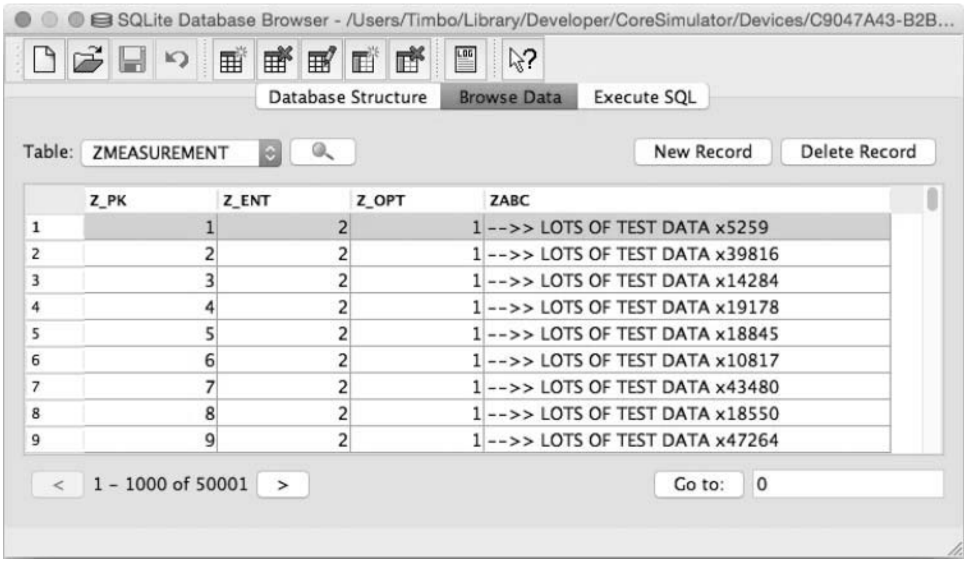
```
func demo () {
    let context = CDHelper.shared.context
    let request = NSFetchRequest(entityName: "Measurement")
    request.fetchLimit = 50

    do {
        if let measurements = try context.executeFetchRequest(request) as?
➥ [Measurement] {
            for measurement in measurements {
                print("Fetched Measurement Object \(measurement.abc!)")
            }
        }
    } catch {
        print("ERROR executing a fetch request: \(error)")
    }
}
```

Update Groceries as follows to print a sample of the store contents to the console log:

1. Replace the `demo` function in `AppDelegate.swift` with the code from Listing 3.3.
2. Run the application. The console log should show 50 rows of seemingly random measurement objects.
3. Examine the contents of the `LocalStore.sqlite` file using **SQLite Database Browser**, as explained previously in Chapter 2. Figure 3.4 shows the expected results when viewing the ZMEASUREMENT table, which is the data for the Measurement entity.

Close the SQLite Database Browser before continuing.



	Z_PK	Z_ENT	Z_OPT	ZABC
1	1	2	1	-->> LOTS OF TEST DATA x5259
2	2	2	1	-->> LOTS OF TEST DATA x39816
3	3	2	1	-->> LOTS OF TEST DATA x14284
4	4	2	1	-->> LOTS OF TEST DATA x19178
5	5	2	1	-->> LOTS OF TEST DATA x18845
6	6	2	1	-->> LOTS OF TEST DATA x10817
7	7	2	1	-->> LOTS OF TEST DATA x43480
8	8	2	1	-->> LOTS OF TEST DATA x18550
9	9	2	1	-->> LOTS OF TEST DATA x47264

Figure 3.4 Test data ready for the next parts of this chapter

Default Migration

Sometimes, you need more control than what lightweight migration offers. Let's say, for instance, you want to replace the **Measurement** entity with another entity called **Amount**. You also want the **abc** attribute from the **Measurement** entity to end up as an **xyz** attribute in the **Amount** entity. Any existing **abc** data should also be migrated to the **xyz** attribute. To achieve these requirements, you need to create a model mapping to manually specify what maps to where.

When the persistent store option `NSInferMappingModelAutomaticallyOption` is true (`1`), Core Data still checks to see whether there are any model-mapping files it should use before trying to infer automatically. It is recommended that you disable this setting while you're testing a mapping model. This way, you can be certain that the mapping model is being used and is functioning correctly.

Update Groceries as follows to disable automatic model mapping:

1. Set the `NSInferMappingModelAutomaticallyOption` option in the `localStore` variable of `CDHelper.swift` to false by changing the `1` to a `0`.

Update Groceries as follows to add a new model in preparation for the migration from the **Measurement** entity to the **Amount** entity:

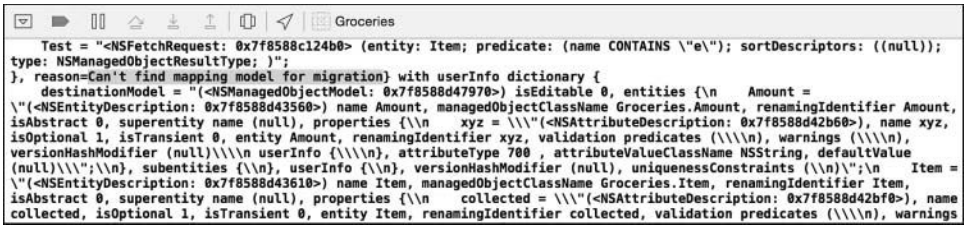
1. Optionally take a snapshot or back up the project.
2. Add a new model version called **Model 3** based on **Model 2** (Editor > Add Model Version...).
3. Set **Model 3** as the current model version.
4. Select **Model 3.xcdatamodel**.
5. Delete the **Measurement** entity.
6. Add a new entity called **Amount** with a **String** attribute called **xyz**.
7. Create an `NSManagedObject` subclass of the **Amount** entity. When it comes time to save the class file, don't forget to save the file in the **Data Model** group and check the **Groceries** target.
8. Replace the `demo` function of `AppDelegate.swift` with the code from Listing 3.4. Similar to the code being replaced, this code simply fetches a small sample of **Amount** data instead of **Measurement** data.
9. Run the application, which should throw the "Can't find mapping model for migration" error shown in Figure 3.5.

Listing 3.4 **Fetching Test Amount Data (`AppDelegate.swift demo`)**

```
func demo () {
    let context = CDHelper.shared.context
    let request = NSFetchRequest(entityName: "Amount")
    request.fetchLimit = 50

    do {
        if let amounts = try context.executeFetchRequest(request) as? [Amount] {
            for amount in amounts {
                print("Fetched Amount Object \(amount.xyz!)")
            }
        }
    } catch {
        print("ERROR executing a fetch request: \(error)")
    }
}
```

To resolve the error shown in Figure 3.5, you need to create a mapping model that shows where attributes map. Specifically, the requirement is to map the old Measurement **abc** attribute to the new Amount **xyz** attribute.



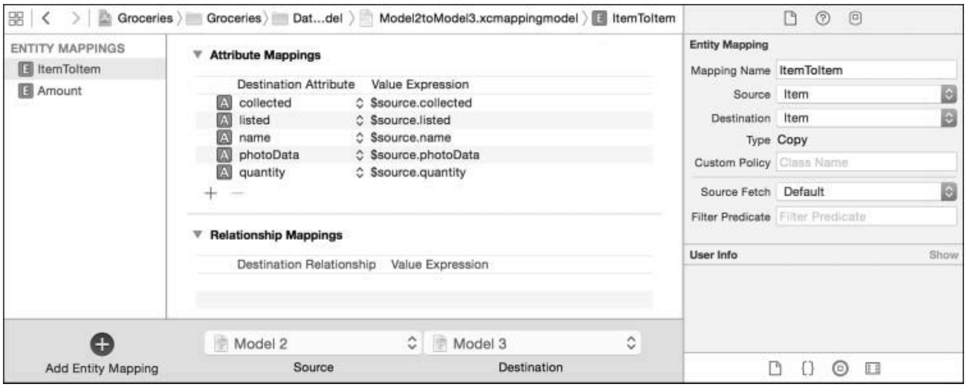
```
    Test = "<NSFetchRequest: 0x7f8588c124b0> (entity: Item; predicate: (name CONTAINS \"e\"); sortDescriptors: ((null));
type: NSManagedObjectResultType; )";
}, reason=Can't find mapping model for migration} with userInfo dictionary {
    destinationModel = "(<NSManagedObjectModel: 0x7f8588d47970>) isEditable 0, entities {\n    Amount =
\"(<NSEntityDescription: 0x7f8588d43560>) name Amount, managedObjectClassName Groceries.Amount, renamingIdentifier Amount,
isAbstract 0, superentity name (null), properties {\\n    xyz = \\\"(<NSAttributeDescription: 0x7f8588d42b60>), name xyz,
isOptional 1, isTransient 0, entity Amount, renamingIdentifier xyz, validation predicates (\\\\n), warnings (\\\\n),
versionHashModifier (null)\\\\n userInfo {\\\\n}, attributeType 700 , attributeValueClassName NSString, defaultValue
(null)\\\";\\n}, subentities {\\n}, userInfo {\\n}, versionHashModifier (null), uniquenessConstraints (\\n)\";\n    Item =
\"(<NSEntityDescription: 0x7f8588d43610>) name Item, managedObjectClassName Groceries.Item, renamingIdentifier Item,
isAbstract 0, superentity name (null), properties {\\n    collected = \\\"(<NSAttributeDescription: 0x7f8588d42bf0>), name
collected, isOptional 1, isTransient 0, entity Item, renamingIdentifier collected, validation predicates (\\\\n), warnings
```

Figure 3.5 A mapping model is required when mapping is not inferred

Update Groceries as follows to add a new mapping model:

1. Ensure the **Data Model** group is selected.
2. Click **File** > **New** > **File...**.
3. Select **iOS** > **Core Data** > **Mapping Model** and then click **Next**.
4. Select **Model 2.xcdatamodel** as the **Source Data Model** and then click **Next**.
5. Select **Model 3.xcdatamodel** as the **Target Data Model** and then click **Next**.
6. Set the mapping model name to save as **Model2toModel3**.
7. Ensure the **Groceries** target is checked and then click **Create**.
8. Select **Model2toModel3.xcmappingmodel**.

You should now be presented with the model-mapping editor, as shown in Figure 3.6.



Destination Attribute	Value Expression
collected	$source.collected
listed	$source.listed
name	$source.name
photoData	$source.photoData
quantity	$source.quantity

Entity Mapping

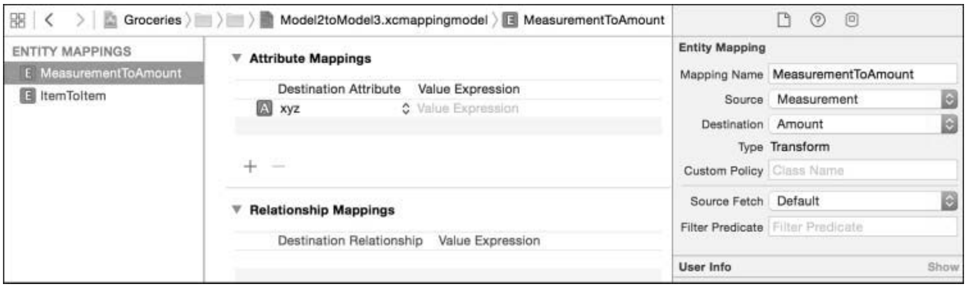
Mapping Name	ItemToItem
Source	Item
Destination	Item
Type	Copy
Custom Policy	Class Name
Source Fetch	Default
Filter Predicate	Filter Predicate

Figure 3.6 The model-mapping editor

The mappings you're presented with are a best guess based on what Core Data can infer on its own. On the left you should see **Entity Mappings**, showing what source entities map to what destination entities. You should also see in Figure 3.6 how the source **Item** entity has already inferred that it should map to the destination **Item** entity, which is a fair assumption. The naming standard of an entity mapping is **SourceToDestination**. With this in mind, notice the **Amount** entity doesn't seem to have a source entity because it never existed in the source model.

Update Groceries as follows to map the old Measurement entity to the new Amount entity:

1. Select the **Amount** entity mapping.
2. Click **View** > **Utilities** > **Show Mapping Model Inspector** (if that's not visible in the menu system, press **Option**+⌘+**3**). You need to be able to see the pane shown on the right in Figure 3.7.
3. Set the **Source** of the **Amount** entity mapping to **Measurement**. The expected result is shown in Figure 3.7.



Entity Mapping
Mapping Name: MeasurementToAmount
Source: Measurement
Destination: Amount
Type: Transform
Custom Policy: Class Name
Source Fetch: Default
Filter Predicate: Filter Predicate

Figure 3.7 Custom entity mapping of MeasurementToAmount

Because **Measurement** was selected as the source entity for the **Amount** destination entity, the Entity Mapping Name was automatically renamed to **MeasurementToAmount**. In addition, the mapping type changed from **Add** to **Transform**. For more complex implementations, you can specify a custom policy in the form of an `NSEntityMigrationPolicy` subclass. By overriding `createDestinationInstancesForSourceInstance` in the subclass, you can manipulate the data that's migrated. For example, you could intercept the values of the **abc** attribute, set them all to title case, and then migrate them to the **xyz** attribute.

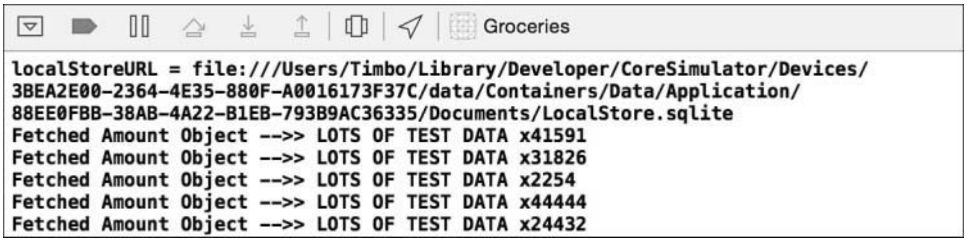
The Source Fetch option shown at the bottom right of Figure 3.7 allows you to limit the migrated data to the results of a predicated (filtered) fetch. This is useful if you only want a subset of the existing data to be migrated. The predicate format you use here is the same as the format you would use when normally configuring a predicate, except you use `$source` variables. An example of a predicate that would filter out nil source data from the **abc** attribute is `$source.abc != nil`.

Select the **ItemToItem** entity mapping shown previously in Figure 3.6 and examine its attribute mappings. Notice how each destination attribute has a **Value Expression** set. Now examine the

MeasurementToAmount entity mapping. Notice there's no value expression for the **xyz** destination attribute. This means that the **xyz** attribute has no source attribute, and you need to set one using the same format used in the **ItemToItem** entity mapping. The original requirement was to map the **abc** attribute to the **xyz** attribute, so that's what needs configuring here.

Update Groceries as follows to set an appropriate value expression for the **xyz** destination attribute:

1. Set the **Value Expression** for the **xyz** destination attribute of the **MeasurementToAmount** entity mapping to **$source.abc**.
2. Run the application. So long as the migration has been successful, you should see the expected result in the console log, as shown in Figure 3.8.



```
localStoreURL = file:///Users/Timbo/Library/Developer/CoreSimulator/Devices/
3BEA2E00-2364-4E35-880F-A0016173F37C/data/Containers/Data/Application/
88EE0FBB-38AB-4A22-B1EB-793B9AC36335/Documents/LocalStore.sqlite
Fetched Amount Object -->> LOTS OF TEST DATA x41591
Fetched Amount Object -->> LOTS OF TEST DATA x31826
Fetched Amount Object -->> LOTS OF TEST DATA x2254
Fetched Amount Object -->> LOTS OF TEST DATA x44444
Fetched Amount Object -->> LOTS OF TEST DATA x24432
```

Figure 3.8 Results of a successfully mapped model

To verify the migration has persisted to the store, examine the contents of the `LocalStore.sqlite` file using the techniques discussed in Chapter 2. The expected result is shown in Figure 3.9, which illustrates the new ZAMOUNT table (that is, Amount entity) with the data from the old Measurement entity.

Close the SQLite Database Browser before continuing.

Migration Manager

Instead of letting a persistent store coordinator perform store migrations, you may want to manually migrate stores using an instance of `NSMigrationManager`. Using a migration manager still uses a mapping model; however, the difference is you have total control over the migration and the ability to report progress. To be certain that migration is being handled manually, automatic migration should be disabled.

Update Groceries as follows to disable automatic migration:

1. Set the `NSMigratePersistentStoresAutomaticallyOption` option in the `localStore` variable of `CDHelper.swift` to false by changing the `1` to a `0`.

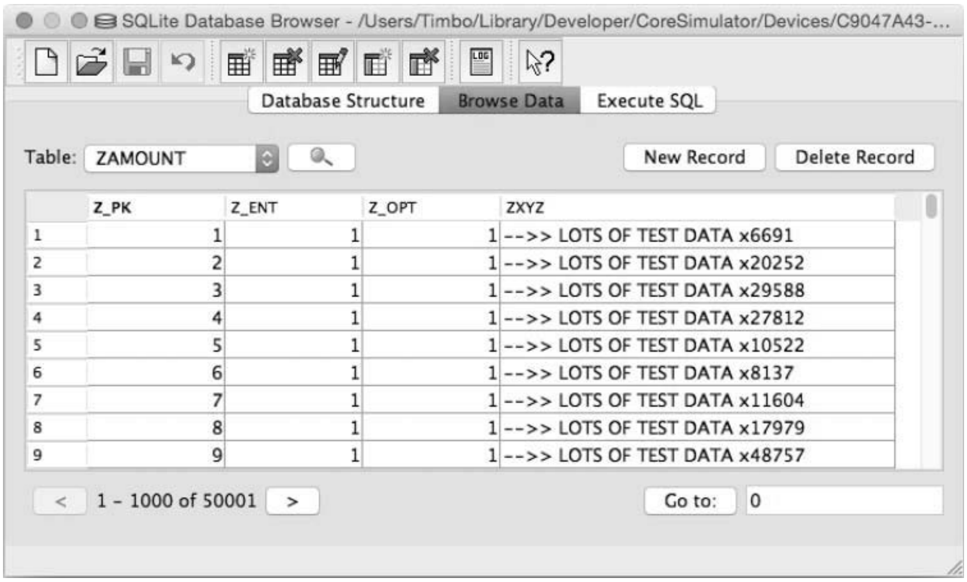

SQLite Database Browser - /Users/Timbo/Library/Developer/CoreSimulator/Devices/C9047A43-...
Database Structure
Browse Data
Execute SQL
New Record
Delete Record
Go to:

Table: ZAMOUNT

	Z_PK	Z_ENT	Z_OPT	ZXYZ
1	1	1	1	-->> LOTS OF TEST DATA x6691
2	2	1	1	-->> LOTS OF TEST DATA x20252
3	3	1	1	-->> LOTS OF TEST DATA x29588
4	4	1	1	-->> LOTS OF TEST DATA x27812
5	5	1	1	-->> LOTS OF TEST DATA x10522
6	6	1	1	-->> LOTS OF TEST DATA x8137
7	7	1	1	-->> LOTS OF TEST DATA x11604
8	8	1	1	-->> LOTS OF TEST DATA x17979
9	9	1	1	-->> LOTS OF TEST DATA x48757

1 - 1000 of 50001

Go to: 0

Figure 3.9 A successfully mapped model

Reporting on the progress of a migration is useful for keeping the user informed (and less annoyed) about a slow launch. Although most migrations should be fast, some large databases requiring complex changes can take a while to migrate. To keep the user interface responsive, the migration must be performed on a background thread. At the same time, the user interface has to be responsive to provide updates to the user. The challenge is to prevent the user from attempting to use the application during the migration. This is because the data won't be ready yet, so you don't want the user staring at a blank screen wondering what's going on. This is where a migration progress view comes into play.

Update Groceries as follows to configure a migration View Controller:

1. Select **Main.storyboard**.
2. Drag a new **View Controller** onto the storyboard, placing it above the existing Navigation Controller.
3. Drag a new **Label** and **Progress View** onto the new View Controller.
4. Position the **Progress View** directly in the center of the View Controller and then position the **Label** above it in the center.
5. Widen the **Label** and **Progress View** to the width of the View Controller margins, as shown in the center of Figure 3.10.

6. Configure the **Label** with **Centered** text that reads **Migration Progress 0%**, as shown in the center of Figure 3.10.
7. Configure the **Progress View** progress to **0**.
8. Select the View Controller and set its **Storyboard ID** to `migration` using **Identity Inspector** (**Option+⌘+3**).
9. Optionally configure the following layout constraints by holding down the control key and dragging from the progress bar toward the applicable margin. You may skip this step if you're uncomfortable with constraints as it is not critical.
   - Leading Space to Container Margin
   - Trailing Space to Container Margin
   - Center Vertically In Container
10. Optionally configure the following layout constraints by holding down the control key and dragging from the progress label toward the applicable margin. You may skip this step if you're uncomfortable with constraints as it is not critical.
    - Leading Space to Container Margin
    - Trailing Space to Container Margin
    - Vertical Spacing from the progress bar

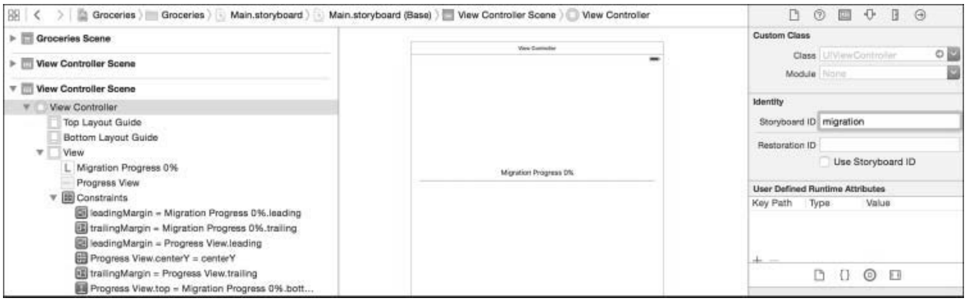


Figure 3.10 Migration View Controller

Introducing MigrationVC.swift (Migration View Controller Code)

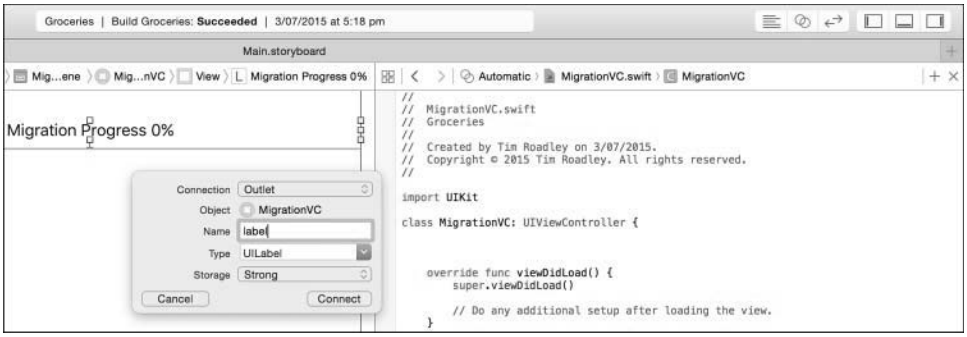
The new migration View Controller has `UILabel` and `UIProgressView` interface elements that need updating during a migration. This means that a way to refer to these interface elements in code is required. A new `UIViewController` subclass called `MigrationVC` should be created for this purpose.

Update Groceries as follows to add a `MigrationVC` file to a new group:

1. Right-click the existing **Groceries** group and then select **New Group**.
2. Set the new group name to **View Controllers**. This group will contain all of the view controllers. As a side note, feel free to move `ViewController.swift` to the trash because it is no longer required.
3. Select the **View Controllers** group.
4. Click **File** > **New** > **File...**.
5. Create a new **iOS** > **Source** > **Cocoa Touch Class** and then click **Next**.
6. Set the subclass to `UIViewController` and the filename to `MigrationVC`.
7. Ensure the language is **Swift** and then click **Next**.
8. Ensure the **Groceries** target is checked and that the new file will be saved in the Groceries project directory; then click **Create**.
9. Select **Main.storyboard**.
10. Set the **Custom Class** of the new migration View Controller to `MigrationVC` using **Identity Inspector** (**Option**+⌘+**3**) while the View Controller is selected. This is in the same place as where the **Storyboard ID** was set.
11. Show the **Assistant Editor** by clicking **View** > **Assistant Editor** > **Show Assistant Editor** (or pressing **Option**+⌘+**Return**).
12. Ensure the **Assistant Editor** is automatically showing `MigrationVC.swift`. The top-right of Figure 3.11 shows what this looks like. If you need to, just click **Manual** or **Automatic** while the migration View Controller is selected and select `MigrationVC.swift`.
13. Hold down the control key while dragging a line from the migration progress label to the code in `MigrationVC.swift` on the line before the `viewDidLoad` function. When you let go of the mouse button, a pop-up appears. In the pop-up, set the **Name** to **label** and ensure the **Storage** is set to **Strong** before clicking **Connect**. Figure 3.11 shows the intended configuration.
14. Repeat the technique in step 13 to create a linked `UIProgressView` variable from the progress view called **progressView**.

There should now be an `@IBOutlet` called `label` and an `@IBOutlet` called `progressView` in `MigrationVC.swift`. You may now switch back to the Standard Editor (⌘ + **return**).

When a migration occurs, notifications that communicate progress need to be sent. For the progress bar to reflect the progress, a new function is required in `MigrationVC.swift`. In addition, this function needs to be called every time a progress update is observed. Listing 3.5 shows the new code involved in bold.



Connection: Outlet
Object: MigrationVC
Name: label
Type: UILabel
Storage: Strong

```
//
//  MigrationVC.swift
//  Groceries
//
//  Created by Tim Roadley on 3/07/2015.
//  Copyright © 2015 Tim Roadley. All rights reserved.
//

import UIKit

class MigrationVC: UIViewController {


    override func viewDidLoad() {
        super.viewDidLoad()

        // Do any additional setup after loading the view.
    }
```

Figure 3.11 Creating storyboard-linked properties to `MigrationVC.swift`

Listing 3.5 **Migration View Controller (`MigrationVC.swift`)**

```
import UIKit

class MigrationVC: UIViewController {

    @IBOutlet var label: UILabel!
    @IBOutlet var progressView: UIProgressView!

    // MARK: - MIGRATION
    func progressChanged (note:AnyObject?) {
        if let _note = note as? NSNotification {
            if let progress = _note.object as? NSNumber {
                let progressFloat:Float = round(progress.floatValue * 100)
                let text = "Migration Progress: \(progressFloat)%"
                print(text)

                dispatch_async(dispatch_get_main_queue(), {
                    self.label.text = text
                    self.progressView.progress = progress.floatValue
                })
            } else {print("\(__FUNCTION__) FAILED to get progress")}
        } else {print("\(__FUNCTION__) FAILED to get note")}
    }

    override func viewDidLoad() {
        super.viewDidLoad()

        NSNotificationCenter.defaultCenter().addObserver(self, selector:
➥"progressChanged:", name: "migrationProgress", object: nil)
    }
    deinit {
        NSNotificationCenter.defaultCenter().removeObserver(self, name:
"migrationProgress", object: nil)
    }
}
```

The `progressChanged` function simply unwraps the progress notification and constructs a string with the migration completion percentage. It then updates the user interface with this information. Of course, none of this can happen without first adding an observer of the `migrationProgress` variable in the `viewDidLoad` function. When the view deinitializes, it is unregistered as an observer of the `migrationProgress` variable.

Update Groceries as follows to ensure migration progress is reported to the user:

1. Replace all code in `MigrationVC.swift` with the code from Listing 3.5.

The user interface is now positioned to report migration progress to the user. The next step is to implement the code required to perform a manual migration.

Introducing CDMigration.swift (Core Data Migration Code)

To keep `CDHelper.swift` small, the code required to perform a managed migration is put in a new class called `CDMigration.swift`. The starting point to this class is shown in Listing 3.6.

Listing 3.6 **Migration View Controller Shared Instance (`CDMigration.swift shared`)**

```
import UIKit
import CoreData

private let _sharedCDMigration = CDMigration()
class CDMigration: NSObject {

    // MARK: - SHARED INSTANCE
    class var shared : CDMigration {
        return _sharedCDMigration
    }
}
```

Just like `CDHelper.swift`, `CDMigration.swift` has a `shared` function that makes it easy to use because you can call it from anywhere in the project via `CDMigration.shared`.

Update Groceries as follows to implement `CDMigration.swift`:

1. Select the **Generic Core Data Classes** group.
2. Click **File** > **New** > **File...**.
3. Create a new **iOS** > **Source** > **Swift File** and then click **Next**.

4. Set the filename to `CDMigration` and ensure the **Groceries** target is checked.
5. Ensure the Groceries project directory is open and then click **Create**.
6. Replace the contents of `CDMigration.swift` with the code from Listing 3.6.

To handle migrations manually, three supporting functions are required. One function checks that a given store exists and another checks that it needs migrating. A successful migration generates a separate compatible store, so as soon as migration completes, this new store needs to replace the incompatible one. The final supporting function does exactly that—it replaces the incompatible store with the migrated store. Listing 3.7 shows the code involved with these three supporting functions.

Listing 3.7 **Migration View Controller Supporting Functions (`CDMigration.swift storeExistsAtPath, store, replaceStore`)**

```
// MARK: - SUPPORTING FUNCTIONS
func storeExistsAtPath(storeURL:NSURL) -> Bool {
    if let _storePath = storeURL.path {
        if NSFileManager.defaultManager().fileExistsAtPath(_storePath) {
            return true
        }
    } else {print("\(__FUNCTION__) FAILED to get store path")}
    return false
}
func store(storeURL:NSURL, isCompatibleWithModel model:NSManagedObjectModel) -> Bool {

    if self.storeExistsAtPath(storeURL) == false {
        return true // prevent migration of a store that does not exist
    }

    do {
        var _metadata:[String : AnyObject]?
        _metadata = try NSPersistentStoreCoordinator.metadataForPersistentStoreOfType
➥(NSSQLiteStoreType, URL: storeURL, options: nil)
        if let metadata = _metadata {
            if model.isConfiguration(nil, compatibleWithStoreMetadata: metadata) {

                print("The store is compatible with the current version of the model")
                return true
            }
        } else {print("\(__FUNCTION__) FAILED to get metadata")}
    } catch {
        print("ERROR getting metadata from \(storeURL) \(error)")
    }
    print("The store is NOT compatible with the current version of the model")
    return false
}
func replaceStore(oldStore:NSURL, newStore:NSURL) throws {

    let manager = NSFileManager.defaultManager()

    do {
        try manager.removeItemAtURL(oldStore)
        try manager.moveItemAtURL(newStore, toURL: oldStore)
    }
}
```

The `storeExistsAtPath` function uses `NSFileManager` to determine whether a store exists at the given URL. It returns a `Bool` indicating the result.

The `store:isCompatibleWithModel` function first checks that a store exists at the given path. If there is no store, `true` is returned because this prevents a migration from being attempted. If a store exists at the given URL, it is checked for model compatibility against the given model. To do this, the model used to create the store is drawn from the store's metadata and then compared to the given model via its `isConfiguration:compatibleWithStoreMetadata` function.

The `replaceStore` function uses `NSFileManager` to remove the incompatible store from the file system and then replaces it with the compatible store.

Update Groceries as follows to implement a new `SUPPORTING FUNCTIONS` section:

1. Add the code from Listing 3.7 to the bottom of `CDMigration.swift` before the last curly brace.

When a migration is in progress, the value of the migration manager's `migrationProgress` variable is constantly updated. This is information that the user needs to see, so a function is required to react whenever the `migrationProgress` value changes. Listing 3.8 shows a new function that posts a notification whenever this value changes.

Listing 3.8 **Migration View Controller Progress Reporting (`CDMigration.swift observeValueForKeyPath`)**

```
// MARK: - PROGRESS REPORTING
override func observeValueForKeyPath(keyPath: String?, ofObject object: AnyObject?,
➥ change: [String : AnyObject]?, context: UnsafeMutablePointer<Void>) {

    if object is NSMigrationManager, let manager = object as? NSMigrationManager {

        if let notification = keyPath {
            NSNotificationCenter.defaultCenter().postNotificationName(notification,
➥ object: NSNumber(float: manager.migrationProgress))
        }
    } else {print("observeValueForKeyPath did not receive a NSMigrationManager
➥ class")}
}
```

Update Groceries as follows to implement a new `PROGRESS REPORTING` section:

1. Add the code from Listing 3.8 to the bottom of `CDMigration.swift` before the last curly brace.

The next function is where the actual migration happens. Most of this function is used to gather all the pieces required to perform a migration. Listing 3.9 shows the code involved.

Listing 3.9 **Migration (`CDMigration.swift migrateStore`)**

```
// MARK: - MIGRATION
func migrateStore(store:NSURL, sourceModel:NSManagedObjectModel,
➥destinationModel:NSManagedObjectModel) {

    if let tempdir = store.URLByDeletingLastPathComponent {
        let tempStore = tempdir.URLByAppendingPathComponent("Temp.sqlite")
        let mappingModel = NSMappingModel(fromBundles: nil, forSourceModel:
➥sourceModel, destinationModel: destinationModel)
        let migrationManager = NSMigrationManager(sourceModel: sourceModel,
➥destinationModel: destinationModel)
        migrationManager.addObserver(self, forKeyPath: "migrationProgress", options:
➥NSKeyValueObservingOptions.New, context: nil)

        do {

            try migrationManager.migrateStoreFromURL(store, type: NSSQLiteStoreType,
➥ options: nil,withMappingModel: mappingModel, toDestinationURL: tempStore,
➥destinationType: NSSQLiteStoreType, destinationOptions: nil)
            try replaceStore(store, newStore: tempStore)

            print("SUCCESSFULLY MIGRATED \(store) to the Current Model")

        } catch {
            print("FAILED MIGRATION: \(error)")
        }
        migrationManager.removeObserver(self, forKeyPath: "migrationProgress")
    } else {print("\(__FUNCTION__) FAILED to prepare temporary directory")}
}
```

The `migrateStore` function needs to be given a store to migrate, a source model to migrate from, and destination model to migrate to. The source model could have been taken from the given store's metadata; however, seeing as this step is performed first in another function, this approach saves repeated code.

The first thing `migrateStore` does is prepare four variables:

- The `tempdir` variable holds the URL to the given store and is used to build a URL to a temporary store used for migration.
- The `tempStore` variable holds the URL to the temporary store used for migration.
- The `mappingModel` variable holds an instance of `NSMappingModel` specific to the models being migrated from and to. The migration will fail without a mapping model.
- The `migrationManager` variable holds an instance of `NSMigrationManager` based on the source and destination models. An observer is added for the `migrationProgress` variable so that the `observeValueForKeyPath` function is called whenever the `migrationProgress` variable changes.

All these variables are then used to make a call to the `migrateStoreFromURL` function, which is responsible for migrating the given store to be compatible with the destination model. Once this is complete, the old incompatible store is removed and the new compatible store is put in its place.

Update Groceries as follows to implement a new `MIGRATION` section:

1. Add the code from Listing 3.9 to the bottom of `CDMigration.swift` before the final closing curly brace.

The migration code that has just been implemented needs to be called from a background thread so that the user interface can be updated without freezing. This, along with the instantiation of the progress view that the user sees, is shown in Listing 3.10.

Listing 3.10 **Migration Progress (`CDMigration.swift migrateStoreWithProgressUI`)**

```
func migrateStoreWithProgressUI(store:NSURL, sourceModel:NSManagedObjectModel,
➥destinationModel:NSManagedObjectModel) {

    // Show migration progress view preventing the user from using the app
    let storyboard = UIStoryboard(name: "Main", bundle: nil)

    if let initialVC = UIApplication.sharedApplication().keyWindow?.rootViewController
➥as? UINavigationController {

        if let migrationVC = storyboard.instantiateViewControllerWithIdentifier
➥("migration") as? MigrationVC {

            initialVC.presentViewController(migrationVC, animated: false, completion: {
                dispatch_async(dispatch_get_global_queue(DISPATCH_QUEUE_PRIORITY_
➥BACKGROUND, 0), {
                    print("BACKGROUND Migration started...")
                    self.migrateStore(store, sourceModel: sourceModel,
➥destinationModel: destinationModel)
                    dispatch_async(dispatch_get_main_queue(), {
                        // trigger the stack setup again, this time with the upgraded
➥ store
                        let _ = CDHelper.shared.localStore
                        dispatch_after(2, dispatch_get_main_queue(), {
                            migrationVC.dismissViewControllerAnimated(false,
➥ completion: nil)
                        })
                    })
                })
            })
        } else {print("FAILED to find a view controller with a story board id of
➥'migration'")}
    } else {print("FAILED to find the root view controller, which is supposed to be a
➥ navigation controller")}
}
```

The `migrateStoreWithProgressUI` function uses a storyboard identifier to instantiate and present the migration view. Once the view is blocking user interaction the migration can begin. The `migrateStore` function is called on a background thread. Once migration is complete, the `localStore` is loaded as usual, the migration view is dismissed, and normal use of the application can resume.

Update Groceries as follows to implement the `migrateStoreWithProgressUI` function:

1. Add the code from Listing 3.10 to the `MIGRATION` section at the bottom of `CDMigration.swift` before the last curly brace.

The final piece of code required in `CDMigration.swift` is used to migrate the store if necessary. This function is called from the `setupCoreData` function of `CDHelper.swift`, which is run as a part of initialization. Listing 3.11 shows the code involved.

Listing 3.11 **Migration (`CDMigration.swift migrateStoreIfNecessary`)**

```
func migrateStoreIfNecessary (storeURL:NSURL, destinationModel:NSManagedObjectModel) {

    if storeExistsAtPath(storeURL) == false {
        return
    }

    if store(storeURL, isCompatibleWithModel: destinationModel) {
        return
    }

    do {
        var _metadata:[String : AnyObject]?
        _metadata = try NSPersistentStoreCoordinator.metadataForPersistentStoreOfType
➥ (NSSQLiteStoreType, URL: storeURL, options: nil)
```

```
        if let metadata = _metadata, let sourceModel =
➥ NSManagedObjectModel.mergedModelFromBundles([NSBundle.mainBundle()],
➥forStoreMetadata: metadata) {
            self.migrateStoreWithProgressUI(storeURL, sourceModel: sourceModel,
➥ destinationModel: destinationModel)
        }
    } catch {
        print("\(__FUNCTION__) FAILED to get metadata \(error)")
    }
}
```

Once it's established that the given store exists, a model compatibility check is performed and the store is migrated if necessary. The model used to create the given store is drawn from the store's metadata. This is then given to the `migrateStoreWithProgressUI` function.

Update Groceries as follows to implement the `migrateStoreIfNecessary` function:

1. Add the code from Listing 3.11 to `MIGRATION` section at the bottom of `CDMigration.swift` before the last curly brace.

When `CDHelper.swift` initializes, a call is made to `setupCoreData`. This is an ideal time to check that the `localStore` is compatible with the current model, before it's needed. The new code required in the `setupCoreData` is shown in bold in Listing 3.12.

Listing 3.12 **Migration During Setup (`CDHelper.swift setupCoreData`)**

```
func setupCoreData() {

    // Model Migration
    if let _localStoreURL = self.localStoreURL {
        CDMigration.shared.migrateStoreIfNecessary(_localStoreURL, destinationModel:
➥ self.model)
    }

    // Load Local Store
    _ = self.localStore
}
```

Update Groceries as follows to ensure a manual migration is triggered as required:

1. Replace the `setupCoreData` function of `CDHelper.swift` with the code from Listing 3.12.

Currently the `localStore` variable of `CDHelper.swift` always tries to return a store. If it tried to return a store that wasn't compatible with the current model, the application would throw an error. To prevent this, a check is needed to see whether the store needs migrating before it is loaded. This check is needed only when migration is handled manually, so the bold code in Listing 3.13 wouldn't be required otherwise.

Listing 3.13 **Triggering Migration Manager (`CDHelper.swift localStore`)**

```
lazy var localStore: NSPersistentStore? = {

    let useMigrationManager = true
    if let _localStoreURL = self.localStoreURL {
        if useMigrationManager == true &&
            CDMigration.shared.storeExistsAtPath(_localStoreURL) &&
            CDMigration.shared.store(_localStoreURL, isCompatibleWithModel:
➥self.model) == false {
            return nil // Don't return a store if it's not compatible with the model
        }
    }

    let options:[NSObject:AnyObject] = [NSSQLitePragmasOption:["journal_
➥mode":"DELETE"],
                                       NSMigratePersistentStoresAutomaticallyOption:0,
                                       NSInferMappingModelAutomaticallyOption:0]
    var _localStore:NSPersistentStore?
    do {
        _localStore = try self.coordinator.addPersistentStoreWithType
➥(NSSQLiteStoreType, configuration: nil, URL: self.localStoreURL, options: options)
        return _localStore
    } catch {
        return nil
    }
}()
```

Update Groceries as follows to ensure a `localStore` is not returned when the migration manager is used and a manual migration is required:

1. Replace the `localStore` variable in `CDHelper.swift` with the code from Listing 3.13.

For progress to be shown to the user, the interface needs to be ready before a migration is triggered. This means that the first call to anything Core Data related should be made from an existing view after it has loaded. To demonstrate the migration process, a small amount of code needs to be applied to the existing table view. The only table view in the application so far is the Prepare table view, where the user adds items to the shopping list. Listing 3.14 shows the minimal code involved that triggers a store model migration. Note that the table view won't be configured to display anything until later in the book.

Listing 3.14 **The Prepare Table View Controller (`PrepareTVC.swift`)**

```
import UIKit

class PrepareTVC: UITableViewController {

    override func viewDidLoad() {
        super.viewDidLoad()
    }
    override func viewDidAppear(animated: Bool) {
        super.viewDidAppear(animated)
        // Trigger Demo Code
        if let appDelegate = UIApplication.sharedApplication().delegate as?
➥AppDelegate {
            appDelegate.demo()
        }
    }
    override func didReceiveMemoryWarning() {
        super.didReceiveMemoryWarning()
    }
    override func tableView(tableView: UITableView, numberOfRowsInSection section:
➥Int) -> Int {
        return 0
    }
    override func numberOfSectionsInTableView(tableView: UITableView) -> Int {
        return 0
    }
}
```

The `PrepareTVC.swift` code is the bare minimum code required to show a table view. You might notice that the view is configured to return no rows or sections, as the intent for the moment is just to show model migration progress.

Update Groceries as follows to implement `PrepareTVC.swift`:

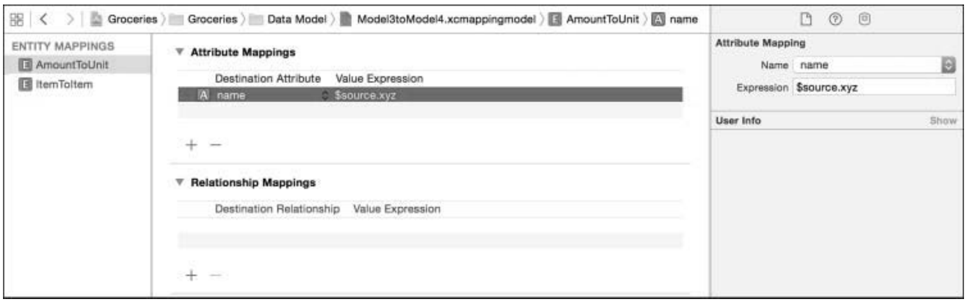
1. Right-click the existing **Groceries** group and then select **New Group**.
2. Set the new group name to **Table View Controllers**.
3. Select the **Table View Controllers** group.
4. Click **File** > **New** > **File...**.
5. Create a new **iOS** > **Source** > **Swift File** and then click **Next**.
6. Set the filename to `PrepareTVC` and ensure the **Groceries** target is checked.
7. Ensure the Groceries project directory is open and then click **Create**.
8. Replace the contents of `PrepareTVC.swift` with the code from Listing 3.14.
9. Select **Main.storyboard**.
10. Set the **Custom Class** of the Table View Controller to `PrepareTVC` using **Identity Inspector** (**Option+⌘+3**) while the Table View Controller is selected.
11. Remove the call to `CDHelper.shared` from the `application:didFinishLaunching WithOptions` function of `AppDelegate.swift`. This code would otherwise trigger a migration before the user interface was ready.

12. Remove the call to `demo()` from the `application:applicationDidBecomeActive` function of `AppDelegate.swift`. This code would otherwise trigger a migration before the user interface was ready.

Almost everything is in place to perform a manual migration; however, a new managed object model and mapping model are required to show what attributes map to where.

Update Groceries as follows to prepare the new model:

1. Add a model version called **Model 4** based on **Model 3**.
2. Set **Model 4** as the current model.
3. Select **Model 4.xcdatamodel**.
4. Delete the **Amount** entity.
5. Add a new entity called **Unit** with a **String** attribute called **name**.
6. Set the default value of the **name** attribute to **New Unit**.
7. Create an `NSManagedObject` subclass of the **Unit** entity. When it comes time to save the class file, don't forget to check the **Groceries** target and ensure that the **Data Model** group is selected.
8. Create a new mapping model with **Model 3** as the source and **Model 4** as the target. When it comes time to save the mapping model file, don't forget to check the **Groceries** target and save the mapping model as **Model3toModel4**.
9. Select **Model3toModel4.xcmappingmodel**.
10. Select the **Unit** entity mapping.
11. Set the **Source** of the **Unit** entity to **Amount** and the **Value Expression** of the **name** destination attribute to **$source.xyz**. You should see the **Unit** entity mapping automatically renamed to **AmountToUnit**, as shown in Figure 3.12.



Destination Attribute | Value Expression
name | $source.xyz

Attribute Mapping
Name: name
Expression: $source.xyz

Figure 3.12 Mapping model for AmountToUnit

You're almost ready to perform a migration; however, the fetch request in the `demo` function still refers to the old Amount entity. Listing 3.15 shows an updated version of this function.

Listing 3.15 **Fetching Test Unit Data (`AppDelegate.swift demo`)**

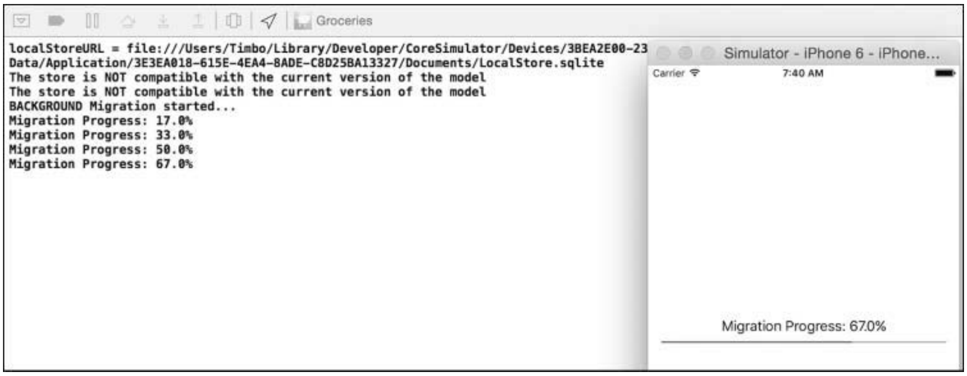
```
func demo () {
    let context = CDHelper.shared.context
    let request = NSFetchRequest(entityName: "Unit")
    request.fetchLimit = 50

    do {
        if let units = try context.executeFetchRequest(request) as? [Unit] {
            for unit in units {
                print("Fetched Unit Object \(unit.name!)")
            }
        }
    } catch {
        print("ERROR executing a fetch request: \(error)")
    }
}
```

Update Groceries as follows to refer to the Unit entity instead of the Amount entity:

1. Replace the `demo` function of `AppDelegate.swift` with the code shown in Listing 3.15. This code just fetches 50 **Unit** objects from the persistent store.

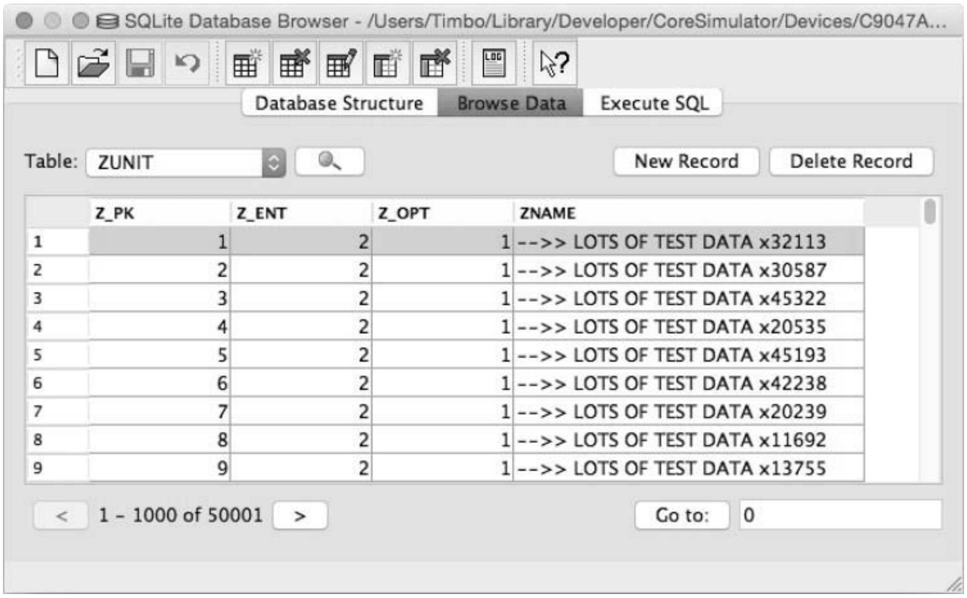
The migration manager is finally ready! Run the application and *pay close attention!* You should see the migration manager flash before your eyes, alerting you to the progress of the migration. The progress is also shown in the console log (see Figure 3.13).



```
localStoreURL = file:///Users/Timbo/Library/Developer/CoreSimulator/Devices/3BEA2E00-23
Data/Application/3E3EA018-615E-4EA4-8ADE-C8D25BA13327/Documents/LocalStore.sqlite
The store is NOT compatible with the current version of the model
The store is NOT compatible with the current version of the model
BACKGROUND Migration started...
Migration Progress: 17.0%
Migration Progress: 33.0%
Migration Progress: 50.0%
Migration Progress: 67.0%
```

Figure 3.13 Visible migration progress

Examine the contents of the ZUNIT table in the `LocalStore.sqlite` file using the techniques discussed in Chapter 2. The expected result is shown in Figure 3.14.


SQLite Database Browser - /Users/Timbo/Library/Developer/CoreSimulator/Devices/C9047A...
Database Structure
Browse Data
Execute SQL
Table: ZUNIT
New Record
Delete Record
Go to: 0

	Z_PK	Z_ENT	Z_OPT	ZNAME
1	1	2	1	-->> LOTS OF TEST DATA x32113
2	2	2	1	-->> LOTS OF TEST DATA x30587
3	3	2	1	-->> LOTS OF TEST DATA x45322
4	4	2	1	-->> LOTS OF TEST DATA x20535
5	5	2	1	-->> LOTS OF TEST DATA x45193
6	6	2	1	-->> LOTS OF TEST DATA x42238
7	7	2	1	-->> LOTS OF TEST DATA x20239
8	8	2	1	-->> LOTS OF TEST DATA x11692
9	9	2	1	-->> LOTS OF TEST DATA x13755

1 - 1000 of 50001

Figure 3.14 Successful use of migration manager

If you reproduced the results shown in Figure 3.14, give yourself a pat on the back because you successfully implemented three types of model migration! The rest of the book uses lightweight migrations, so it needs to be re-enabled. Before you continue, close the SQLite Database Browser.

Update Groceries as follows to re-enable lightweight migration:

1. Set `useMigrationManager` to `false` in the `localStore` variable of `CDHelper.swift`.
2. Set the `NSMigratePersistentStoresAutomaticallyOption` option in the `localStore` variable of `CDHelper.swift` to true by changing the `0` to a `1`.
3. Set the `NSInferMappingModelAutomaticallyOption` option in the `localStore` variable of `CDHelper.swift` to true by changing the `0` to a `1`.
4. Comment out the call to `migrateStoreIfNecessary` from the `setupCoreData` function of `CDHelper.swift`.
5. Replace the code in the `demo` function of `AppDelegate.swift` with a call to `CDHelper.shared`. This ensures that the Core Data stack is set up without a reliance on particular entities.

The old mapping models and `NSManagedObject` subclasses of entities that don't exist anymore are no longer needed. Although you could remove them, leave them in the project for reference sake.

Summary

You've now experienced lightweight migration, default migration, and using a migration manager to display progress. You should now be able to make an informed decision when determining between migration options for your own applications. Don't forget that the only migration option for iCloud-enabled Core Data applications is lightweight migration. Adding model versions should now be a familiar procedure because the model has changed several times already.

Exercises

Why not build on what you've learned by experimenting?

1. Set the current model version to **Model 3** and run the application. It should not throw an error because the downgrade of data is inferred automatically. Note that this is only because `NSInferMappingModelAutomaticallyOption` has been re-enabled. In reality, you would need a **Model4toModel3** mapping model to map attributes properly.
2. Examine the contents of the ZAMOUNT table in `LocalStore.sqlite` and you'll notice something critical: Where has all the data gone? There was no mapping model, so all the ZUNIT data was lost during the downgrade!
3. Set the current model to **Model 4** and then run the application to trigger an automatic lightweight migration. This should be fast because there is no data in the store.