Includes iOS 8 SDK

Pro iOS Persistence

Using Core Data

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Contents at a Glance

Introduction

The world has gone mobile, and it seems that iOS apps lead the charge. People use their iPhone, iPads, and soon their Apple Watches to consume, produce, and store a diversity of information. As you develop applications to run on these Apple devices, you'll appreciate the polish that Apple has spread on its persistence framework: Core Data. No other mobile platform offers a persistence layer that approaches Core Data's power, ease of use, or flexibility. With each release of the iOS Software Development Kit (SDK), Apple grows and improves the Core Data framework.

We've written and rewritten this book several times as Core Data has continued to grow. Last summer, as we neared completion of this book, Apple surprised us all with the announcement of its new Swift programming language. After discussion between ourselves and with the folks at Apress, we concluded that the proper response to Swift's advent was to rewrite anew and incorporate every example in this book in both Objective-C and Swift. We have some bruises and scars from that experience, of course, as all the Swift early adopters can attest. With each new release of Xcode, we had to revisit chapters we thought done because some bits of code no longer compiled under the new Xcode. We believe we've caught all the errant ?s and !s, but apologize in advance if any slipped through.

What You'll Need

To follow along with this book, you'll need a Mac running OS X Mavericks or OS X Yosemite, and you'll need Xcode 6. You'll be happiest if you're running the latest point version of Xcode 6, particularly if you use the Swift code samples. Language support for Swift continues to improve with each release of Xcode. You can download the latest version of Xcode 6 from the Mac App Store.

This text doesn't cover beginning iOS development, whether in Objective-C or Swift, so you should have at least a basic understanding of either Objective-C or Swift, and also of Cocoa Touch and iOS development.

What You'll Find

This book approaches iOS persistence and Core Data from both theoretical and practical perspectives, so you'll learn generally how Core Data works and how its pieces fit together, and also you'll be guided step-by-step how to incorporate this powerful persistence framework into your applications. You'll see how to implement every topic we treat both in Objective-C and in Swift. We cover a range of topics, including how to build your Core Data data models, how to query your data, how to migrate data across model versions, how to encrypt data, how to use Core Data on different threads, how to store data in the cloud, and how to tune performance.

You can read the book cover to cover, but for the best results we recommend you read it in front of your computer, typing in the code samples to understand how they work and what they do. We also recommend that you keep this book as a reference for your ongoing Core Data needs and challenges.

How This Book Is Organized

We've organized this book to build from basic principles to advanced topics, so you'll probably gain the most if you work through the book from front to back. Chapter titles clearly mark the subject matter they contain, however, so if you're looking for information on a specific topic, feel free to jump directly to that chapter.

Source Code and Errata

You can download the source code for this book from the Apress web site at `www.apress.com`. We've released all the code under the MIT license (`http://opensource.org/licenses/MIT`), so feel free to use it in your own projects, whether personal or commercial. Check the errata section of the Apress web site for any corrections to code or text.

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Chapter 1

Touring Core Data

That computer in your purse or pocket—the one that purportedly places phone calls—stores gigabytes' worth of data: pictures, e-mails, texts, tweets, restaurant reviews, high scores, books, what your friends ate for breakfast, and countless other combinations of zeros and ones that inform and entertain you every day. As Apple's offering to manage data, Core Data manages much of that information, and the percentage of Core Data–managed information on iOS devices continues to grow. In this chapter, we'll discover why.

This chapter explains what Core Data is and what components Core Data comprises. It outlines and explains the basic classes that Core Data uses and how they work together. It shows how to set up Core Data in your applications, whether you take advantage of Xcode's Core Data code generation or add Core Data functionality by hand. It also shows the basics of creating an object model for your objects, storing objects, and retrieving them.

In this chapter, you build two applications: one that tells Xcode to set up Core Data for you and one to which you add Core Data by hand. Neither application has an interface beyond a blank screen, but, rather, they both focus on Core Data interaction. Applications in later chapters will have actual user interfaces, but be patient and focus on learning the basics of Core Data. The information you learn in this chapter will provide a solid foundation for you throughout the rest of this book and with your own Core Data projects.

What Is Core Data?

Imagine computers couldn't store data. Imagine each time you powered on your iPhone or iPad, you started fresh with each application you worked with. All your documents were gone: your school papers, your budget projection spreadsheets, your crafted pitch presentations for another round of venture capitalist funding, all vanished. You're back to Level 1 on Angry Birds. You have no more grumpy cat pictures. Your texts from last night have disappeared (which, for some of you, might be a good thing). In short, your device is the classic tabula rasa, day after day, blank and empty of any data, and not very useful.

What those imaginary computers lack is persistence: the ability to store and retrieve data over time. We want to persist information, like our pictures and our high scores and our documents. Core Data, Apple's solution for persistence, allows applications to persist data of any form and retrieve it.

Core Data isn't technically a database, although it usually stores its data in one (an SQLite database, to be precise). It's not an object-relational mapper (ORM), though it can feel like one. It's truly an object graph, allowing you to create, store, and retrieve objects that have attributes and relationships to other objects. Its simplicity and power allow you to persist data of any form, from basic data models to complex.

Core Data Components

Newcomers to Core Data often express dismay at the complexity of the framework, but as we'll see, that initial response is unfounded. Cocoa's predilection for long names probably contributes to the mistaken sense of the complexity; after all, `NSPersistentStoreCoordinator` is a mouthful. Once you get past the long names, however, and understand the purpose of each of the classes, you'll recognize both the elegance and the simplicity of the Core Data framework.

We can divide the Core Data classes into two groups: the ones we generally set up once, when our programs launch, and the ones we work with throughout the running time of our programs. In addition, Cocoa provides a set of classes that Core Data uses that aren't limited in scope to Core Data. Core Data leverages classes like `NSPredicate` and `NSSortDescriptor`, which are also used in other contexts in Cocoa applications, to augment its capabilities. We'll touch on those other classes throughout this book.

Let's first discuss the classes we set up once, when our programs launch. These classes are

- `NSPersistentStore`
- `NSPersistentStoreCoordinator`
- `NSManagedObjectModel`

The `NSPersistentStore` class represents a persistent store: a place on your device's file system that actually stores data. This is usually an SQLite database, though Core Data also offers other types of persistent stores:

- XML (OS X only)
- Atomic
- In-memory

XML stores, which are available only on OS X, store data (as you'd guess) in XML files. Atomic stores, so named because they read and write the entire data store when accessed, can be useful if you want to create your own file format for storing files. Core Data provides one atomic store implementation called the binary store type, and you can create custom stores based on atomic stores. Understand, though, that atomic stores tend to be slower, especially as your data set grows large, because they write and read the data files atomically. In-memory stores are useful if you don't require your data to persist beyond the current launch of the application but still want to use the power of Core Data to interact with the data. Most, if not all, of your persistent stores will be SQLite stores, though. They're fast, since they can read and write partial data, and they persist data beyond just the current launch of your applications. Each of your applications will often have one persistent store, though they can have more than one.

The `NSPersistentStoreCoordinator` class represents a persistent store coordinator, which coordinates among persistent stores, object models, and object contexts. The persistent store coordinator uses an object model, which we'll see next, and ties it to one or more persistent stores. It also coordinates the storage and retrieval of objects between one or more managed object contexts and one or more persistent stores. It's in a sense the hub of Core Data, tying together all the Core Data classes. Luckily for you, though, it's easy to create and configure, and then it performs all its complicated magic for you while your application runs.

The `NSManagedObjectModel` class represents a managed object model or, more simply, an object model, which looks so much like a data model that you're forgiven for thinking of it in that way. Just as an entity-relationship (ER) diagram defines tables, columns, and relationships, an object model defines entities, attributes, and relationships. You can create an object model in code, but Xcode provides an object model editor that lets you visually create object models that your application loads and uses.

You use the next two classes throughout the runtime of your applications. They are

- `NSManagedObjectContext`
- `NSManagedObject`

The `NSManagedObjectContext` class represents a managed object context, or just an object context. Your applications can use one or more of these, though often they'll use only one. Object contexts provide places for objects to live, and the Apple documentation calls it a "scratch pad." You create objects in the object context, retrieve objects from the object context, and tell the object context to save itself. The object context takes care of talking to the persistent store coordinator to actually store and retrieve objects. You'll talk to the object contexts a lot in your Core Data applications.

The `NSManagedObject` class represents a managed object, or an object that Core Data manages. You can think of these as rows in a database. Managed objects have attributes and relationships, as defined by an object model, and use key-value coding (KVC) so you can easily set and get their data. You can also create a subclass of `NSManagedObject` to create properties that match your object model and convenience methods to work with your managed objects.

Figure 1-1 shows the Core Data classes and how they work together.

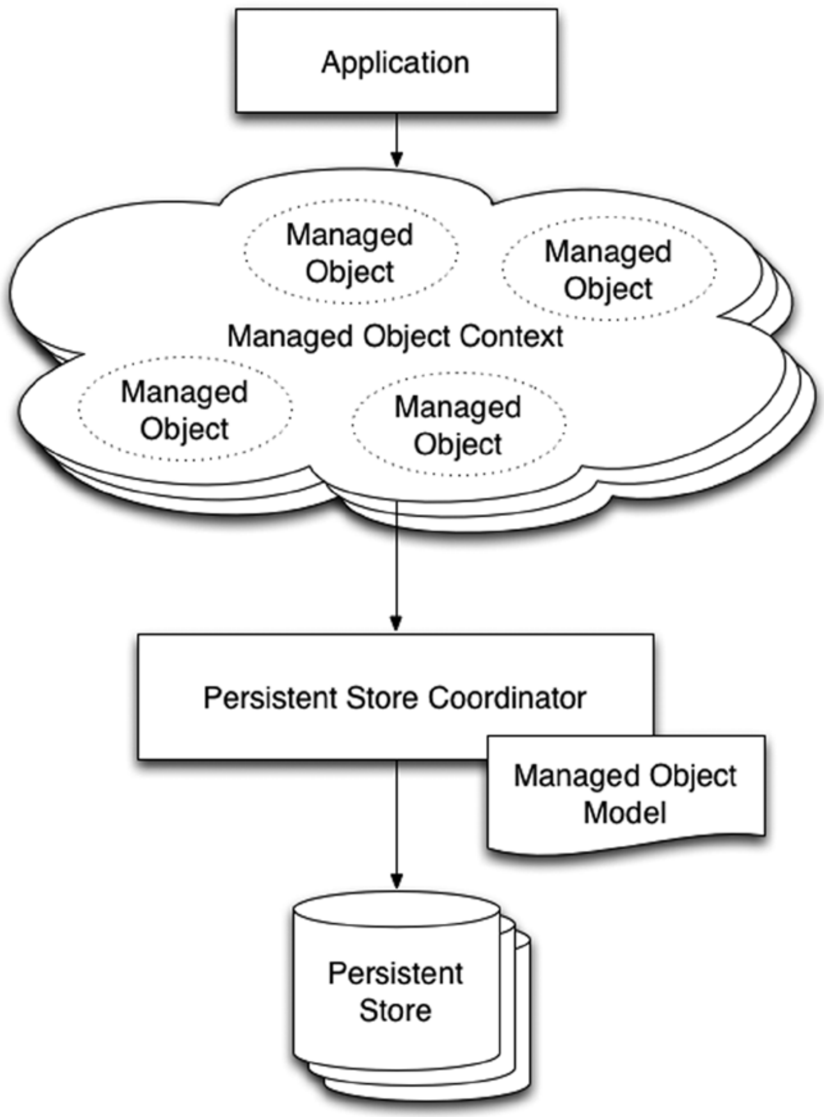


Figure 1-1. The Core Data classes

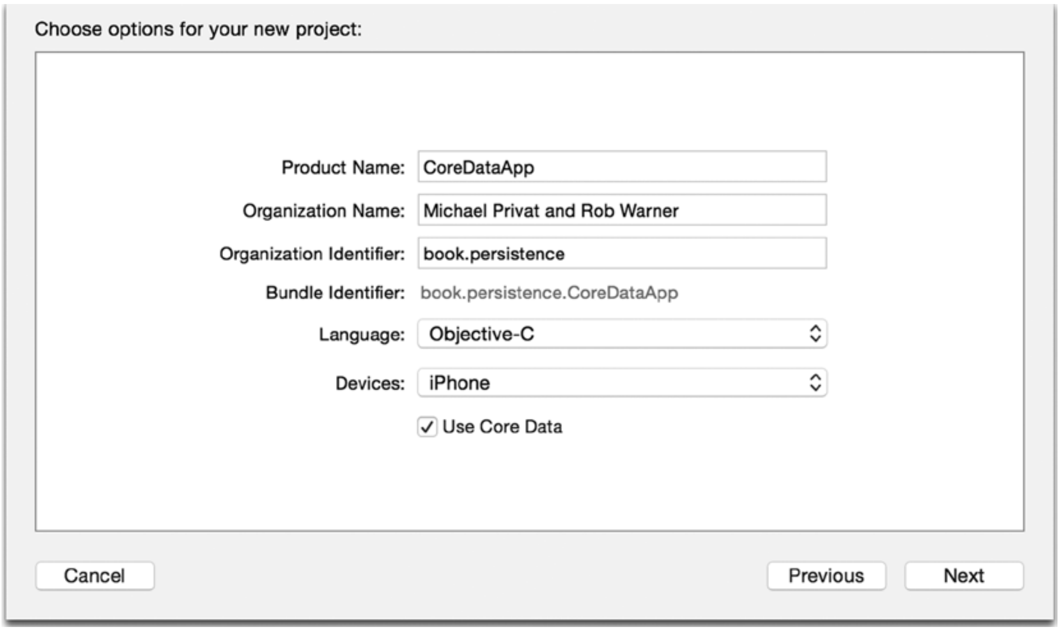
Creating a New Core Data Project

Theory and diagrams work well for gaining an understanding of how something works, but actual working code cements the concepts into true comprehension. We've talked about theory and seen a diagram; now, let's see Core Data in practice. In this section, we create an Xcode project that uses Core Data from its outset. Later in this chapter, we show how to add Core Data to an existing project.

This first application, not so imaginatively named CoreDataApp, stores `Person` objects with a single attribute, `name`. It has a blank screen for an interface, so you can't interact with it. You run it, it creates data in an SQLite database, and then we use the `sqlite3` command-line application to browse the database.

Creating the Project

Launch Xcode and create a new single view application project. Call it CoreDataApp and set the organization identifier to `book.persistence`. Make sure the Use Core Data check box is checked, as shown in Figure 1-2, and create and save the project. Throughout this book, we use Objective-C as the primary language, but we include Swift versions of the listings as well.


Choose options for your new project:

Product Name: CoreDataApp
Organization Name: Michael Privat and Rob Warner
Organization Identifier: book.persistence
Bundle Identifier: book.persistence.CoreDataApp
Language: Objective-C
Devices: iPhone
✓ Use Core Data

***Figure 1-2.** Creating the CoreDataApp project*

Touring the Core Data Components

By checking the Use Core Data check box, you've instructed Xcode to add the Core Data framework to your project. If you selected Objective-C as the project language, Xcode has added the Core Data header file, `CoreData/CoreData.h`, to the project's `AppDelegate.h` file. If you selected Swift as the language, you'll find the line `import CoreData` in the project's `AppDelegate.swift` file.

You've also told Xcode to create a model that will be loaded into an `NSManagedObjectModel` instance in your application. To see this, expand the CoreDataApp folder in Xcode's Project Navigator. You should see an entry called `CoreDataApp.xcdatamodeld`, which is a directory that contains the various artifacts that make up the project's data model. When we build the application, Xcode will compile this to a directory called `CoreDataApp.momd` inside the application bundle. This directory will contain the artifacts that CoreDataApp loads to create the `NSManagedObjectModel` instance.

Finally, you've told Xcode to create properties in your application delegate class, `AppDelegate`, to materialize the Core Data stack. Open the header file, `AppDelegate.h`, which should match Listing 1-1.

Listing 1-1. `AppDelegate.h`

```
#import <UIKit/UIKit.h>
#import <CoreData/CoreData.h>

@interface AppDelegate : UIResponder <UIApplicationDelegate>

@property (strong, nonatomic) UIWindow *window;

@property (readonly, strong, nonatomic) NSManagedObjectContext *managedObjectContext;
@property (readonly, strong, nonatomic) NSManagedObjectModel *managedObjectModel;
@property (readonly, strong, nonatomic) NSPersistentStoreCoordinator *persistentStoreCoordinator;

- (void)saveContext;
- (NSURL *)applicationDocumentsDirectory;

@end
```

You should recognize the three Core Data properties: `managedObjectContext`, `managedObjectModel`, and `persistentStoreCoordinator`. Xcode puts them all in the application delegate class, which works fine, but application delegate classes tend to grow to unwieldy sizes. When we add Core Data to an existing project later in this chapter, we use a different approach that partitions the Core Data stack to a different class.

You should also notice two methods that Xcode has created to help us with Core Data interaction.

```
- (void)saveContext;- (NSURL *)applicationDocumentsDirectory;
```

The `saveContext` method gives us a central location for saving the managed object context. We can save the managed object context from anywhere in the code, of course, but having one place to do the save allows us to do things like localize error handling. Chapter 4 goes more in depth into error handling. Xcode has generated some default error handling in the generated `saveContext` method that works well enough for now. Ultimately, the `saveContext` method checks whether we have any changes floating in the managed object context by calling its `hasChanges` method, and then calls `save`.

The `applicationDocumentsDirectory` method returns, as you would imagine, this application's documents directory. The persistent store coordinator calls this method to determine where on the file system to create the persistent store.

The Swift version of the generated project doesn't have a header file, of course, but it has the same properties, as well as corresponding calls for the method declarations we just examined (`saveContext` and `applicationDocumentsDirectory:`). The source doesn't group the properties for the Core Data stack together, but if you read through `AppDelegate.swift`, you'll find them, initialized using closures (not shown here), as Listing 1-2 shows.

Listing 1-2. Core Data properties in `AppDelegate.swift`

```
lazy var managedObjectModel: NSManagedObjectModel
lazy var persistentStoreCoordinator: NSPersistentStoreCoordinator?
lazy var managedObjectContext: NSManagedObjectContext?
```

Initializing the Core Data Components

Xcode's generated code for Core Data initializes the Core Data stack lazily, when its components are first accessed. You can certainly use this approach for all your Core Data applications, and for CoreDataApp we'll leave the default Xcode implementation. You also, however, can set up your Core Data stack when your application launches. We also use that approach in this book.

The Core Data stack for CoreDataApp initializes when you first access the managed object context, materialized by the `managedObjectContext` property. Listing 1-3 contains the code for `managedObjectContext`'s Objective-C accessor, and Listing 1-4 shows the same accessor in Swift.

Listing 1-3. The Accessor for `managedObjectContext in Objective-C`

```
// Returns the managed object context for the application.
// If the context doesn't already exist, it is created and bound to the persistent store coordinator
for the application.
- (NSManagedObjectContext *)managedObjectContext
{
  if (_managedObjectContext != nil) {
    return _managedObjectContext;
  }

  NSPersistentStoreCoordinator *coordinator = [self persistentStoreCoordinator];
  if (coordinator != nil) {
    _managedObjectContext = [[NSManagedObjectContext alloc] init];
    [_managedObjectContext setPersistentStoreCoordinator:coordinator];
  }
  return _managedObjectContext;
}
```

Listing 1-4. The Accessor for `managedObjectContext` in Swift

```
lazy var managedObjectContext: NSManagedObjectContext? = {
  // Returns the managed object context for the application (which is already bound to the
  persistent store coordinator for the application.) This property is optional since there are
  legitimate error conditions that could cause the creation of the context to fail.
  let coordinator = self.persistentStoreCoordinator
  if coordinator == nil {
    return nil
  }
  var managedObjectContext = NSManagedObjectContext()
  managedObjectContext.persistentStoreCoordinator = coordinator
  return managedObjectContext
}()
```

As the comment generated by Xcode attests, the accessor checks to see whether the `managedObjectContext` property (synthesized as `_managedObjectContext`) has been created. If so, the accessor returns it. If not, it retrieves the `persistentStoreCoordinator` property, allocates and initializes the managed object context, and sets its persistent store coordinator to the retrieved `persistentStoreCoordinator`.

The accessor for `persistentStoreCoordinator`, shown in Listing 1-5 (Objective-C) and Listing 1-6 (Swift), does its own lazy initialization. Note that we've removed the long comment about error handling, which Chapter 4 covers. As you can see, this code checks whether the `persistentStoreCoordinator` property (synthesized as `_persistentStoreCoordinator`) has been created. If not, it determines the URL (uniform resource locator) for the persistent store by tacking the file name, `CoreDataApp.sqlite (or CoreDataAppSwift.sqlite)`, onto the directory returned by the `applicationDocumentsDirectory` helper discussed earlier in this chapter, and stores it in `storeURL`. It then allocates the `persistentStoreCoordinator` property, initializes it with the managed object model returned by the `managedObjectModel` accessor, and adds a persistent store that points to the URL created in `storeURL`.

Listing 1-5. The Objective-C Accessor for `persistentStoreCoordinator`

```
// Returns the persistent store coordinator for the application.
// If the coordinator doesn't already exist, it is created and the application's store added to it.
- (NSPersistentStoreCoordinator *)persistentStoreCoordinator
{
  if (_persistentStoreCoordinator != nil) {
    return _persistentStoreCoordinator;
  }
    NSURL *storeURL = [[self applicationDocumentsDirectory] URLByAppendingPathComponent:
    @"CoreDataApp.sqlite"];

  NSError *error = nil;
  _persistentStoreCoordinator = [[NSPersistentStoreCoordinator alloc] initWithManagedObjectModel:
  [self managedObjectModel]];
  if (![_persistentStoreCoordinator addPersistentStoreWithType:NSSQLiteStoreType configuration:
  nil URL:storeURL options:nil error:&error]) {
    /* Comment deleted */
    NSLog(@"Unresolved error %@, %@", error, [error userInfo]);
    abort();
  }

  return _persistentStoreCoordinator;
}
```

Listing 1-6. The Swift Accessor for `persistentStoreCoordinator`

```
lazy var persistentStoreCoordinator: NSPersistentStoreCoordinator? = {
    // The persistent store coordinator for the application. This implementation creates and return
    a coordinator, having added the store for the application to it. This property is optional since
    there are legitimate error conditions that could cause the creation of the store to fail.
    // Create the coordinator and store
    var coordinator: NSPersistentStoreCoordinator? = NSPersistentStoreCoordinator(managedObjectMode
    l: self.managedObjectModel)
    let url = self.applicationDocumentsDirectory.URLByAppendingPathComponent("CoreDataAppSwift.
    sqlite")
    var error: NSError? = nil
    var failureReason = "There was an error creating or loading the application's saved data."
    if coordinator!.addPersistentStoreWithType(NSSQLiteStoreType, configuration: nil, URL: url,
    options: nil, error: &error) == nil {
        coordinator = nil
        // Report any error we got.
        let dict = NSMutableDictionary()
        dict[NSLocalizedDescriptionKey] = "Failed to initialize the application's saved data"
        dict[NSLocalizedFailureReasonErrorKey] = failureReason
        dict[NSUnderlyingErrorKey] = error
        error = NSError(domain: "YOUR_ERROR_DOMAIN", code: 9999, userInfo: dict)
        // Replace this with code to handle the error appropriately.
        // abort() causes the application to generate a crash log and terminate. You should not use
        this function in a shipping application, although it may be useful during development.
        NSLog("Unresolved error \(error), \(error!.userInfo)")
        abort()
    }

    return coordinator
}()
```

We have one more piece of lazy initialization to review, found in the accessor for managedObjectModel and shown in Listing 1-7 (Objective-C) and Listing 1-8 (Swift). This code, like the other accessors, returns the managedObjectModel property (synthesized as _managedObjectModel) if it has been initialized. Otherwise, the code initializes it by storing the URL for the compiled managed object model, CoreDataApp.momd (CoreDataAppSwift.momd), in the modelURL variable, allocating the managedObjectModel property, and initializing it with the URL to the managed object model.

Listing 1-7. The Objective-C Accessor for managedObjectModel

```
// Returns the managed object model for the application.
// If the model doesn't already exist, it is created from the application's model.
- (NSManagedObjectModel *)managedObjectModel
{
  if (_managedObjectModel != nil) {
    return _managedObjectModel;
  }
  NSURL *modelURL = [[NSBundle mainBundle] URLForResource:@"CoreDataApp" withExtension:@"momd"];
  _managedObjectModel = [[NSManagedObjectModel alloc] initWithContentsOfURL:modelURL];
  return _managedObjectModel;
}
```

Listing 1-8. The Swift Accessor for managedObjectModel

```
lazy var managedObjectModel: NSManagedObjectModel = {
    // The managed object model for the application. This property is not optional. It is a fatal
error for the application not to be able to find and load its model.
    let modelURL = NSBundle.mainBundle().URLForResource("CoreDataAppSwift", withExtension: "momd")!
    return NSManagedObjectModel(contentsOfURL: modelURL)!
}()
```

The lazy-initialization approach works just fine and ensures that all pieces of the Core Data stack get initialized when they're needed. Feel free to continue to use this approach in your Core Data–based applications. The second application we build in this chapter, PersistenceApp, takes a different approach: it contains all the Core Data interactions in a single class, `Persistence`, that directly initializes the Core Data stack. Feel free to use either approach in your Core Data applications.

Creating a Managed Object Model

Xcode has created an empty object model for us, `CoreDataApp.xcdatamodeld` (or `CoreDataAppSwift.xcdatamodeld`), which you can see by selecting it in the Xcode Project Navigator (see Figure 1-3).

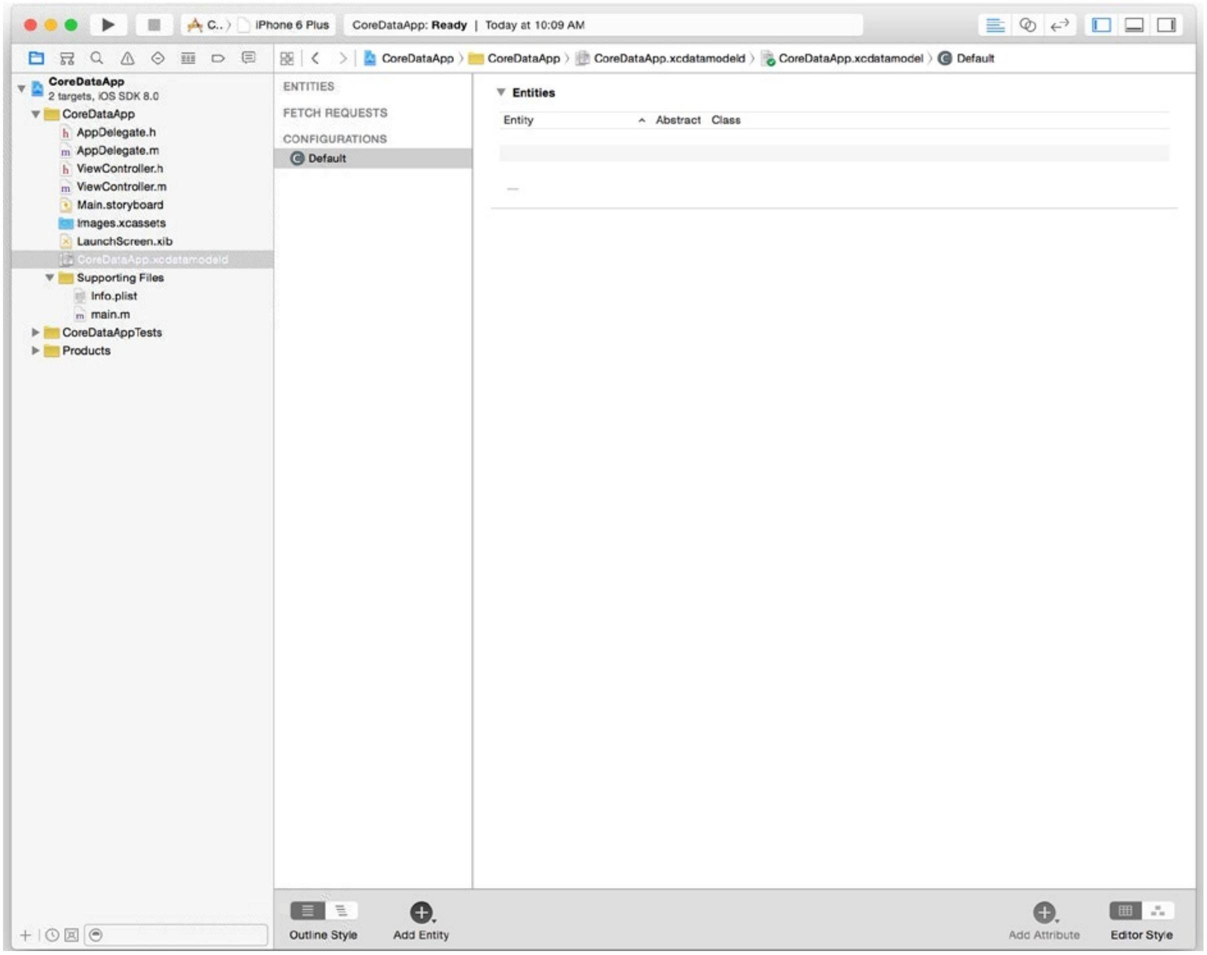


Figure 1-3. An empty object model

For the CoreDataApp application, we want to create a single entity called `Person` that has a single attribute called `name`. Note the convention of capitalizing the entity name and lowercasing the attribute name; this naming approach is optional but conforms well to standard coding practices. We use it throughout the book.

To create this entity, click the Add Entity button at the bottom of the Xcode window. This will create an entity called `Entity`. Rename it `Person`. Then, click the + button under Attributes and create an attribute called `name` and change its type from `Undefined` to `String`. Your object model should now match Figure 1-4.

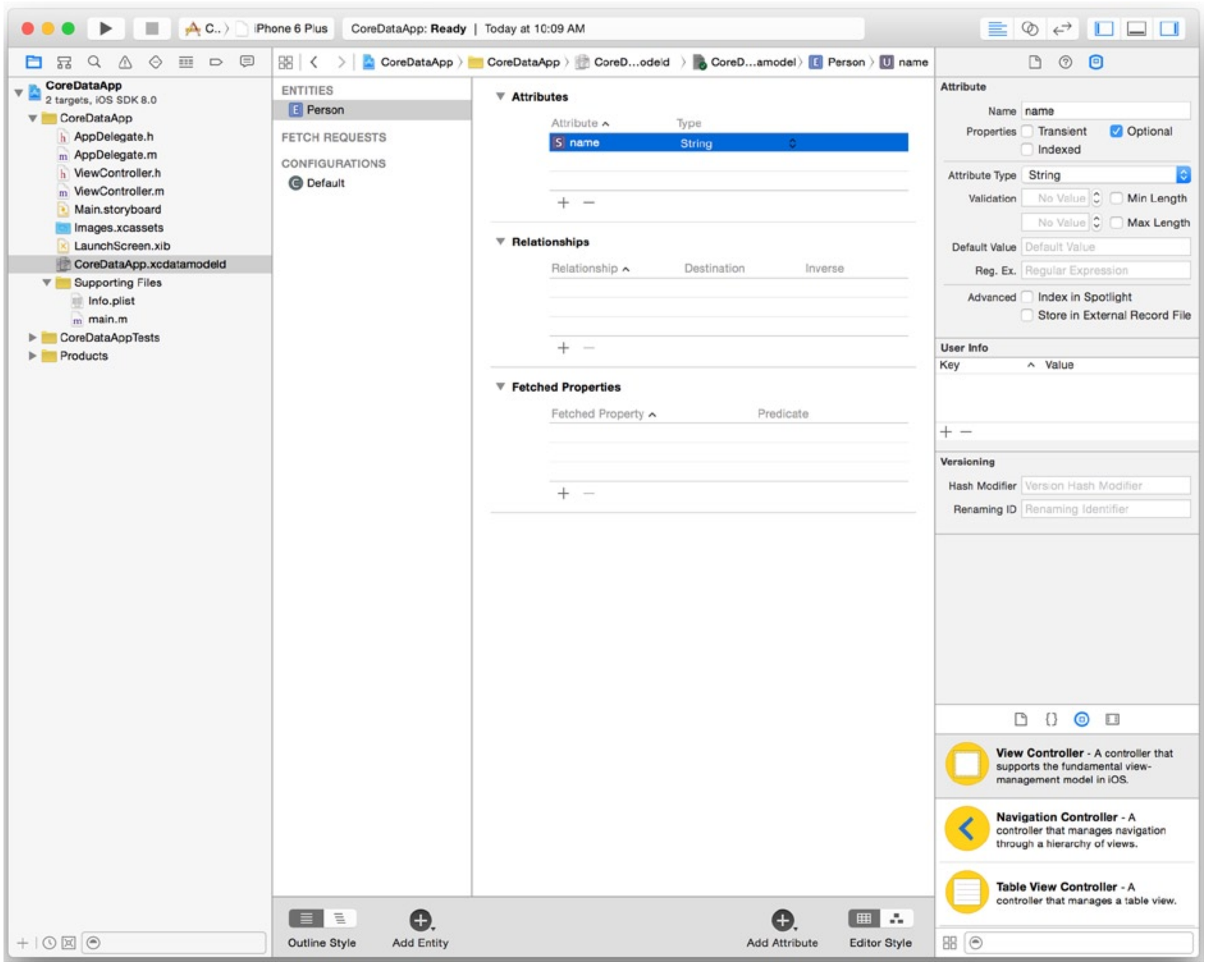


***Figure 1-4.** The object model with the `Person` entity*

Xcode will compile and load this object model into the `managedObjectModel` property.

Adding Some Objects

Before running the CoreDataApp application, open AppDelegate.m, add code to the applicati on:didFinishLaunchingWithOptions: method to initialize the Core Data stack by accessing the managedObjectContext property, create some managed objects, and save the managed object context. Listing 1-9 shows the updated method.

Listing 1-9. The Updated application:didFinishLaunchingWithOptions: Method

```
- (BOOL)application:(UIApplication *)application didFinishLaunchingWithOptions:(NSDictionary *)
launchOptions {
  NSManagedObject *object1 = [NSEntityDescription insertNewObjectForEntityForName:@"Person"
  inManagedObjectContext:self.managedObjectContext];
  [object1 setValue:@"Tarzan" forKey:@"name"];

  NSManagedObject *object2 = [NSEntityDescription insertNewObjectForEntityForName:@"Person"
  inManagedObjectContext:self.managedObjectContext];
  [object2 setValue:@"Jane" forKey:@"name"];

  [self saveContext];

  return YES;
}
```

If you're working with Swift, open AppDelegate.swift instead, and update as shown in Listing 1-10.

Listing 1-10. The updated application:didFinishLaunchingWithOptions: function

```
func application(application: UIApplication!, didFinishLaunchingWithOptions launchOptions:
NSDictionary!) -> Bool {
  let object1 = NSEntityDescription.insertNewObjectForEntityForName("Person",
  inManagedObjectContext: self.managedObjectContext!) as NSManagedObject
  object1.setValue("Tarzan", forKey: "name")

  let object2 = NSEntityDescription.insertNewObjectForEntityForName("Person",
  inManagedObjectContext: self.managedObjectContext!) as NSManagedObject
  object2.setValue("Jane", forKey: "name")

  saveContext()

  return true
}
```

This code creates two new Person managed objects, object1 and object2, and sets their name attributes to "Tarzan" and "Jane," respectively. Note that managed objects use Cocoa's standard KVC to set values for attributes. You can also create custom classes for your entities with direct accessors for attributes, so that you can write code as follows:

```
object1.name = @"Tarzan";
```

Chapter 2 discusses custom classes.

We create the managed objects by inserting them into a managed object context: our `managedObjectContext` property. By accessing that property, we start the chain that initializes our entire Core Data stack.

After creating the two managed objects, this code saves the managed object context using the `saveContext` helper, before throwing a blank window onto the screen. Build and run the application to create the managed objects in the persistent store and see the blank window. Then stop the application.

Viewing the Data

The CoreDataApp application doesn't have any code to display the contents of its persistent store. How, then, can we verify that the application actually created and stored data? For that, we examine the SQLite database file, `CoreDataApp.sqlite or CoreDataAppSwift.sqlite`, directly. When you run the application in the iOS Simulator, the application writes this file to a directory below your home directory. The easiest way to find this file is to open a terminal and type

```
find ~ -name 'CoreDataApp.sqlite'
```

Once you locate the file, change to that directory and open the file using the sqlite3 application.

```
sqlite3 CoreDataApp.sqlite
```

Alternatively, you can open the file directly using the `find` command:

```
find ~ -name 'CoreDataApp.sqlite' -exec sqlite3 {} \;
```

Let's first examine the database schema by typing the `.schema` command at the `sqlite>` prompt.

```
sqlite> .schema
CREATE TABLE ZPERSON ( Z_PK INTEGER PRIMARY KEY, Z_ENT INTEGER, Z_OPT INTEGER, ZNAME VARCHAR );
CREATE TABLE Z_METADATA (Z_VERSION INTEGER PRIMARY KEY, Z_UUID VARCHAR(255), Z_PLIST BLOB);
CREATE TABLE Z_PRIMARYKEY (Z_ENT INTEGER PRIMARY KEY, Z_NAME VARCHAR, Z_SUPER INTEGER, Z_MAX INTEGER);
```

You see three tables, two of which (`Z_METADATA` and `Z_PRIMARYKEY`) Core Data uses for database management tasks. The third, `ZPERSON`, stores `Person` entities. You can see it has a column called `ZNAME`, of type `VARCHAR`, for storing the `name` attribute. Note that this schema, including tables, table names, and column names, among others, are undocumented implementation details subject to change. You can't rely on these patterns and should never access SQLite databases directly in any of your Core Data–based applications. For testing purposes, however, like what we're doing here, you're safe to mess around.

Let's verify that the CoreDataApp application created and stored the two `Person` managed objects:

```
sqlite> select * from zperson;
1|1|1|Tarzan
2|1|1|Jane
sqlite> .quit
```

You can confirm that, indeed, the CoreDataApp application has successfully used the Core Data framework to create and store data.

Adding Core Data to an Existing Project

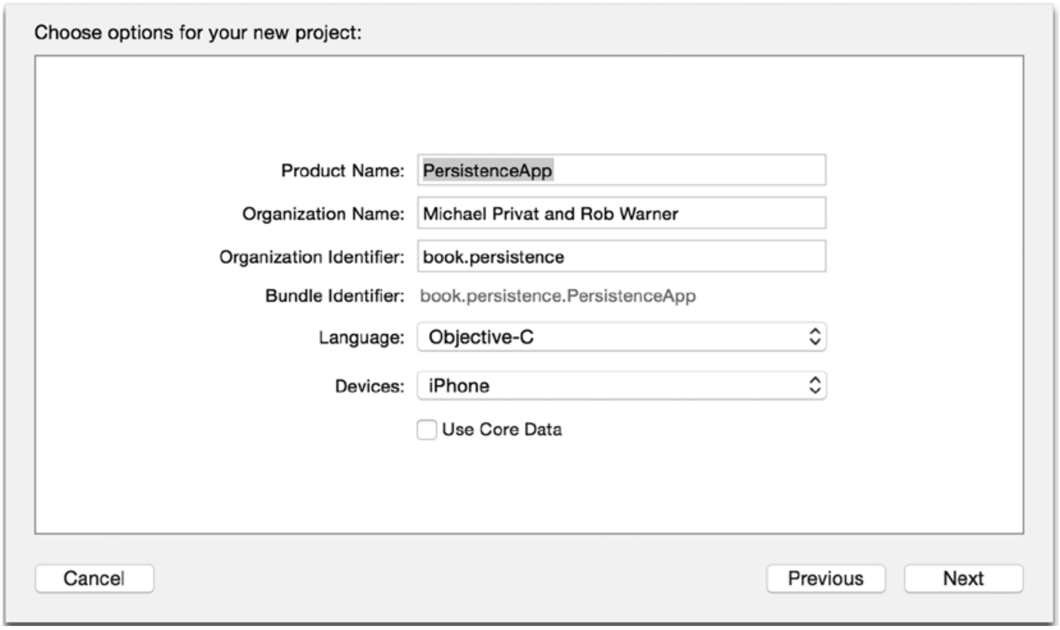
Now that you understand how Core Data works, you can see how easy it is to add to an existing project. Just follow the same steps that Xcode does when you check the Use Core Data check box.

- Import the Core Data header file (`CoreData/CoreData.h`) or add `@import CoreData` for Objective-C, or add `import CoreData` for Swift.
- Add a managed object model to your application.
- Add code to your application to initialize the Core Data stack and grant access to the managed object context.

You can mimic Xcode's generated code for initializing the Core Data stack or follow a different pattern. We use both approaches throughout this book. However you approach the problem, the basic steps are the same.

Creating a Core Data-less Application

To add Core Data to an existing application, we must first have a Core Data-less application to add to. Create a new Xcode project using the single view application template and call it PersistenceApp. Be sure to uncheck the Use Core Data check box (see Figure 1-5).


Choose options for your new project:

Product Name: PersistenceApp
Organization Name: Michael Privat and Rob Warner
Organization Identifier: book.persistence
Bundle Identifier: book.persistence.PersistenceApp
Language: Objective-C
Devices: iPhone
☐ Use Core Data

Figure 1-5. Creating the PersistenceApp project

Adding the Core Data Framework

Your application must link against the Core Data framework, aptly named `CoreData.framework`, in order to use Core Data classes. While adding the Core Data framework to your project used to require a dozen mouse clicks, Xcode's recent updates have introduced the notion of module imports. To link the Core Data framework to your project, simply add an `@import CoreData;` directive when you need access to Core Data classes in your Objective-C project, or `import CoreData` in your Swift project. Xcode will do the rest of the linking work.

Adding a Managed Object Model

A Core Data–based application requires a managed object model, so add a new file to the PersistenceApp group using the Core Data ⦿ Data Model template. Yes, even Xcode calls it a data model, not a managed object model. You can call the model whatever you'd like; you just have to match the name when creating your persistence store. For the sake of convention, though, call it `PersistenceApp.xcdatamodeld`. When you're done, you should have an empty Core Data model called `PersistenceApp.xcdatamodeld`, as shown in Figure 1-6.

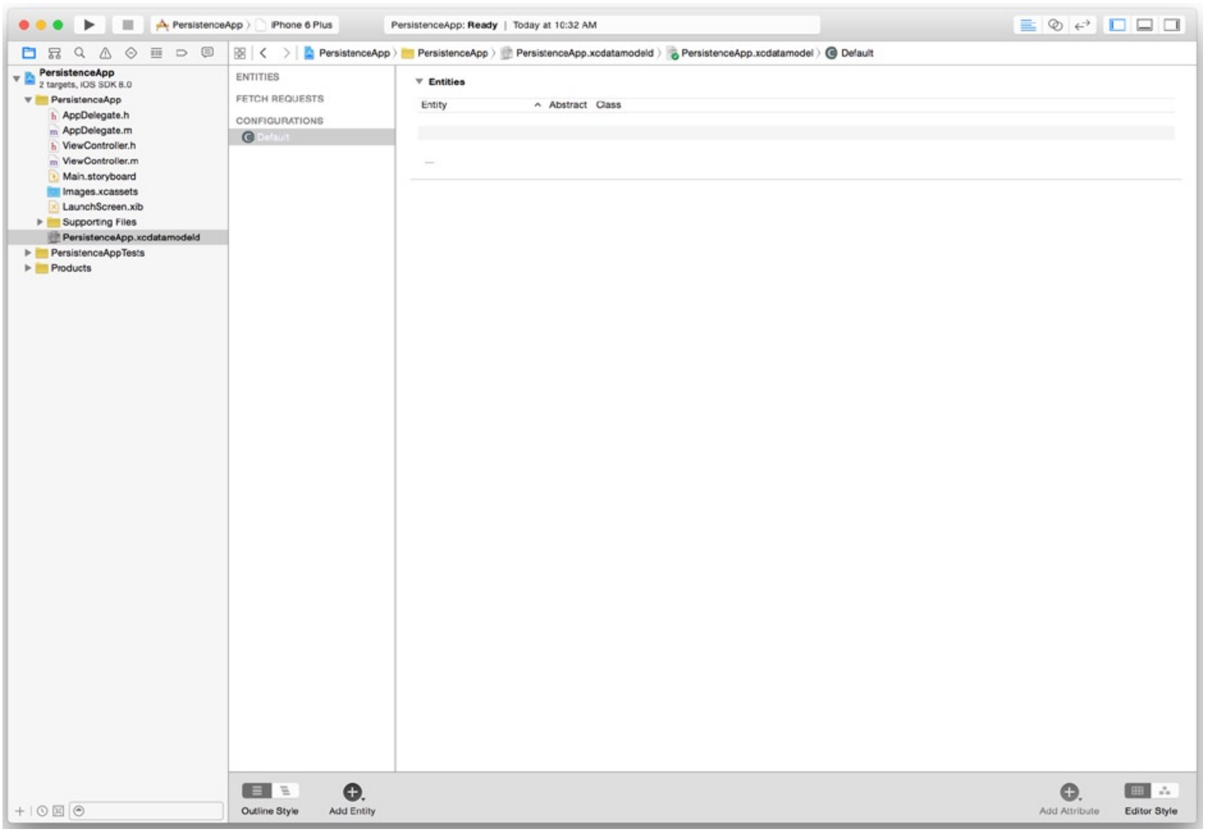


Figure 1-6. The empty `PersistenceApp.xcdatamodeld` managed object model

We'll add entities and attributes to the model later. For now, we'll continue to focus on adding everything necessary for Core Data to the application.

Adding and Initializing the Core Data Stack

For the PersistenceApp application, we're going to put all the Core Data stuff into a separate class called `Persistence`, and add an instance of that class as a property in our `AppDelegate` class. This will allow us to keep our `AppDelegate` class's code cleaner and provide a clean interface for Core Data access.

Create a new file in the `PersistenceApp` group using the Source ⦿ Cocoa Touch Class template, call it `Persistence`, and make it a subclass of `NSObject`. Now, if you're doing this in Objective-C, add the Core Data properties and helper method declarations to `Persistence.h`, as shown in Listing 1-11.

Listing 1-11. `Persistence.h`

```
#import <Foundation/Foundation.h>
@import CoreData;

@interface Persistence : NSObject

@property (readonly, strong, nonatomic) NSManagedObjectContext *managedObjectContext;
@property (readonly, strong, nonatomic) NSManagedObjectModel *managedObjectModel;
@property (readonly, strong, nonatomic) NSPersistentStoreCoordinator *persistentStoreCoordinator;

- (void)saveContext;
- (NSURL *)applicationDocumentsDirectory;

@end
```

In the implementation file, `Persistence.m`, add implementations for the two helper methods, which don't deviate much from the Xcode-generated versions, as shown in Listing 1-12.

Listing 1-12. Helper Method Implementations in `Persistence.m`

```
- (void)saveContext {
  NSError *error;
  if ([self.managedObjectContext hasChanges] && ![self.managedObjectContext save:&error]) {
    NSLog(@"Unresolved error %@, %@", error, [error userInfo]);
    abort();
  }
}

- (NSURL *)applicationDocumentsDirectory {
  return [[[NSFileManager defaultManager] URLsForDirectory:NSDocumentDirectory
  inDomains:NSUserDomainMask] lastObject];
}
```

Notice that we don't check whether the managedObjectContext property is nil before saving, because we're going to create it when the Persistence instance is initialized so we know it won't be nil. We retain the naive error handling, though, for now.

To initialize the Core Data stack, add an implementation for init that creates the managed object model, the persistent store coordinator, and the managed object context, as shown in Listing 1-13.

Listing 1-13. Initializing the Core Data Stack in Persistence.m

```
- (id)init {
  self = [super init];
  if (self != nil) {
    // Initialize the managed object model
    NSURL *modelURL = [[NSBundle mainBundle] URLForResource:@"PersistenceApp"
    withExtension:@"momd"];
    _managedObjectModel = [[NSManagedObjectModel alloc] initWithContentsOfURL:modelURL];

    // Initialize the persistent store coordinator
    NSURL *storeURL = [[self applicationDocumentsDirectory] URLByAppendingPathComponent:
    @"PersistenceApp.sqlite"];

    NSError *error = nil;
    _persistentStoreCoordinator = [[NSPersistentStoreCoordinator alloc]
    initWithManagedObjectModel:self.managedObjectModel];
    if (![_persistentStoreCoordinator addPersistentStoreWithType:NSSQLiteStoreType
                                                   configuration:nil
                                                             URL:storeURL
                                                         options:nil
                                                           error:&error]) {
      NSLog(@"Unresolved error %@, %@", error, [error userInfo]);
      abort();
    }

    // Initialize the managed object context
    _managedObjectContext = [[NSManagedObjectContext alloc] init];
    [_managedObjectContext setPersistentStoreCoordinator:self.persistentStoreCoordinator];
    }
  return self;
}
```

In Chapter 9, we modify this approach to use threads for better performance, but for now we perform all the initialization on the main thread.

To finish initializing the Core Data stack, we add a Persistence property to the application delegate and create it when the application loads. Open AppDelegate.h, add a forward declaration for Persistence, and add the property, so that the file matches Listing 1-14.

Listing 1-14. AppDelegate.h

```
#import <UIKit/UIKit.h>

@class Persistence;

@interface AppDelegate : UIResponder <UIApplicationDelegate>

@property (strong, nonatomic) UIWindow *window;
@property (strong, nonatomic) Persistence *persistence;

@end
```

Next, open AppDelegate.m and add an import for Persistence.h:

```
#import "Persistence.h"
```

As the last step of initializing the Core Data stack, allocate and initialize the persistence property in the application:didFinishLaunchingWithOptions method. This method should now match Listing 1-15.

Listing 1-15. Allocating and Initializing the persistence Property

```
- (BOOL)application:(UIApplication *)application didFinishLaunchingWithOptions:(NSDictionary *)
launchOptions {
  self.persistence = [[Persistence alloc] init];
  return YES;
}
```

If you're building this project in Swift, your work follows the same sort of pattern, albeit without the header files. In your Persistence class, add a variable for your managed object context. We'll do all the initialization in the closure for this managed object context variable. You also add helpers for saving the context and getting the application document directory. Listing 1-16 shows the updated Persistence.swift file, and Listing 1-17 shows the additions to AppDelegate.swift to create a Persistence instance. Note that the Core Data stack will initialize when we create the Persistence instance; if we wanted, instead, to initialize Core Data when the managed object context is first accessed, we'd simply add the @lazy annotation to the managed object context variable.

Listing 1-16. Persistence.swift Updated for Core Data

```
import Foundation
import CoreData

class Persistence: NSObject {

  var managedObjectContext: NSManagedObjectContext? = {
    // Initialize the managed object model
    let modelURL = NSBundle.mainBundle().URLForResource("PersistenceAppSwift", withExtension:
    "momd")!
    let managedObjectModel = NSManagedObjectModel(contentsOfURL: modelURL)
    // Initialize the persistent store coordinator
    let storeURL = Persistence.applicationDocumentsDirectory.URLByAppendingPathComponent("Persisten
    ceAppSwift.sqlite")
    var error: NSError? = nil
    let persistentStoreCoordinator = NSPersistentStoreCoordinator(managedObjectModel:
    managedObjectModel!)
    if persistentStoreCoordinator.addPersistentStoreWithType(NSSQLiteStoreType, configuration: nil,
    URL: storeURL, options: nil, error: &error) == nil {
      abort()
    }

    // Initialize the managed object context
    var managedObjectContext = NSManagedObjectContext()
    managedObjectContext.persistentStoreCoordinator = persistentStoreCoordinator

    return managedObjectContext
  }()

  func saveContext() {
    var error: NSError? = nil

    if  {
      if managedObjectContext.hasChanges && !managedObjectContext.save(&error) {
        abort()
      }
    }
  }

  class var applicationDocumentsDirectory: NSURL {
    let urls = NSFileManager.defaultManager().URLsForDirectory(.DocumentDirectory, inDomains:
    .UserDomainMask)
    return urls[urls.endIndex-1] as NSURL
  }
}
```

Listing 1-17. The Updated AppDelegate.swift

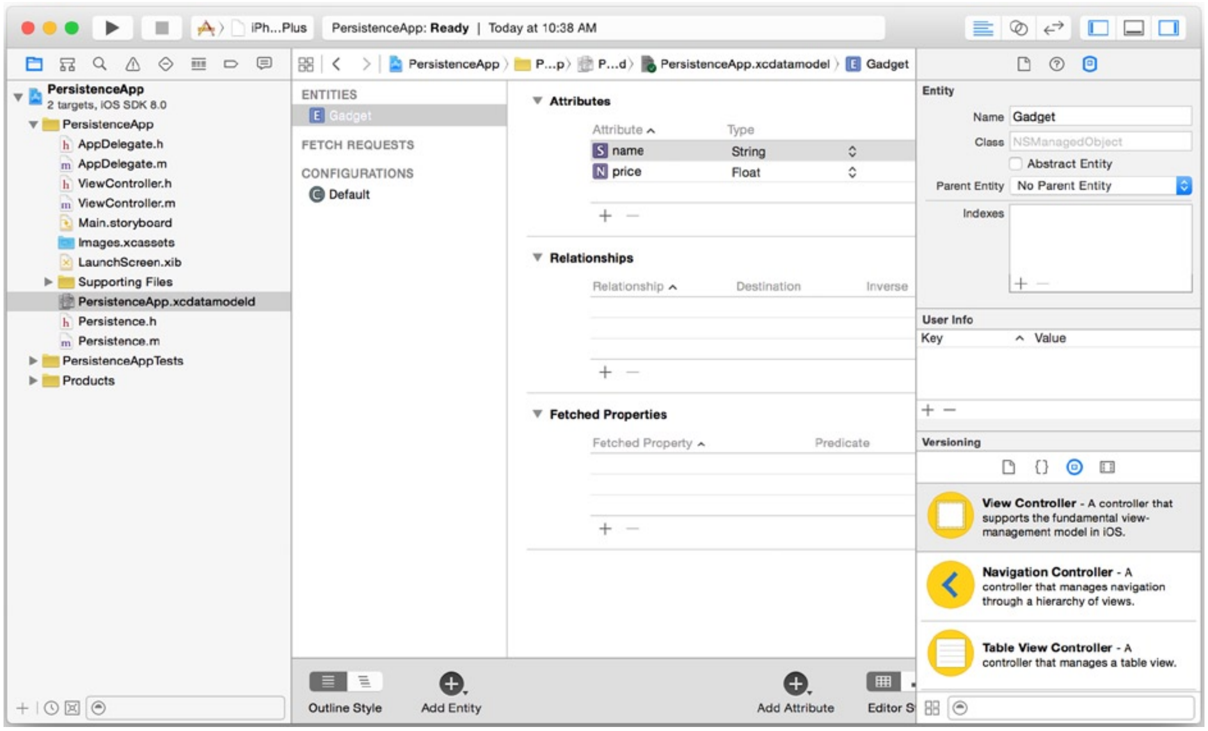
```
import UIKit
import CoreData

@UIApplicationMain
class AppDelegate: UIResponder, UIApplicationDelegate {

  var window: UIWindow?
  var persistence: Persistence?

  func application(application: UIApplication!, didFinishLaunchingWithOptions launchOptions:
  NSDictionary!) -> Bool {
    persistence = Persistence()
    return true
  }
  /* Code snipped */
}
```

The Core Data stack now properly initializes when the application runs, but without an object model or any objects in it, we can't really see evidence of that. The next step is to create an object model.

Creating the Object Model

At this point, we've added all the Core Data pieces to the application that Xcode would have done for us had we checked the Use Core Data check box. For an application that you manually add Core Data to, you create the object model in the same way that you did for an application for which you checked Xcode's Use Core Data check box.

For PersistenceApp, we store gadgets that have a name and a price. Open the object model, `PersistenceApp.xcdatamodeld`, in Xcode's Project Navigator, and add a `Gadget` entity with a `String` attribute called `name` and a `Float` attribute called `price`. Your data model should match Figure 1-7.



Attributes

Attribute	Type
name	String
price	Float

Entity

Name	Gadget
Class	NSManagedObject
	Abstract Entity
Parent Entity	No Parent Entity
Indexes	

***Figure 1-7.** The `Gadget` entity in the `PersistenceApp.xcdatamodeld` managed object model*

Now that we have an object model, we can create some objects in it.

Adding Objects to PersistenceApp

Once again, we use the `application:didFinishLaunchingWithOptions` method to add objects to the object model. This time, however, we'll do that work in another method that we call from `application:didFinishLaunchingWithOptions`. Also, instead of relying on the `sqlite3` command-line tool to view the stored data, we fetch the objects from the persistent store and log them to the console—again, from a separate method. To begin, add calls to the two methods that we will create in `application:didFinishLaunchingWithOptions`, so that the code matches Listing 1-18 (Objective-C) or Listing 1-19 (Swift).

Listing 1-18. Adding Calls to Create and Fetch Objects (Objective-C)

```
- (BOOL)application:(UIApplication *)application didFinishLaunchingWithOptions:(NSDictionary *)
launchOptions {
  self.persistence = [[PAPersistence alloc] init];
  [self createObjects];
  [self fetchObjects];

  return YES;
}
```

Listing 1-19. Adding Calls to Create and Fetch Objects (Swift)

```
func application(application: UIApplication!, didFinishLaunchingWithOptions launchOptions:
NSDictionary!) -> Bool {
  persistence = Persistence()

  createObjects()
  fetchObjects()

  return true
}
```

Then, create implementations for the new methods. The `createObjects` method should look familiar; as before, you create the objects in the managed object context, then save the context. This code creates four `Gadget` instances: an iPad, an iPad Mini, an iPhone, and an iPod touch. The prices for them are in US dollars, and may or may not be accurate! Listing 1-20 shows the Objective-C code, and Listing 1-21 shows the Swift code. One thing to notice: since KVC requires object values, not primitives, the prices we set on the objects are `NSNumber` instances, not primitive floats.

Listing 1-20. The Objective-C `createObjects` Method

```
- (void)createObjects {
  NSManagedObject *iPad = [NSEntityDescription insertNewObjectForEntityForName:@"Gadget"
  inManagedObjectContext:self.persistence.managedObjectContext];
  [iPad setValue:@"iPad" forKey:@"name"];
  [iPad setValue:@499.0f forKey:@"price"];

  NSManagedObject *iPadMini = [NSEntityDescription insertNewObjectForEntityForName:@"Gadget"
  inManagedObjectContext:self.persistence.managedObjectContext];
  [iPadMini setValue:@"iPad Mini" forKey:@"name"];
  [iPadMini setValue:@329.0f forKey:@"price"];

  NSManagedObject *iPhone = [NSEntityDescription insertNewObjectForEntityForName:@"Gadget"
  inManagedObjectContext:self.persistence.managedObjectContext];
  [iPhone setValue:@"iPhone" forKey:@"name"];
  [iPhone setValue:@199.0f forKey:@"price"];
  NSManagedObject *iPodTouch = [NSEntityDescription insertNewObjectForEntityForName:@"Gadget"
inManagedObjectContext:self.persistence.managedObjectContext];
  [iPodTouch setValue:@"iPod touch" forKey:@"name"];
  [iPodTouch setValue:@299.0f forKey:@"price"];

  [self.persistence saveContext];
}
```

Listing 1-21. The Swift `createObjects` function

```
  func createObjects() {
    if let persistence = persistence {
      let iPad = NSEntityDescription.insertNewObjectForEntityForName("Gadget",
      inManagedObjectContext: persistence.managedObjectContext!) as NSManagedObject
      iPad.setValue("iPad", forKey: "name")
      iPad.setValue(499, forKey: "price")

      let iPadMini = NSEntityDescription.insertNewObjectForEntityForName("Gadget",
      inManagedObjectContext: persistence.managedObjectContext!) as NSManagedObject
      iPadMini.setValue("iPad Mini", forKey: "name")
      iPadMini.setValue(329, forKey: "price")

      let iPhone = NSEntityDescription.insertNewObjectForEntityForName("Gadget",
      inManagedObjectContext: persistence.managedObjectContext!) as NSManagedObject
      iPhone.setValue("iPhone", forKey: "name")
      iPhone.setValue(199, forKey: "price")

      let iPodTouch = NSEntityDescription.insertNewObjectForEntityForName("Gadget",
      inManagedObjectContext: persistence.managedObjectContext!) as NSManagedObject
      iPodTouch.setValue("iPod Touch", forKey: "name")
      iPodTouch.setValue(299, forKey: "price")

      persistence.saveContext()
    }
    else {
      println("Error, persistence layer not initialized")
    }
  }
```

The `fetchObjects` method fetches the objects from the persistent store and uses `NSLog` (or `println`) to log them to the console. To fetch objects, we use the `NSFetchRequest` class, which represents a fetch request. A fetch request is tied to a particular entity and contains all the criteria describing what you want to fetch from that entity. With a fetch request, you can do things like set limits, specify criteria that objects must match, sort the results, and use advanced aggregators to massage the results the fetch request returns. Chapter 2 explains more about how to use `NSFetchRequest`, and then Chapter 3 goes deeper into the powers of fetching data. At this point, however, we stay simple in our usage of `NSFetchRequest` and just fetch all of the objects from our `Gadget` entity.

Before iOS 5.0, you typically created and used an `NSFetchRequest` instance by allocating and initializing one, creating an `NSEntityDescription` instance, and setting the entity for the `NSFetchRequest` instance to the `NSEntityDescription` instance, as shown in Listing 1-22.

Listing 1-22. Pre-iOS 5.0 `NSFetchRequest` Creation

```
NSFetchRequest *fetchRequest = [[NSFetchRequest alloc] init];
[fetchRequest setEntity:[NSEntityDescription entityForName:@"Gadget"
                                inManagedObjectContext:self.persistence.managedObjectContext]];
```

In iOS 5.0, Apple added a couple of convenience methods for `NSFetchRequest` so you don't have to create an `NSEntityDescription` instance or take two lines of code to tie your `NSFetchRequest` instance to an entity. One is an initializer that takes an entity name, and the other is a class method that takes an entity name. Listing 1-23 shows two ways to create an `NSFetchRequest` instance in iOS 5.0 or later.

Listing 1-23. Creating `NSFetchRequest` Instances in iOS 5.0 and Later

```
NSFetchRequest *fetchRequest1 = [[NSFetchRequest alloc] initWithEntityName:@"Gadget"];
NSFetchRequest *fetchRequest2 = [NSFetchRequest fetchRequestWithEntityName:@"Gadget"];
```

You can use any of the approaches. You might notice, however, that the pre-iOS 5.0 approach specified the managed object context for the entity, while the iOS 5.0-and-later approach does not. How, then, does the `NSFetchRequest` instance know which managed object context to use to find the entity?

The answer to that is that actually executing a fetch request is a method on the managed object context. For the later approaches, the managed object context uses the fetch request's entity name to look up the actual `NSEntityDescription` when it executes the fetch request. Listing 1-24 shows how to execute a fetch request.

Listing 1-24. Executing a Fetch Request

```
NSError *error;
NSManagedObjectContext *managedObjectContext = ...; // Get from somewhere
NSArray *objects = [managedObjectContext executeFetchRequest:fetchRequest error:&error];
```

You can pass `nil` for `error` if you don't care about any error results, but you'll usually want error information so you can handle the errors. Again, Chapter 4 covers error handling.

With this nascent knowledge of fetch requests, we can implement the `fetchObjects` method, as shown in Listing 1-25 (Objective-C) or Listing 1-26 (Swift). This method creates a fetch request, executes it against the managed object context, and displays the results in the console.

Listing 1-25. The Objective-C `fetchObjects` Method

```
- (void)fetchObjects {
  // Fetch the objects
  NSFetchRequest *fetchRequest = [NSFetchRequest fetchRequestWithEntityName:@"Gadget"];
  NSArray *objects = [self.persistence.managedObjectContext executeFetchRequest:fetchRequest
  error:nil];

  // Log the objects
  for (NSManagedObject *object in objects) {
    NSLog(@"%@", object);
  }
}
```

Listing 1-26. The Swift `fetchObjects` function

```
func fetchObjects() {
  if let persistence = persistence {
    let fetchRequest = NSFetchRequest(entityName: "Gadget")
    var error : NSError?
    let objects = persistence.managedObjectContext!.executeFetchRequest(fetchRequest, error: &error)
as [NSManagedObject]
    if let error = error {
      println("Something went wrong: \(error.localizedDescription)")
    }

    for object in objects {
      println(object)
    }
  }
  else {
    println("Error, persistence layer not initialized")
  }
}
```

Build and run the application. You should see a blank screen in the iOS Simulator, and in the Xcode Console you should see output that looks something like the following:

```
2014-07-07 21:49:40.537 PersistenceApp[8878:83583] <NSManagedObject: 0x7faa21e380b0> (entity:
Gadget; id: 0xd000000000040000 <x-coredata://D2570307-5795-4E9A-96C9-7B477D27AB5D/Gadget/p1> ;
data: {
    name = "iPad Mini";
    price = 329;
})
2014-07-07 21:49:40.538 PersistenceApp[8878:83583] <NSManagedObject: 0x7faa21e386a0> (entity:
Gadget; id: 0xd000000000080000 <x-coredata://D2570307-5795-4E9A-96C9-7B477D27AB5D/Gadget/p2> ;
data: {
    name = "iPod touch";
    price = 299;
})
2014-07-07 21:49:40.538 PersistenceApp[8878:83583] <NSManagedObject: 0x7faa21e38580> (entity:
Gadget; id: 0xd0000000000c0000 <x-coredata://D2570307-5795-4E9A-96C9-7B477D27AB5D/Gadget/p3> ;
data: {
    name = iPhone;
    price = 199;
})
2014-07-07 21:49:40.538 PersistenceApp[8878:83583] <NSManagedObject: 0x7faa21e37340> (entity:
Gadget; id: 0xd000000000100000 <x-coredata://D2570307-5795-4E9A-96C9-7B477D27AB5D/Gadget/p4> ;
data: {
    name = iPad;
    price = 499;
})
```

If you're running the Swift version of the app, the output is a little more compact, as the following shows:

```
<NSManagedObject: 0x7be633a0> (entity: Gadget; id: 0x7be68180 <x-coredata://9796AAF7-58AA-4B3A-86B8-
A1897330E17F/Gadget/p1> ; data: {
    name = iPad;
    price = 499;
})
<NSManagedObject: 0x7be66d60> (entity: Gadget; id: 0x7be681e0 <x-coredata://9796AAF7-58AA-4B3A-86B8-
A1897330E17F/Gadget/p2> ; data: {
    name = iPhone;
    price = 199;
})
<NSManagedObject: 0x7be666b0> (entity: Gadget; id: 0x7be681d0 <x-coredata://9796AAF7-58AA-4B3A-86B8-
A1897330E17F/Gadget/p3> ; data: {
    name = "iPad Mini";
    price = 329;
})
<NSManagedObject: 0x7be66e20> (entity: Gadget; id: 0x7be68250 <x-coredata://9796AAF7-58AA-4B3A-86B8-
A1897330E17F/Gadget/p4> ; data: {
    name = "iPod Touch";
    price = 299;
})
```

As before, you can also explore the SQLite database using `sqlite3`, but the log messages evidence that the objects were stored and retrieved.

Wrapping Up

In this chapter, you learned what Core Data is and what it's used for. You learned about the importance of persistence for data. You learned about the components of Core Data and how they work together. You built two Core Data–based applications: one that makes Xcode set up for you, and one in which you set up Core Data for yourself. You stored data in your Core Data persistent stores and retrieved them.

The applications you built in this chapter used anemic object models. In the next chapter, we build on the knowledge from this chapter to create more complex object models. You'll also learn about concepts like sorting and using predicates, and you'll understand the power of the Core Data object model.