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# iOS App Programming Guide

[General](#)



2011-10-12



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# Contents

---

## Introduction      **About iOS App Programming 9**

---

- At a Glance 10
  - Translate Your Initial Idea into an Implementation Plan 10
  - UIKit Provides the Core of Your App 10
  - Apps Must Behave Differently in the Foreground and Background 10
  - iCloud Affects the Design of Your Data Model and UI Layers 11
  - Apps Require Some Specific Resources 11
  - Many App Behaviors Can Be Customized 11
  - Apps Must Be Tuned for Performance 11
  - The iOS Environment Affects Many App Behaviors 12
- How to Use This Document 12
- Prerequisites 12
- See Also 12

---

## Chapter 1      **App Design Basics 15**

---

- Doing Your Initial Design 15
- Learning the Fundamental iOS Design Patterns and Techniques 15
- Translating Your Initial Design into an Action Plan 16
- Starting the App Creation Process 17

---

## Chapter 2      **Core App Objects 21**

---

- The Core Objects of Your App 21
- The Data Model 24
  - Defining a Custom Data Model 24
  - Defining a Structured Data Model Using Core Data 26
  - Defining a Document-Based Data Model 27
- The User Interface 28
  - Building an Interface Using UIKit Views 28
  - Building an Interface Using Views and OpenGL ES 29
- The App Bundle 30

---

## Chapter 3      **App States and Multitasking 35**

---

- Managing App State Changes 35
- The App Launch Cycle 37
- Responding to Interruptions 42
- Moving to the Background 43
- Returning to the Foreground 46
- App Termination 48

The Main Run Loop	49
Background Execution and Multitasking	51
Determining Whether Multitasking Is Available	51
Executing a Finite-Length Task in the Background	52
Scheduling the Delivery of Local Notifications	53
Implementing Long-Running Background Tasks	54
Being a Responsible Background App	58
Opting out of Background Execution	59
Concurrency and Secondary Threads	60

---

**Chapter 4****iCloud Storage 61**

Design Considerations for iCloud Apps	61
Configuring Your App's iCloud Entitlements	63
Using iCloud Document Storage	64
Determining if iCloud Document Storage is Available	66
Incorporating File Presenters into Your Workflow	66
Manipulating Files and Directories in iCloud	66
Choosing a Strategy to Respond to Version Conflicts	67
Incorporating Search into Your Infrastructure	68
Determining the Transfer Status of a File or Directory	69
Working With Files That Are Not Yet Downloaded	70
Updating Your User Interface for iCloud	70
Using iCloud in Conjunction with Databases	71
Using iCloud Key-Value Data Storage	74
Being a Responsible iCloud App	75

---

**Chapter 5****App-Related Resources 77**

App Store Required Resources	77
The Information Property List File	77
Declaring the Required Device Capabilities	78
Declaring Your App's Supported Document Types	80
App Icons	81
App Launch (Default) Images	83
Providing Launch Images for Different Orientations	84
Providing Device-Specific Launch Images	85
Providing Launch Images for Custom URL Schemes	85
The Settings Bundle	86
Localized Resource Files	87

---

**Chapter 6****Advanced App Tricks 89**

Creating a Universal App	89
Updating Your Info.plist Settings	89
Implementing Your View Controllers and Views	90

Adding Runtime Checks for Newer Symbols	91
Using Runtime Checks to Create Conditional Code Paths	91
Updating Your Resource Files	92
Preserving the State of Your App’s User Interface	92
Launching in Landscape Mode	93
Installing App-Specific Data Files at First Launch	94
Protecting Data Using On-Disk Encryption	94
Tips for Developing a VoIP App	95
Configuring Sockets for VoIP Usage	96
Installing a Keep-Alive Handler	97
Configuring Your App’s Audio Session	97
Using the Reachability Interfaces to Improve the User Experience	98
Communicating with Other Apps	98
Implementing Custom URL Schemes	99
Registering Custom URL Schemes	99
Handling URL Requests	100
Showing and Hiding the Keyboard	104
Turning Off Screen Locking	104

---

**Chapter 7      Performance Tuning 105**

Make App Backups More Efficient	105
What Is Backed Up?	105
Files Saved During App Updates	106
Use Memory Efficiently	106
Observe Low-Memory Warnings	107
Reduce Your App’s Memory Footprint	107
Allocate Memory Wisely	108
Move Work off the Main Thread	109
Floating-Point Math Considerations	109
Reduce Power Consumption	109
Tune Your Code	111
Improve File Access Times	111
Tune Your Networking Code	112
Tips for Efficient Networking	112
Using Wi-Fi	112
The Airplane Mode Alert	113

---

**Appendix A      The iOS Environment 115**

Specialized System Behaviors	115
The Virtual Memory System	115
The Automatic Sleep Timer	115
Multitasking Support	116
Security	116
The App Sandbox	116

[Keychain Data 117](#)

**[Document Revision History 119](#)**

---

# Figures, Tables, and Listings

<b>Chapter 2</b>	<b>Core App Objects 21</b>
	Figure 2-1 Key objects in an iOS app 22 Figure 2-2 Using documents to manage the content of files 27 Figure 2-3 Building your interface using view objects 29 Figure 2-4 Building your interface using OpenGL ES 30 Table 2-1 The role of objects in an iOS app 22 Table 2-2 Data classes in the Foundation framework 24 Table 2-3 A typical app bundle 31 Listing 2-1 Definition of a custom data object 25
<b>Chapter 3</b>	<b>App States and Multitasking 35</b>
	Figure 3-1 State changes in an iOS app 36 Figure 3-2 Launching an app into the foreground 38 Figure 3-3 Launching an app into the background 39 Figure 3-4 Handling alert-based interruptions 42 Figure 3-5 Moving from the foreground to the background 44 Figure 3-6 Transitioning from the background to the foreground 46 Figure 3-7 Processing events in the main run loop 50 Table 3-1 App states 36 Table 3-2 Notifications delivered to waking apps 47 Table 3-3 Common types of events for iOS apps 50 Listing 3-1 The <code>main</code> function of an iOS app 40 Listing 3-2 Checking for background support in earlier versions of iOS 52 Listing 3-3 Starting a background task at quit time 52 Listing 3-4 Scheduling an alarm notification 53
<b>Chapter 4</b>	<b>iCloud Storage 61</b>
	Figure 4-1 Pushing document changes to iCloud 65 Table 4-1 Differences between document and key-value storage 62
<b>Chapter 5</b>	<b>App-Related Resources 77</b>
	Figure 5-1 Custom preferences displayed by the Settings app 86 Table 5-1 Dictionary keys for the <code>UIRequiredDeviceCapabilities</code> key 79 Table 5-2 Sizes for images in the <code>CFBundleIconFiles</code> key 82 Table 5-3 Typical launch image dimensions 83 Table 5-4 Launch image orientation modifiers 84

**Chapter 6**

**Advanced App Tricks 89**

---

- |             |  |     |
|-------------|--|-----|
| Figure 6-1  | Defining a custom URL scheme in the <code>Info.plist</code> file | 100 |
| Figure 6-2  | Launching an app to open a URL                                   | 101 |
| Figure 6-3  | Waking a background app to open a URL                            | 102 |
| Table 6-1   | Configuring stream interfaces for VoIP usage                     | 96  |
| Table 6-2   | Keys and values of the <code>CFBundleURLTypes</code> property    | 99  |
| Listing 6-1 | Handling a URL request based on a custom scheme                  | 103 |

**Chapter 7**

**Performance Tuning 105**

---

- |           |   |     |
|-----------|---|-----|
| Table 7-1 | Tips for reducing your app's memory footprint | 107 |
| Table 7-2 | Tips for allocating memory                    | 108 |

**Appendix A**

**The iOS Environment 115**

---

- |            |                            |     |
|------------|----------------------------|-----|
| Figure A-1 | Sandbox directories in iOS | 117 |
|------------|----------------------------|-----|

# About iOS App Programming

This document is the starting point for creating iOS apps. It describes the fundamental architecture of iOS apps, including how the code you write fits together with the code provided by iOS. This document also offers practical guidance to help you make better choices during your design and planning phase and guides you to the other documents in the iOS developer library that contain more detailed information about how to address a specific task.



The contents of this document apply to all iOS apps running on all types of iOS devices, including iPad, iPhone, and iPod touch.

**Note:** Development of iOS apps requires an Intel-based Macintosh computer with the iOS SDK installed.

## At a Glance

The starting point for any new app is identifying the design choices you need to make and understanding how those choices map to an appropriate implementation.

### Translate Your Initial Idea into an Implementation Plan

Every great iOS app starts with a great idea, but translating that idea into actions requires some planning. Every iOS app relies heavily on design patterns, and those design patterns influence much of the code you need to write. So before you write any code, take the time to explore the possible techniques and technologies available for writing that code. Doing so can save you a lot of time and frustration.

**Relevant Chapter:** “[App Design Basics](#)” (page 15)

### UIKit Provides the Core of Your App

The core infrastructure of an iOS app is built from objects in the UIKit framework. The objects in this framework provide all of the support for handling events, displaying content on the screen, and interacting with the rest of the system. Understanding the role these objects play, and how you modify them to customize the default app behavior, is therefore very important for writing apps quickly and correctly.

**Relevant Chapter:** “[Core App Objects](#)” (page 21)

### Apps Must Behave Differently in the Foreground and Background

An iOS device runs multiple apps simultaneously but only one app—the foreground app—has the user’s attention at any given time. The current foreground app is the only app allowed to present a user interface and respond to touch events. Other apps remain in the background, usually asleep but sometimes running additional code. Transitioning between the foreground and background states involves changing several aspects of your app’s behavior.

**Relevant Chapter:** "[App States and Multitasking](#)" (page 35)

## iCloud Affects the Design of Your Data Model and UI Layers

iCloud allows you to share the user's data among multiple instances of your app running on different iOS and Mac OS X devices. Incorporating support for iCloud into your app involves changing many aspects of how you manage your files. Because files in iCloud are accessible by more than just your app, all file operations must be synchronized to prevent data corruption. And depending on your app and how it presents its data, iCloud can also require changes to portions of your user interface.

**Relevant Chapter:** "[iCloud Storage](#)" (page 61)

## Apps Require Some Specific Resources

There are some resources that must be present in all iOS apps. Most apps include images, sounds, and other types of resources for presenting the app's content but the App Store also requires some specific resources be present. The reason is that iOS uses several specific resources when presenting your app to the user and when coordinating interactions with other parts of the system. So these resources are there to improve the overall user experience.

**Relevant Chapter:** "[App-Related Resources](#)" (page 77)

## Many App Behaviors Can Be Customized

The core architecture of all apps may be the same, but there are still ways for you to tweak the high-level design of your app. Some of these tweaks are how you add specific high-level features, such as data protection and URL handling. Others affect the design of specific types of apps, such as VoIP apps.

**Relevant Chapter:** "[Advanced App Tricks](#)" (page 89)

## Apps Must Be Tuned for Performance

Great apps are always tuned for the best possible performance. For iOS apps, performance means more than just writing fast code. It often means writing better code so that your user interface remains responsive to user input, your app does not degrade battery life significantly, and your app does not impact other system resources. Before you can tune your code, though, learn about the types of changes that are likely to provide the most benefit.

**Relevant Chapter:** “[Performance Tuning](#)” (page 105)

## The iOS Environment Affects Many App Behaviors

There are aspects of iOS itself that impact how you design and write applications. Because iOS is built for mobile devices, it takes a more active role in providing security for apps. Other system behaviors also affect everything from how memory is managed to how the system responds to hardware input. All of these system behaviors affect the way you design your apps.

**Relevant Appendix:** “[The iOS Environment](#)” (page 115)

## How to Use This Document

This document provides important information about the core objects of your app and how they work together. This document does not address the creation of any specific type of iOS app. Instead, it provides a tour of the architecture that is common to all iOS apps and highlights key places where you can modify that architecture to meet your needs. Whenever possible, the document also offers tips and guidance about ways to implement features related to the core app architecture.

## Prerequisites

This document is the main entry-point guide for designing an iOS app. This guide also covers many of the practical aspects involved with implementing your app. However, this book assumes that you have already installed the iOS SDK and configured your development environment. You must perform those steps before you can start writing and building iOS apps.

If you are new to iOS app development and want an overview of iOS development process, including information about how to configure your development environment, see [App Development Overview](#).

## See Also

For additional information related to app design, see the following documents:

- For guidance about how to design an iOS app, read *iOS Human Interface Guidelines*. This book provides you with tips and guidance about how to create a great experience for users of your app. It also conveys the basic design philosophy surrounding iOS apps.
- If you are not sure what is possible in an iOS app, read *iOS Technology Overview*. This book provides a summary of iOS technologies and the situations where you might want to use them. This book is not required reading but is a good reference during the brainstorming phase of your project.

## INTRODUCTION

### About iOS App Programming

If you are interested in a more hands-on approach to creating iOS apps, you should read *Your First iOS App*. This tutorial walks you through the app-creation process from start to finish, showing you how to create a simple app and get it running.

## INTRODUCTION

About iOS App Programming

# App Design Basics

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If you are new to developing iOS apps, you might be wondering where the app development process starts. After devising your initial idea for an app, you need to turn that idea into an action plan for implementing your app. From a design perspective, you need to make some high-level decisions about the best course of action for implementing your ideas. You also need to set up your initial Xcode project in a way that makes it easy to proceed with development.

If you are new to developing iOS apps altogether, spend some time familiarizing yourself with the basic concepts. There are tutorials to help you jump right in if you want to start writing code, but iOS is a system built from basic design patterns. Taking a little bit of time to learn those patterns will help you tremendously later.

## Doing Your Initial Design

There are many ways to design an app, and many of the best approaches do not involve writing any code. A great app starts with a great idea that you then expand into a more full-featured product description. Early in the design phase, it helps to understand just what you want your app to do. Write down the set of high-level features that would be required to implement your idea. Prioritize those features based on what you think your users will need. Do a little research into iOS itself so that you understand its capabilities and how you might be able to use them to achieve your goals. And sketch out some rough interface designs on paper to visualize how your app might look.

The goal of your initial design is to answer some very important questions about your app. The set of features and the rough design of your interface help you think about what will be required later when you start writing code. At some point, you need to translate the information displayed by your app into a set of data objects. Similarly, the look of your app has an overwhelming influence on the choices you must make when implementing your user interface code. Doing your initial design on paper (as opposed to on the computer) gives you the freedom to come up with answers that are not limited by what is easy to do.

Of course, the most important thing you can do before starting your initial design is read *iOS Human Interface Guidelines*. That book describes several strategies for doing your initial design. It also offers tips and guidance about how to create apps that work well in iOS. You might also read *iOS Technology Overview* to understand how the capabilities of iOS and how you might use those capabilities to achieve your design goals.

## Learning the Fundamental iOS Design Patterns and Techniques

No matter what type of app you are creating, there are a few fundamental design patterns and techniques that you must know before you start writing code. In iOS, the system frameworks provide critical infrastructure for your app and in most cases are the only way to access the underlying hardware. In turn, the frameworks use many specific design patterns and assume that you are familiar with them. Understanding these design patterns is therefore an important first step to understanding how the system can help you develop your app.

The most important design patterns you must know are:

- Model-View-Controller—This design pattern governs the overall structure of your app.
- Delegation—This design pattern facilitates the transfer information and data from one object to another.
- Target-action—This design pattern translates user interactions with buttons and controls into code that your app can execute.
- Block objects—You use blocks to implement callbacks and asynchronous code.
- Sandboxing—All iOS apps are placed in sandboxes to protect the system and other apps. The structure of the sandbox affects the placement of your app’s files and has implications for data backups and some app-related features.

Accurate and efficient memory management is important for iOS apps. Because iOS apps typically have less usable memory than a comparable desktop computer, apps need to be aggressive about deleting unneeded objects and be lazy about creating objects in the first place. Apps that use the compiler’s **Automatic Reference Counting (ARC)** feature already get a very efficient way of managing memory that is similar to garbage collection but without many of the performance penalties. If you are not using ARC, you must manage memory yourself by explicitly retaining and releasing objects.

There are other design patterns that you might see used occasionally or use yourself in your own code. For a complete overview of the design patterns and techniques you will use to create iOS apps, see *Cocoa Fundamentals Guide*.

## Translating Your Initial Design into an Action Plan

iOS assumes that all apps are built using the Model-View-Controller design pattern. Therefore, the first step you can take toward achieving this goal is to choose an approach for the data and view portions of your app.

- Choose a basic approach for your data model:
  - **Existing data model code**—If you already have data model code written in a C-based language, you can integrate that code directly into your iOS apps. Because iOS apps are written in Objective-C, they work just fine with code written in other C-based languages. Of course, there is also benefit to writing an Objective-C wrapper for any non Objective-C code.
  - **Custom objects data model**—A custom object typically combines some simple data (strings, numbers, dates, URLs, and so on) with the business logic needed to manage that data and ensure its consistency. Custom objects can store a combination of scalar values and pointers to other objects. For example, the Foundation framework defines classes for many simple data types and for storing collections of other objects. These classes make it much easier to define your own custom objects.
  - **Structured data model**—If your data is highly structured—that is, it lends itself to storage in a database—use Core Data (or SQLite) to store the data. Core Data provides a simple object-oriented model for managing your structured data. It also provides built-in support for some advanced features like undo and iCloud. (SQLite files cannot be used in conjunction with iCloud.)
- Decide whether you need support for documents:

The job of a document is to manage your app's in-memory data model objects and coordinate the storage of that data in a corresponding file (or set of files) on disk. Documents normally connote files that the user created but apps can use documents to manage non user facing files too. One big advantage of using documents is that the `UIDocument` class makes interacting with iCloud and the local file system much simpler. For apps that use Core Data to store their content, the `UIManagedDocument` class provides similar support.

- Choosing an approach for your user interface:

- **Building block approach**—The easiest way to create your user interface is to assemble it using existing view objects. Views represent visual elements such as tables, buttons, text fields, and so on. You use many views as-is but you can also customize the appearance and behavior of standard views as needed to meet your needs. You can also implement new visual elements using custom views and mix those views freely with the standard views in your interface. The advantages of views are that they provide a consistent user experience and they allow you to define complex interfaces quickly and with relatively little code.
- **OpenGL ES-based approach**—If your app requires frequent screen updates or sophisticated rendering, you probably need to draw that content directly using OpenGL ES. The main use of OpenGL ES is for games and apps that rely heavily on sophisticated graphics, and therefore need the best performance possible.

## Starting the App Creation Process

After you formulate your action plan, it is time to start coding. If you are new to writing iOS apps, it is good to take some time to explore the initial Xcode templates that are provided for development. These templates greatly simplify the work you have to do and make it possible to have an app up and running in minutes. These templates also allow you to customize your initial project to support your specific needs more precisely. To that end, when creating your Xcode project, you should already have answers to the following questions in mind:

- **What is the basic interface-style of your app?** Different types of app require different sets of initial views and view controllers. Knowing how you plan to organize your user interface lets you select an initial project template that is most suited to your needs. You can always change your user interface later, but choosing the most appropriate template first makes starting your project much easier.
- **Do you want to create a Universal app or one targeted specifically for iPad or iPhone?** Creating a universal app requires specifying different sets of views and view controllers for iPad and iPhone and dynamically selecting the appropriate set at runtime. Universal apps are preferred because they support more iOS devices but do require you to factor your code better for each platform. For information about how a universal app affects the code you write, see “[Creating a Universal App](#)” (page 89).
- **Do you want your app to use storyboards?** Storyboards simplify the design process by showing both the views and view controllers of your user interface and the transitions between them. Storyboards are supported in iOS 5 and later and are enabled by default for new projects. If your app must run on earlier versions of iOS, though, you cannot use storyboards and should continue to use nib files.
- **Do you want to use Core Data for your data model?** Some types of apps lend themselves naturally to a structured data model, which makes them ideal candidates for using Core Data. For more information about Core Data and the advantages it offers, see *Core Data Programming Guide*.

From these questions, you can use Xcode to create your initial project files and start coding.

1. If you have not yet installed Xcode, do so and configure your iOS development team. For detailed information about setting up your development teams and preparing your Xcode environment, see [“App Development Overview”](#).
2. Create your initial Xcode project.
3. Before writing any code, build and run your new Xcode project. Target your app for iOS Simulator so that you can see it run.

Every new Xcode project starts you with a fully functional (albeit featureless) app. The app itself should run and display the default views found in the main storyboard or nib file, which are probably not very interesting. The reason that the app runs at all, though, is because of the infrastructure provided to you by UIKit. This infrastructure initializes the app, loads the initial interface file, and checks the app in with the system so that it can start handling events. For more information about this infrastructure and the capabilities it provides, see [“The Core Objects of Your App”](#) (page 21) and [“The App Launch Cycle”](#) (page 37).

4. Start writing your app’s primary code.

For new apps, you probably want to start creating the classes associated with your app’s data model first. These classes usually have no dependencies on other parts of your app and should be something you can work on initially. For information about ways to build your data model, see [“The Data Model”](#) (page 24).

You might also want to start playing around with designs for your user interface by adding views to your main storyboard or nib file. From these views, you can also start identifying the places in your code where you need to respond to interface-related changes. For an overview of user interfaces and where they fit into your app’s code, see [“The User Interface”](#) (page 28).

If your app supports iCloud, you should incorporate support for iCloud into your classes at an early stage. For information about adding iCloud support to your app, see [“iCloud Storage”](#) (page 61).

5. Add support for app state changes.

In iOS, the state of an app determines what it is allowed to do and when. App states are managed by high-level objects in your app but can affect many other objects as well. Therefore, you need to consider how the current app state affects your data model and view code and update that code appropriately. For information about app states and how apps run in the foreground and background, see [“App States and Multitasking”](#) (page 35).

6. Create the resources needed to support your app.

Apps submitted to the App Store are expected to have specific resources such as icons and launch images to make the overall user experience better. Well-factored apps also make heavy use of resource files to keep their code separate from the data that code manipulates. This factoring makes it much easier to localize your app, tweak its appearance, and perform other tasks without rewriting any code. For information about the types of resources found in a typical iOS app and how they are used, see [“The App Bundle”](#) (page 30) and [“App-Related Resources”](#) (page 77).

7. As needed, implement any app-specific behaviors that are relevant for your app.

There are many ways to modify the way your app launches or interacts with the system. For information about the most common types of app customizations, see [“Advanced App Tricks”](#) (page 89).

**8.** Add the advanced features that make your app unique.

iOS includes many other frameworks for managing multimedia, advanced rendering, game content, maps, contacts, location tracking, and many other advanced features. For an overview of the frameworks and features you can incorporate into your apps, see *iOS Technology Overview*.

**9.** Do some basic performance tuning for your app.

All iOS apps should be tuned for the best possible performance. Tuned apps run faster but also use system resources, such as memory and battery life, more efficiently. For information about areas to focus on during the tuning process, see “[Performance Tuning](#)” (page 105).

**10.** Iterate.

App development is an iterative process. As you add new features, you might need to revisit some or all of the preceding steps to make adjustments to your existing code.

## CHAPTER 1

### App Design Basics

# Core App Objects

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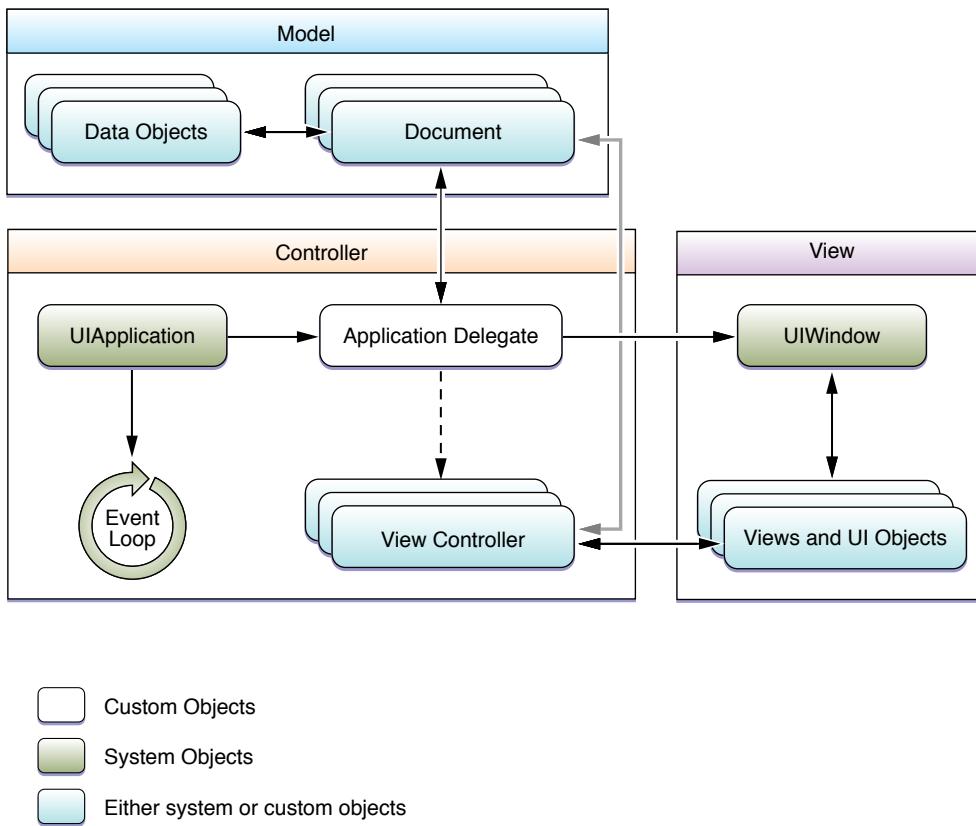
UIKit provides the infrastructure for all apps but it is your custom objects that define the specific behavior of your app. Your app consists of a handful of specific UIKit objects that manage the event loop and the primary interactions with iOS. Through a combination of subclassing, delegation, and other techniques, you modify the default behaviors defined by UIKit to implement your app.

In addition to customizing the UIKit objects, you are also responsible for providing or defining other key sets of objects. The largest set of objects is your app's data objects, the definition of which is entirely your responsibility. You must also provide a set of user interface objects, but fortunately UIKit provides numerous classes to make defining your interface easy. In addition to code, you must also provide the resources and data files you need to deliver a shippable app.

## The Core Objects of Your App

From the time your app is launched by the user, to the time it exits, the UIKit framework manages much of the app's core behavior. At the heart of the app is the `UIApplication` object, which receives events from the system and dispatches them to your custom code for handling. Other UIKit classes play a part in managing your app's behavior too, and all of these classes have similar ways of calling your custom code to handle the details.

To understand how UIKit objects work with your custom code, it helps to understand a little about the objects make up an iOS app. Figure 2-1 shows the objects that are most commonly found in an iOS app, and Table 2-1 describes the roles of each object. As you can see from the diagram, iOS apps are organized around the model-view-controller design pattern. This pattern separates the data objects in the model from the views used to present that data. This separation promotes code reuse by making it possible to swap out your views as needed and is especially useful when creating universal apps—that is, apps that can run on both iPad and iPhone.

**Figure 2-1** Key objects in an iOS app**Table 2-1** The role of objects in an iOS app

Object	Description
UIApplication object	You use the <code>UIApplication</code> object essentially as is—that is, without subclassing. This controller object manages the app event loop and coordinates other high-level app behaviors. Your own custom app-level logic resides in your app delegate object, which works in tandem with this object.
App delegate object	The <b>app delegate</b> is a custom object created at app launch time, usually by the <code>UIApplicationMain</code> function. The primary job of this object is to handle state transitions within the app. For example, this object is responsible for launch-time initialization and handling transitions to and from the background. For information about how you use the app delegate to manage state transitions, see “ <a href="#">Managing App State Changes</a> ” (page 35).  In iOS 5 and later, you can use the app delegate to handle other app-related events. The Xcode project templates declare the app delegate as a subclass of <code>UIResponder</code> . If the <code>UIApplication</code> object does not handle an event, it dispatches the event to your app delegate for processing. For more information about the types of events you can handle, see <a href="#">UIResponder Class Reference</a> .

Object	Description
Documents and data model objects	<p><b>Data model objects</b> store your app’s content and are specific to your app. For example, a banking app might store a database containing financial transactions, whereas a painting app might store an image object or even the sequence of drawing commands that led to the creation of that image. (In the latter case, an image object is still a data object because it is just a container for the image data.)</p> <p>Apps can also use <b>document objects</b> (custom subclasses of <code>UIDocument</code>) to manage some or all of their data model objects. Document objects are not required but offer a convenient way to group data that belongs in a single file or file package. For more information about documents, see “<a href="#">Defining a Document-Based Data Model</a>” (page 27).</p>
View controller objects	<p><b>View controller objects</b> manage the presentation of your app’s content on screen. A view controller manages a single view and its collection of subviews. When presented, the view controller makes its views visible by installing them in the app’s window.</p> <p>The <code>UIViewController</code> class is the base class for all view controller objects. It provides default functionality for loading views, presenting them, rotating them in response to device rotations, and several other standard system behaviors. UIKit and other frameworks define additional view controller classes to implement standard system interfaces such as the image picker, tab bar interface, and navigation interface.</p> <p>For detailed information about how to use view controllers, see <i>View Controller Programming Guide for iOS</i>.</p>
UIWindow object	<p>A <code>UIWindow</code> object coordinates the presentation of one or more views on a screen. Most apps have only one window, which presents content on the main screen, but apps may have an additional window for content displayed on an external display.</p> <p>To change the content of your app, you use a view controller to change the views displayed in the corresponding window. You never replace the window itself.</p> <p>In addition to hosting views, windows work with the <code>UIApplication</code> object to deliver events to your views and view controllers.</p>
View, control, and layer objects	<p>Views and controls provide the visual representation of your app’s content. A <b>view</b> is an object that draws content in a designated rectangular area and responds to events within that area. <b>Controls</b> are a specialized type of view responsible for implementing familiar interface objects such as buttons, text fields, and toggle switches.</p> <p>The UIKit framework provides standard views for presenting many different types of content. You can also define your own custom views by subclassing <code>UIView</code> (or its descendants) directly.</p> <p>In addition to incorporating views and controls, apps can also incorporate Core Animation layers into their view and control hierarchies. <b>Layer objects</b> are actually data objects that represent visual content. Views use layer objects intensively behind the scenes to render their content. You can also add custom layer objects to your interface to implement complex animations and other types of sophisticated visual effects.</p>

What distinguishes one iOS app from another is the data it manages (and the corresponding business logic) and how it presents that data to the user. Most interactions with UIKit objects do not define your app but help you to refine its behavior. For example, the methods of your app delegate let you know when the app is changing states so that your custom code can respond appropriately.

For information about the specific behaviors of a given class, see the corresponding class reference. For more information about how events flow in your app and information about your app's responsibilities at various points during that flow, see “[App States and Multitasking](#)” (page 35).

## The Data Model

Your app’s data model comprises your data structures and the business logic needed to keep that data in a consistent state. You never want to design your data model in total isolation from your app’s user interface; however, the implementation of your data model objects should be separate and not rely on the presence of specific views or view controllers. Keeping your data separate from your user interface makes it easier to implement a universal app—one that can run on both iPad and iPhone—and also makes it easier to reuse portions of your code later.

If you have not yet defined your data model, the iOS frameworks provide help for doing so. The following sections highlight some of the technologies you can use when defining specific types of data models.

### Defining a Custom Data Model

When defining a custom data model, create custom objects to represent any high-level constructs but take advantage of the system-supplied objects for simpler data types. The Foundation framework provides many objects (most of which are listed in Table 2-2) for managing strings, numbers, and other types of simple data in an object-oriented way. Using these objects is preferable to defining new objects both because it saves time and because many other system routines expect you to use the built-in objects anyway.

**Table 2-2** Data classes in the Foundation framework

Data	Classes	Description
Strings and text	NSString (NSMutableString) NSAttributedString (NSMutableAttributedString)	Strings in iOS are Unicode based. The string classes provide support for creating and manipulating strings in a variety of ways. The attributed string classes support stylized text and are used only in conjunction with Core Text.
Numbers	NSNumber NSDecimalNumber NSIndexPath	When you want to store numerical values in a collection, use number objects. The <code>NSNumber</code> class can represent integer, floating-point values, Booleans, and <code>char</code> types. The <code>NSIndexPath</code> class stores a sequence of numbers and is often used to specify multi-layer selections in hierarchical lists.
Raw bytes	NSData (NSMutableData) NSValue	For times when you need to store raw streams of bytes, use data objects. Data objects are also commonly used to store objects in an archived form. The <code>NSValue</code> class is typically extended (using categories) and used to archive common data types such as points and rectangles.

Data	Classes	Description
Dates and times	NSDate NSDateComponents	Use date objects to store timestamps, calendar dates, and other time-related information.
URLs	NSURL	In addition to their traditional use for referring to network resources, URLs in iOS are the preferred way to store paths to files. The NSURL class even provides support for getting and setting file-related attributes.
Collections	NSArray (NSMutableArray) NSDictionary (NSMutableDictionary) NSIndexSet (NSMutableIndexSet) NSOrderedSet (NSMutableOrderedSet) NSSet (NSMutableSet)	Use collections to group related objects together in a single place. The Foundation framework provides several different types of collection classes

In addition to data-related objects, there are some other data types that are commonly used by the iOS frameworks to manage familiar types of data. You are encouraged to use these data types in your own custom objects to represent similar types of data.

- `NSInteger/NSUInteger`—Abstractions for scalar signed and unsigned integers that define the integer size based on the architecture.
- `NSRange`—A structure used to define a contiguous portion of a series. For example, you can use ranges to define the selected characters in a string.
- `NSTimeInterval`—The number of seconds (whole and partial) in a given time interval.
- `CGPoint`—An x and y coordinate value that defines a location.
- `CGSize`—Coordinate values that define a set of horizontal and vertical extents.
- `CGRect`—Coordinate values that define a rectangular region.

Of course, when defining custom objects, you can always incorporate scalar values directly into your class implementations. In fact, a custom data object can include a mixture of scalar and object types for its member variables. Listing 2-1 shows a sample class definition for a collection of pictures. The class in this instance contains an array of images and a list of the indexes into that array representing the selected items. The class also contains a string for the collection’s title and a scalar Boolean variable indicating whether the collection is currently editable.

#### **Listing 2-1**      Definition of a custom data object

```
@interface PictureCollection : NSObject {
    NSMutableOrderedSet* pictures;
    NSMutableIndexSet* selection;

    NSString* title;
    BOOL editable;
```

```

}

@property (nonatomic, strong) NSString * title;
@property (nonatomic, readonly) NSOrderedSet* pictures;

// Method definitions...

@end

```

**Note:** When defining data objects, it is strongly recommended that you declare properties for any member variables that you want to expose to clients of the object. Synthesizing these properties in your implementation file automatically creates appropriate accessor methods with the attributes you require. This ensures that object relationships are maintained appropriately and that objects are not released.

Consider how undo operations on your custom objects might be handled. Supporting undo means being able to reverse changes made to your objects cleanly. If your objects incorporate complex business logic, you need to factor that logic in a way that can be undone easily. Here are some tips for implementing undo support in your custom objects:

- Define the methods you need to make sure that changes to your object are symmetrical. For example, if you define a method to add an item, make sure you have a method for removing an item in a similar way.
- Factor out your business logic from the code you use to change the values of member variables.
- For multistep actions, use the current `NSUndoManager` object to group the steps together.

For more information about how to implement undo support in your app, see *Undo Architecture*. For more information about the classes of the Foundation framework, see *Foundation Framework Reference*.

## Defining a Structured Data Model Using Core Data

Core Data is a schema-driven object graph management and persistence framework. Fundamentally, Core Data helps you to save model objects (in the sense of the model-view-controller design pattern) to a file and get them back again. This is similar to archiving (see *Archives and Serializations Programming Guide*), but Core Data offers much more than that.

- Core Data provides an infrastructure for managing all the changes to your model objects. This gives you automatic support for undo and redo, and for maintaining reciprocal relationships between objects.
- It allows you to keep just a subset of your model objects in memory at any given time, which is very important for iOS apps.
- It uses a schema to describe the model objects. You define the principal features of your model classes—including the relationships between them—in a GUI-based editor. This provides a wealth of basic functionality “for free,” including setting of default values and attribute value validation.
- It allows you to maintain disjoint sets of edits of your objects. This is useful if you want to, for example, allow the user to make edits in one view that may be discarded without affecting data displayed in another view.

- It has an infrastructure for data store versioning and migration. This lets you easily upgrade an old version of the user's file to the current version.
- It allows you to store your data in iCloud and access it from multiple devices.

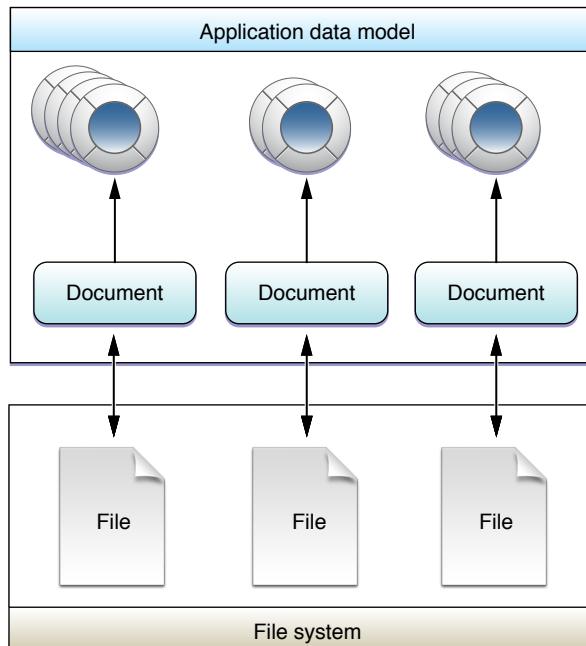
For information about how to use Core Data, see *Core Data Programming Guide*.

## Defining a Document-Based Data Model

A document-based data model is a convenient way to manage the files your app writes to disk. In this type of data model, you use a document object to represent the contents of a single file (or file package) on disk. That document object is responsible for reading and writing the contents of the file and working with your app's view controllers to present the document's contents on screen. The traditional use for document objects is to manage files containing user data. For example, an app that creates and manages text files would use a separate document object to manage each text file. However, you can use document objects for private app data that is also backed by a file.

Figure 2-2 illustrates the typical relationships between documents, files, and the objects in your app's data model. With few exceptions, each document is self-contained and does not interact directly with other documents. The document manages a single file (or file package) and creates the in-memory representation of any data found in that file. Because the contents of each file are unique, the data structures associated with each document are also unique.

**Figure 2-2** Using documents to manage the content of files



You use the `UIDocument` class to implement document objects in your iOS app. This class provides the basic infrastructure needed to handle the file management aspects of the document. Other benefits of `UIDocument` include:

- It provides support for autosaving the document contents at appropriate times.
- It handles the required file coordination for documents stored in iCloud. It also provides hooks for resolving version conflicts.
- It provides support for undoing actions.

You must subclass `UIDocument` in order to implement the specific behavior required by your app's documents. For detailed information about how to implement a document-based app using `UIDocument`, see *Document-Based Application Programming Guide for iOS*.

## The User Interface

Every iOS app has at least one window and one view for presenting its content. The window provides the area in which to display the content and is an instance of the `UIWindow` class. Views are responsible for managing the drawing of your content (and handling touch events) and are instances of the `UIView` class. For interfaces that you build using view objects, your app's window naturally contains multiple view objects. For interfaces built using OpenGL ES, you typically have a single view and use that view to render your content.

View controllers also play a very important role in your app's user interface. A view controller is an instance of the `UIViewController` class and is responsible for managing a single set of views and the interactions between those views and other parts of your app. Because iOS apps have a limited amount of space in which to display content, view controllers also provide the infrastructure needed to swap out the views from one view controller and replace them with the views of another view controller. Thus, view controllers are you how implement transitions from one type of content to another.

You should always think of a view controller object as a self-contained unit. It handles the creation and destruction of its own views, handles their presentation on the screen, and coordinates interactions between the views and other objects in your app.

## Building an Interface Using UIKit Views

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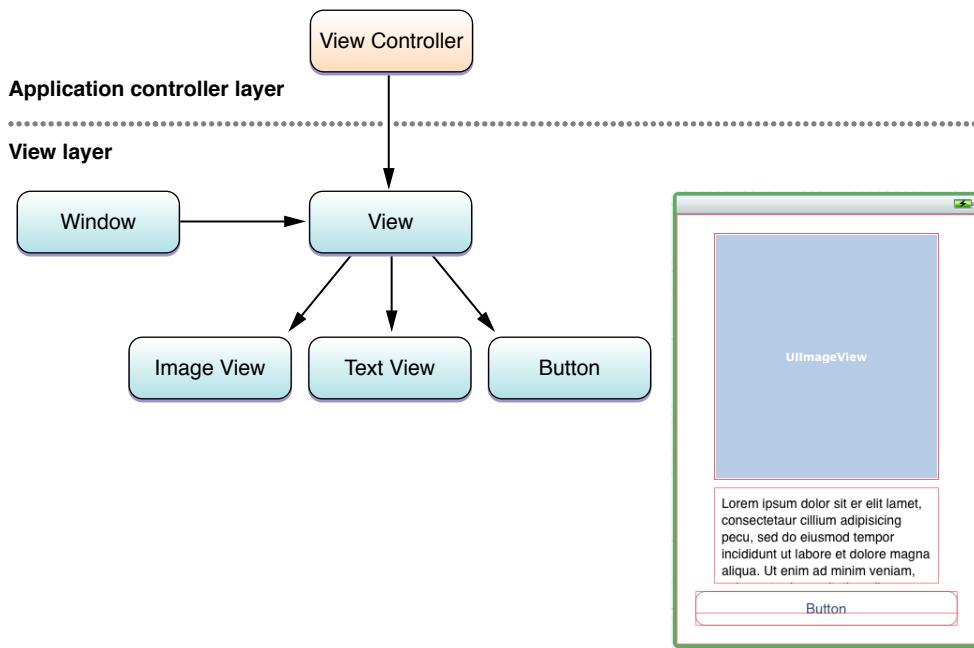
Apps that use UIKit views for drawing are easy to create because you can assemble a basic interface quickly. The UIKit framework provides many different types of views to help present and organize data. Controls—a special type of view—provide a built-in mechanism for executing custom code whenever the user performs appropriate actions. For example, clicking on a button causes the button's associated action method to be called.

The advantage of interfaces based on UIKit views is that you can assemble them graphically using Interface Builder—the visual interface editor built in to Xcode. Interface Builder provides a library of the standard views, controls, and other objects that you need to build your interface. After dragging these objects from the library, you drop them onto the work surface and arrange them in any way you want. You then use inspectors to configure those objects before saving them in a storyboard or nib file. The process of assembling your interface graphically is much faster than writing the equivalent code and allows you to see the results immediately, without the need to build and run your app.

**Note:** You can also incorporate custom views into your UIKit view hierarchies. A custom view is a subclass of `UIView` in which you handle all of the drawing and event-handling tasks yourself. For more information about creating custom views and incorporating them into your view hierarchies, see *View Programming Guide for iOS*.

Figure 2-3 shows the basic structure of an app whose interface is constructed solely using view objects. In this instance, the main view spans the visible area of the window (minus the scroll bar) and provides a simple white background. The main view also contains three subviews: an image view, a text view, and a button. Those subviews are what the app uses to present content to the user and respond to interactions. All of the views in the hierarchy are managed by a single view controller object.

**Figure 2-3** Building your interface using view objects



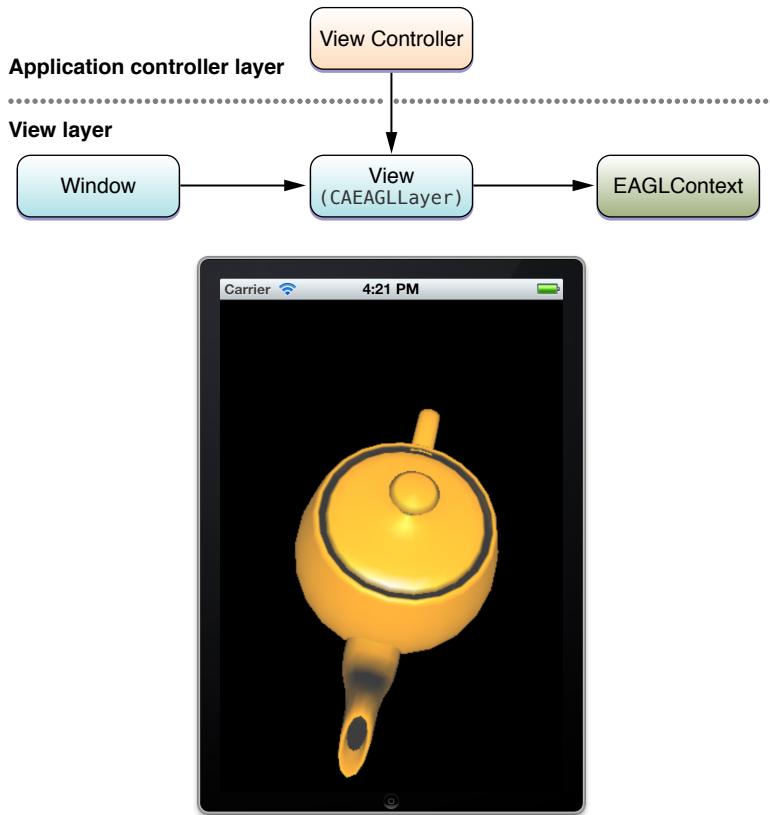
In a typical view-based app, you coordinate the onscreen views using your view controller objects. An app always has one view controller that is responsible for presenting all of the content on the screen. That view controller has a content view, which itself may contain other views. Some view controllers can also act as containers for content provided by other view controllers. For example, a split view controller displays the content from two view controllers side by side. Because view controllers play a vital role in view management, understand how they work and the benefits they provide by reading *View Controller Programming Guide for iOS*. For more information about views and the role they play in apps, see *View Programming Guide for iOS*.

## Building an Interface Using Views and OpenGL ES

Games and other apps that need high frame rates or sophisticated drawing capabilities can add views specifically designed for OpenGL ES drawing to their view hierarchies. The simplest type of OpenGL ES app is one that has a window object and a single view for OpenGL ES drawing and a view controller to manage the presentation and rotation of that content. More sophisticated applications can use a mixture of both OpenGL ES views and UIKit views to implement their interfaces.

Figure 2-4 shows the configuration of an app that uses a single OpenGL ES view to draw its interface. Unlike a UIKit view, the OpenGL ES view is backed by a different type of layer object (a `CAEAGLLayer` object) instead of the standard layer used for view-based apps. The `CAEAGLLayer` object provides the drawing surface that OpenGL ES can render into. To manage the drawing environment, the app also creates an `EAGLContext` object and stores that object with the view to make it easy to retrieve.

**Figure 2-4** Building your interface using OpenGL ES



For information on how to configure OpenGL ES for use in your app, see *OpenGL ES Programming Guide for iOS*.

## The App Bundle

When you build your iOS app, Xcode packages it as a bundle. A **bundle** is a directory in the file system that groups related resources together in one place. An iOS app bundle contains the app executable file and supporting resource files such as app icons, image files, and localized content. Table 2-3 lists the contents of a typical iOS app bundle, which for demonstration purposes is called `MyApp`. This example is for illustrative purposes only. Some of the files listed in this table may not appear in your own app bundles.

**Table 2-3** A typical app bundle

File	Example	Description
App executable	MyApp	The executable file contains your app's compiled code. The name of your app's executable file is the same as your app name minus the .app extension. This file is required.
The information property list file	Info.plist	The Info.plist file contains configuration data for the app. The system uses this data to determine how to interact with the app. This file is required and must be called Info.plist. For more information, see <a href="#">Figure 6-1</a> (page 100).
App icons	Icon.png Icon@2x.png Icon-Small.png Icon-Small@2x.png	Your app icon is used to represent your app on the device's Home screen. Other icons are used by the system in appropriate places. Icons with @2x in their filename are intended for devices with Retina displays. An app icon is required. For information about specifying icon image files, see <a href="#">"App Icons"</a> (page 81).
Launch images	Default.png Default-Portrait.png Default-Landscape.png	The system uses this file as a temporary background while your app is launching. It is removed as soon as your app is ready to display its user interface. At least one launch image is required. For information about specifying launch images, see <a href="#">"App Launch (Default) Images"</a> (page 83).
Storyboard files (or nib files)	MainBoard.storyboard	Storyboards contain the views and view controllers that the app presents on screen. Views in a storyboard are organized according to the view controller that presents them. Storyboards also identify the transitions (called segues) that take the user from one set of views to another. The name of the main storyboard file is set by Xcode when you create your project. You can change the name by assigning a different value to the NSMainStoryboardFile key in the Info.plist file.) Apps that use nib files instead of storyboards can replace the NSMainStoryboardFile key with the NSMainNibFile key and use that key to specify their main nib file. The use of storyboards (or nib files) is optional but recommended.

File	Example	Description
Ad hoc distribution icon	iTunesArtwork	<p>If you are distributing your app ad hoc, include a 512 x 512 pixel version of your app icon. This icon is normally provided by the App Store from the materials you submit to iTunes Connect. However, because apps distributed ad hoc do not go through the App Store, your icon must be present in your app bundle instead. iTunes uses this icon to represent your app. (The file you specify should be the same one you would have submitted to the App Store, if you were distributing your app that way.)</p> <p>The filename of this icon must be <code>iTunesArtwork</code> and must not include a filename extension. This file is required for ad hoc distribution but is optional otherwise.</p>
Settings bundle	<code>Settings.bundle</code>	<p>If you want to expose custom app preferences through the Settings app, you must include a settings bundle. This bundle contains the property list data and other resource files that define your app preferences. The Settings app uses the information in this bundle to assemble the interface elements required by your app.</p> <p>This bundle is optional. For more information about preferences and specifying a settings bundle, see <i>Preferences and Settings Programming Guide</i>.</p>
Nonlocalized resource files	<code>sun.png</code> <code>mydata.plist</code>	<p>Nonlocalized resources include things like images, sound files, movies, and custom data files that your app uses. All of these files should be placed at the top level of your app bundle.</p>
Subdirectories for localized resources	<code>en.lproj</code> <code>fr.lproj</code> <code>es.lproj</code>	<p>Localized resources must be placed in language-specific project directories, the names for which consist of an ISO 639-1 language abbreviation plus the <code>.lproj</code> suffix. (For example, the <code>en.lproj</code>, <code>fr.lproj</code>, and <code>es.lproj</code> directories contain resources localized for English, French, and Spanish.)</p> <p>An iOS app should be internationalized and have a <code>language.lproj</code> directory for each language it supports. In addition to providing localized versions of your app's custom resources, you can also localize your app icon, launch images, and Settings icon by placing files with the same name in your language-specific project directories.</p> <p>For more information, see "<a href="#">Localized Resource Files</a>" (page 87).</p>

From your code, access your app's resource files using an `NSBundle` object:

1. Use the `mainBundle` method of `NSBundle` to obtain your app's main bundle object.
2. Use the methods of the bundle object to obtain the location of the desired resource file.
3. Open (or access) the file and use it.

## Core App Objects

The `pathForResource:ofType:` method is one of several `NSBundle` methods that you can use to retrieve the location of resource files in your bundle. The following example shows how to locate an image file called `sun.png` and create an image object. The first line gets the location of the file in the bundle. The second line creates the `UIImage` object using the data in the file at that location.

```
NSString* imagePath = [[NSBundle mainBundle] pathForResource:@"sun"
ofType:@"png"];
UIImage* sunImage = [[UIImage alloc] initWithContentsOfFile:imagePath];
```

**Note:** Core Foundation also provides routines for accessing bundles. Use the `CFBundleGetMainBundle` function to obtain a `CFBundleRef` opaque type for your app's main bundle. You can then use the other bundle-related Core Foundation functions to locate your resource files.

For information on how to access and use resources in your app, see *Resource Programming Guide*. For more information about the structure of an iOS app bundle, see *Bundle Programming Guide*.

## CHAPTER 2

### Core App Objects

# App States and Multitasking

---

For iOS apps, it is crucial to know whether your app is running in the foreground or the background. Because resources are more limited on iOS devices, an app must behave differently in the background than in the foreground. The operating system also limits what your app can do in the background in order to improve battery life and to improve the user's experience with the foreground app. The operating system notifies your app whenever it moves between the foreground and background. These notifications are your chance to modify your app's behavior.

While your app is in the foreground, the system sends touch events to it for processing. The UIKit infrastructure does most of the hard work of delivering events to your custom objects. All you have to do is override methods in the appropriate objects to process those events. For controls, UIKit simplifies things even further by handling the touch events for you and calling your custom code only when something interesting happens, such as when the value of a text field changes.

As you implement your app, follow these guidelines:

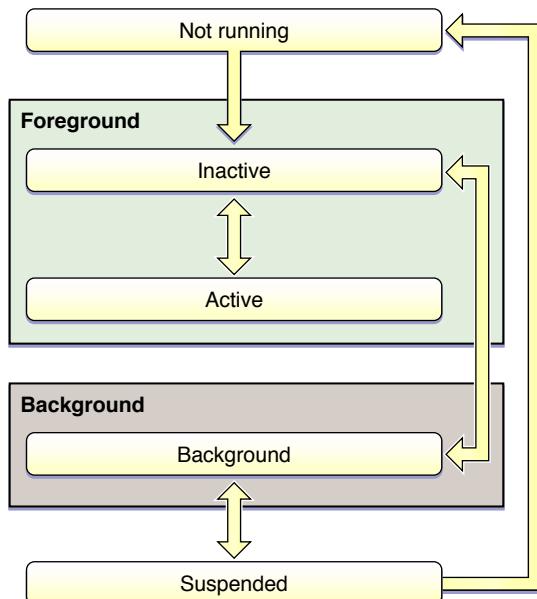
- (**Required**) Respond appropriately to the state transitions that occur. Not handling these transitions properly can lead to data loss and a bad user experience. For a summary of how to respond to state transitions, see [“Managing App State Changes”](#) (page 35).
- (**Required**) When moving to the background, make sure your app adjusts its behavior appropriately. For guidelines about what to do when your app moves to the background, see [“Being a Responsible Background App”](#) (page 58).
- (**Recommended**) Register for any notifications that report system changes your app needs. When an app is suspended, the system queues key notifications and delivers them when the app resumes execution. Apps should use these notifications to make a smooth transition back to execution. For more information, see [“Processing Queued Notifications at Wakeup Time”](#) (page 47).
- (**Optional**) If your app needs to do actual work while in the background, ask the system for the appropriate permissions to continue running. For more information about the types of background work you can do and how to request permission to do that work, see [“Background Execution and Multitasking”](#) (page 51).

## Managing App State Changes

At any given moment, your app is in one of the states listed in Table 3-1. The system moves your app from state to state in response to actions happening throughout the system. For example, when the user presses the Home button, a phone call comes in, or any of several other interruptions occurs, the currently running apps change state in response. [Figure 3-1](#) (page 36) shows the paths that an app takes when moving from state to state.

**Table 3-1** App states

State	Description
Not running	The app has not been launched or was running but was terminated by the system.
Inactive	<p>The app is running in the foreground but is currently not receiving events. (It may be executing other code though.)</p> <p>An app usually stays in this state only briefly as it transitions to a different state. The only time it stays inactive for any period of time is when the user locks the screen or the system prompts the user to respond to some event, such as an incoming phone call or SMS message.</p>
Active	The app is running in the foreground and is receiving events. This is the normal mode for foreground apps.
Background	<p>The app is in the background and executing code. Most apps enter this state briefly on their way to being suspended. However, an app that requests extra execution time may remain in this state for a period of time. In addition, an app being launched directly into the background enters this state instead of the inactive state. For information about how to execute code while in the background, see <a href="#">"Background Execution and Multitasking"</a> (page 51).</p>
Suspended	<p>The app is in the background but is not executing code. The system moves apps to this state automatically and does not notify them before doing so. While suspended, an app remains in memory but does not execute any code.</p> <p>When a low-memory condition occurs, the system may purge suspended apps without notice to make more space for the foreground app.</p>

**Figure 3-1** State changes in an iOS app

**Note:** Apps running in iOS 3.2 and earlier do not enter the background or suspended states. In addition, some devices do not support multitasking or background execution at all, even when running iOS 4 or later. Apps running on those devices also do not enter the background or suspended states. Instead, apps are terminated upon leaving the foreground.

Most state transitions are accompanied by a corresponding call to the methods of your app delegate object. These methods are your chance to respond to state changes in an appropriate way. These methods are listed below, along with a summary of how you might use them.

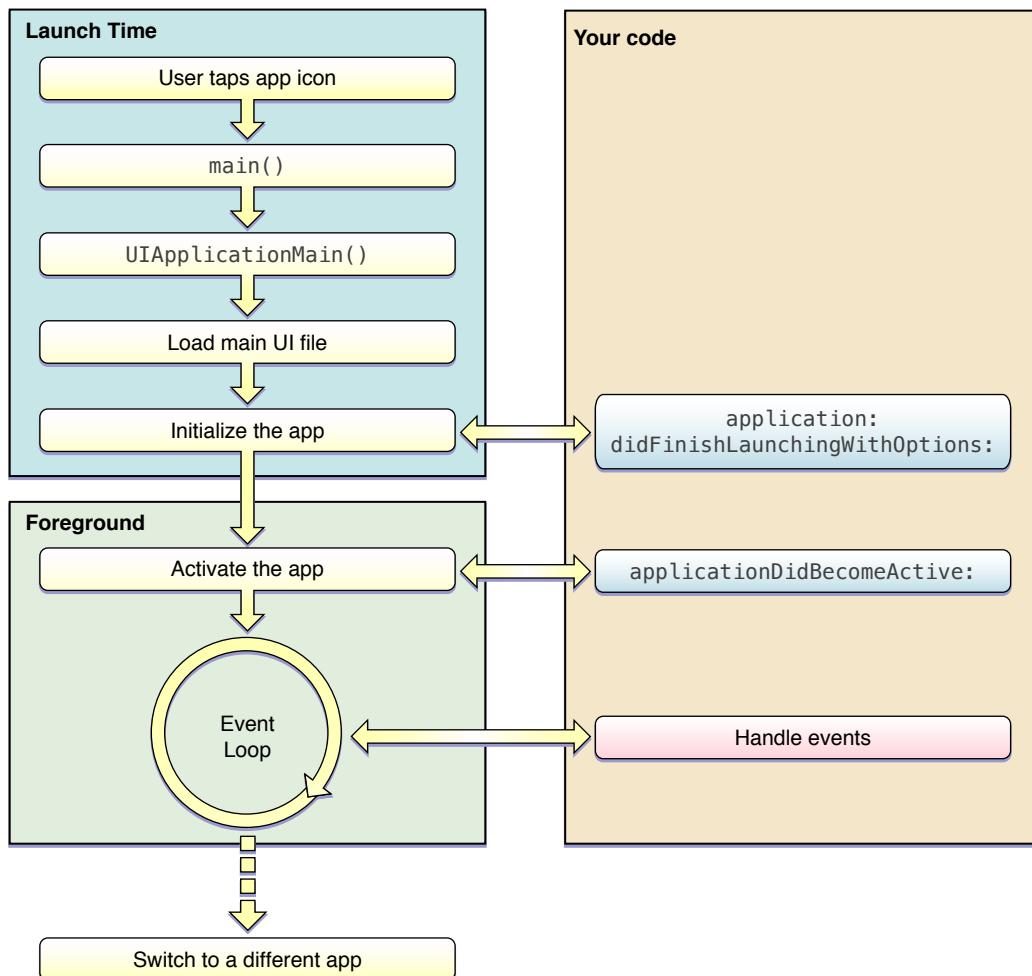
- `application:didFinishLaunchingWithOptions:`—This is your app's first chance to execute code at launch time.
- `applicationDidBecomeActive:`—This is your app's chance to prepare to run as the foreground app.
- `applicationWillResignActive:`—Lets you know that your app is transitioning away from being the foreground app. Use this method to put your app into a quiescent state.
- `applicationDidEnterBackground:`—Lets you know that your app is now running in the background and may be suspended at any time.
- `applicationWillEnterForeground:`—Lets you know that your app is moving out of the background and back into the foreground, but that it is not yet active.
- `applicationWillTerminate:`—Lets you know that your app is being terminated. This method is not called if your app is suspended.

## The App Launch Cycle

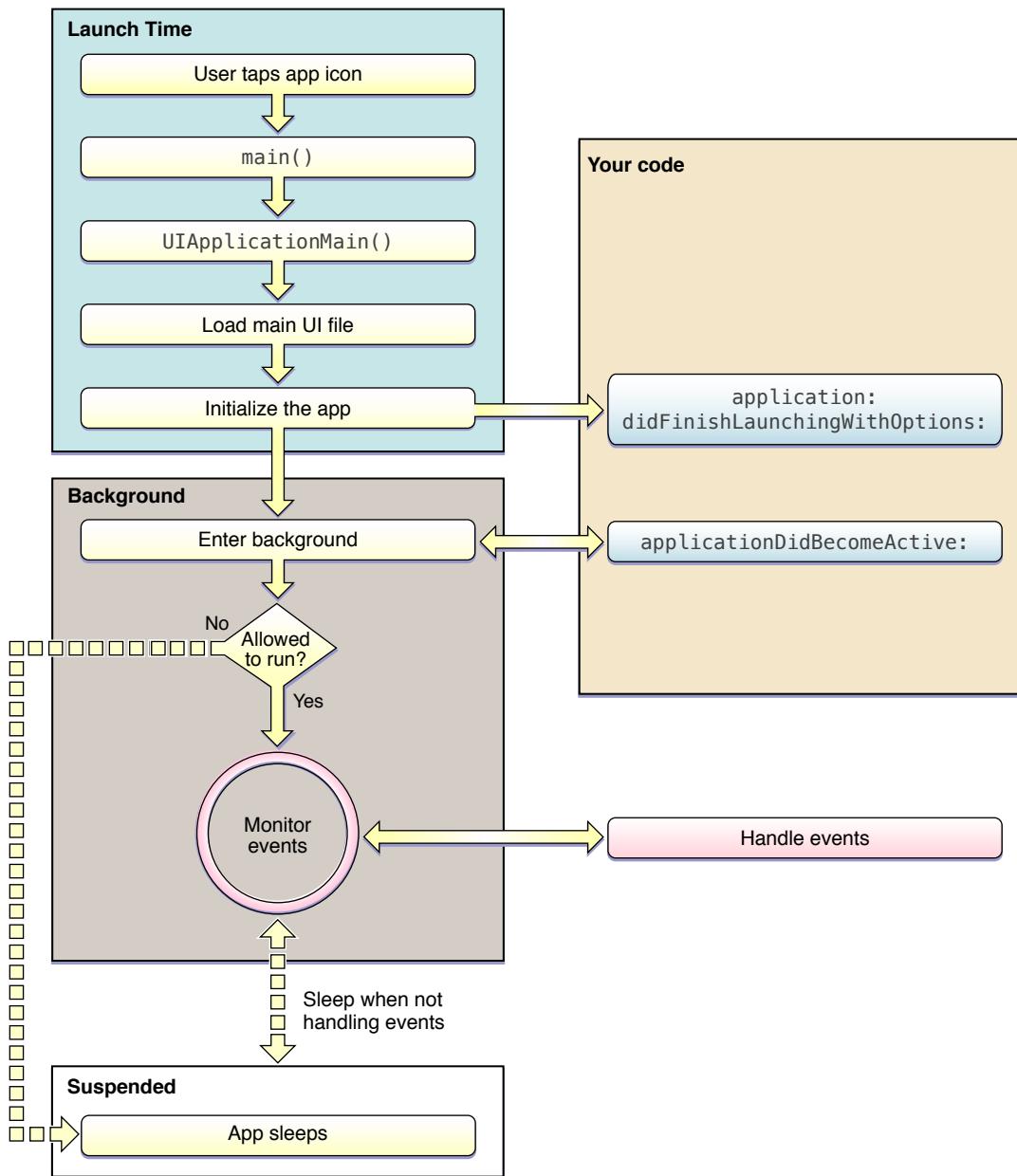
---

When your app is launched, it moves from the not running state to the active or background state, transitioning briefly through the inactive state. As part of the launch cycle, the system creates a process and main thread for your app and calls your app's `main` function on that main thread. The default `main` function that comes with your Xcode project promptly hands control over to the UIKit framework, which does most of the work in initializing your app and preparing it to run.

Figure 3-2 shows the sequence of events that occurs when an app is launched into the foreground, including the app delegate methods that are called.

**Figure 3-2** Launching an app into the foreground

If your app is launched into the background instead—usually to handle some type of background event—the launch cycle changes slightly to the one shown in Figure 3-3. The main difference is that instead of your app being made active, it enters the background state to handle the event and then is suspended shortly afterward. When launching into the background, the system still loads your app’s user interface files but it does not display the app’s window.

**Figure 3-3** Launching an app into the background

To determine whether your app is launching into the foreground or background, check the `applicationState` property of the shared `UIApplication` object in your `application:didFinishLaunchingWithOptions:` method. When the app is launched into the foreground, this property contains the value `UIApplicationStateInactive`. When the app is launched into the background, the property contains the value `UIApplicationStateBackground` instead. You can use this difference to adjust the launch-time behavior of your `application:didFinishLaunchingWithOptions:` method accordingly.

**Note:** When an app is launched so that it can open a URL, the sequence of startup events is slightly different from those shown in Figure 3-2 and Figure 3-3. For information about the startup sequences that occur when opening a URL, see “[Handling URL Requests](#)” (page 100).

## About the main Function

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Like any C-based app, the main entry point for an iOS app at launch time is the `main` function. In an iOS app, the `main` function is used only minimally. Its main job is to hand control to the UIKit framework. Therefore, any new project you create in Xcode comes with a default `main` function like the one shown in Listing 3-1. With few exceptions, you should never change the implementation of this function.

**Listing 3-1** The `main` function of an iOS app

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

int main(int argc, char *argv[])
{
    @autoreleasepool {
        return UIApplicationMain(argc, argv, nil, NSStringFromClass([AppDelegate
class]));
    }
}
```

**Note:** An autorelease pool is used in memory management. It is a Cocoa mechanism used to defer the release of objects created during a functional block of code. For more information about autorelease pools, see [Advanced Memory Management Programming Guide](#).

The `UIApplicationMain` function takes four parameters and uses them to initialize the app. You should never have to change the default values passed into this function. Still, it is valuable to understand their purpose and how they start the app.

- The `argc` and `argv` parameters contain any launch-time arguments passed to the app from the system. These arguments are parsed by the UIKit infrastructure and can otherwise be ignored.
- The third parameter identifies the name of the principal app class. This is the class responsible for running the app. It is recommended that you specify `nil` for this parameter, which causes UIKit to use the `UIApplication` class.
- The fourth parameter identifies the class of your custom app delegate. Your app delegate is responsible for managing the high-level interactions between the system and your code. The Xcode template projects set this parameter to an appropriate value automatically.

Another thing the `UIApplicationMain` function does is load the app’s main user interface file. The main interface file contains the initial view-related objects you plan to display in your app’s user interface. For apps that use storyboards, this function loads the initial view controller from your storyboard and installs it in the window provided by your app delegate. For apps that use nib files, the function loads the nib file contents into memory but does not install them in your app’s window. You must install them yourself in the `application:didFinishLaunchingWithOptions:` method of your app delegate.

An app can have either a main storyboard file or a main nib file but cannot have both. Storyboards, the preferred way to specify your app’s user interface, are not supported on all versions of iOS. Specify the name of your main storyboard file in the `UIStoryboardFile` key of your app’s `Info.plist` file. (For nib-based apps, specify the name of your main nib file using the `NSMainNibFile` key instead.) Normally, Xcode sets the value of this key when you create your project, but you can change it later if needed.

For more information about the `Info.plist` file and how you use it to configure your app, see [Figure 6-1](#) (page 100).

## What to Do at Launch Time

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When your app is launched (either into the foreground or background), use your app delegate’s `application:didFinishLaunchingWithOptions:` method to do the following:

- Check the contents of the launch options dictionary for information about why the app was launched, and respond appropriately.
- Initialize the app’s critical data structures.
- Prepare your app’s window and views for display.

Apps that use OpenGL ES should not use this method to prepare their drawing environment. Instead, they should defer any OpenGL ES drawing calls to the `applicationDidBecomeActive:` method.

- Use any saved preferences or state information to restore the app to its previous runtime state.

If your app uses nib files to manage its views, you should use the `application:didFinishLaunchingWithOptions:` method to prepare your app’s window for display. For nib-based apps, you must create your window object, install the views from your initial view controller, and show the window. For apps that support both portrait and landscape orientations, always set up your window in a portrait orientation. If the device is in a different orientation at launch time, the system automatically rotates your views to the appropriate orientation before displaying the window.

Your `application:didFinishLaunchingWithOptions:` method should always be as lightweight as possible to reduce your app’s launch time. Apps are expected to launch and initialize themselves and start handling events in roughly 5 seconds. If an app does not finish its launch cycle in a timely manner, the system kills it for being unresponsive. Thus, any tasks that might slow down your launch (such as accessing the network) should be executed asynchronously on a secondary thread.

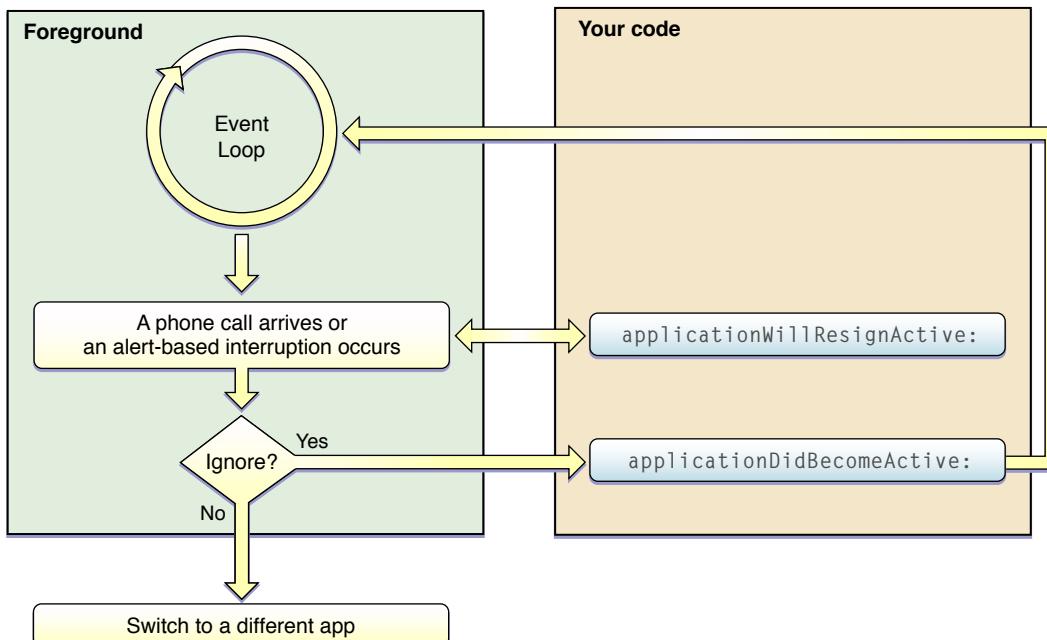
When launching into the foreground, the system also calls the `applicationDidBecomeActive:` method to finish the transition to the foreground. Because this method is called both at launch time and when transitioning from the background, use it to perform any tasks that are common to the two transitions.

When launching into the background, there should not be much for your app to do except get ready to handle whatever event arrived.

## Responding to Interruptions

When an alert-based interruption occurs, such as an incoming phone call, the app moves temporarily to the inactive state so that the system can prompt the user about how to proceed. The app remains in this state until the user dismisses the alert. At this point, the app either returns to the active state or moves to the background state to make way for another app. Figure 3-4 shows the flow of events through your app when an alert-based interruption occurs.

**Figure 3-4** Handling alert-based interruptions



In iOS 5, notifications that display a banner do not deactivate your app in the way that alert-based notifications do. Instead, the banner is laid along the top edge of your app window and your app continues receive touch events as before. However, if the user pulls down the banner to reveal the notification center, your app moves to the inactive state just as if an alert-based interruption had occurred. Your app remains in the inactive state until the user dismisses the notification center or launches another app. At this point, your app moves to the appropriate active or background state. The user can use the Settings app to configure which notifications display a banner and which display an alert.

Pressing the Sleep/Wake button is another type of interruption that causes your app to be deactivated. When the user presses this button, the system disables touch events, deactivates your app, and locks the screen. A locked screen has additional consequences for apps that use data protection to encrypt files. Those consequences are described in ["What to Do When an Interruption Occurs"](#) (page 42).

### What to Do When an Interruption Occurs

Alert-based interruptions result in a temporary loss of control by your app. Your app continues to run in the foreground, but it does not receive touch events from the system. (It does continue to receive notifications and other types of events, such as accelerometer events, though.) In response to this change, your app should do the following in its `applicationWillResignActive:` method:

- Stop timers and other periodic tasks.
- Stop any running metadata queries.
- Do not initiate any new tasks.
- Pause movie playback (except when playing back over AirPlay).
- Games should enter into a pause state.
- Throttle back OpenGL ES frame rates.
- Suspend any dispatch queues or operation queues executing non-critical code. (You can continue processing network requests and other time-sensitive background tasks while inactive.)

When your app is moved back to the active state, its `applicationDidBecomeActive:` method should reverse any of the steps taken in the `applicationWillResignActive:` method. Thus, upon reactivation, your app should restart timers, resume any dispatch queues, and throttle up OpenGL ES frame rates again. However, games should not resume automatically; they should remain paused until the user decides to resume them.

When the user presses the Sleep/Wake button, apps with files protected by the `NSFileProtectionComplete` protection option must close any references to those files. For devices configured with an appropriate password, pressing the Sleep/Wake button locks the screen and forces the system to throw away the decryption keys for files with complete protection enabled. While the screen is locked, any attempts to access the corresponding files will fail. So if you have such files, you should close any references to them in your `applicationWillResignActive:` method and open new references in your `applicationDidBecomeActive:` method.

## Adjusting Your User Interface During a Phone Call

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When the user takes a call and then returns to your app while on the call, the height of the status bar grows to reflect the fact that the user is on a call. Similarly, when the user ends the call, the status bar height shrinks back to its regular size.

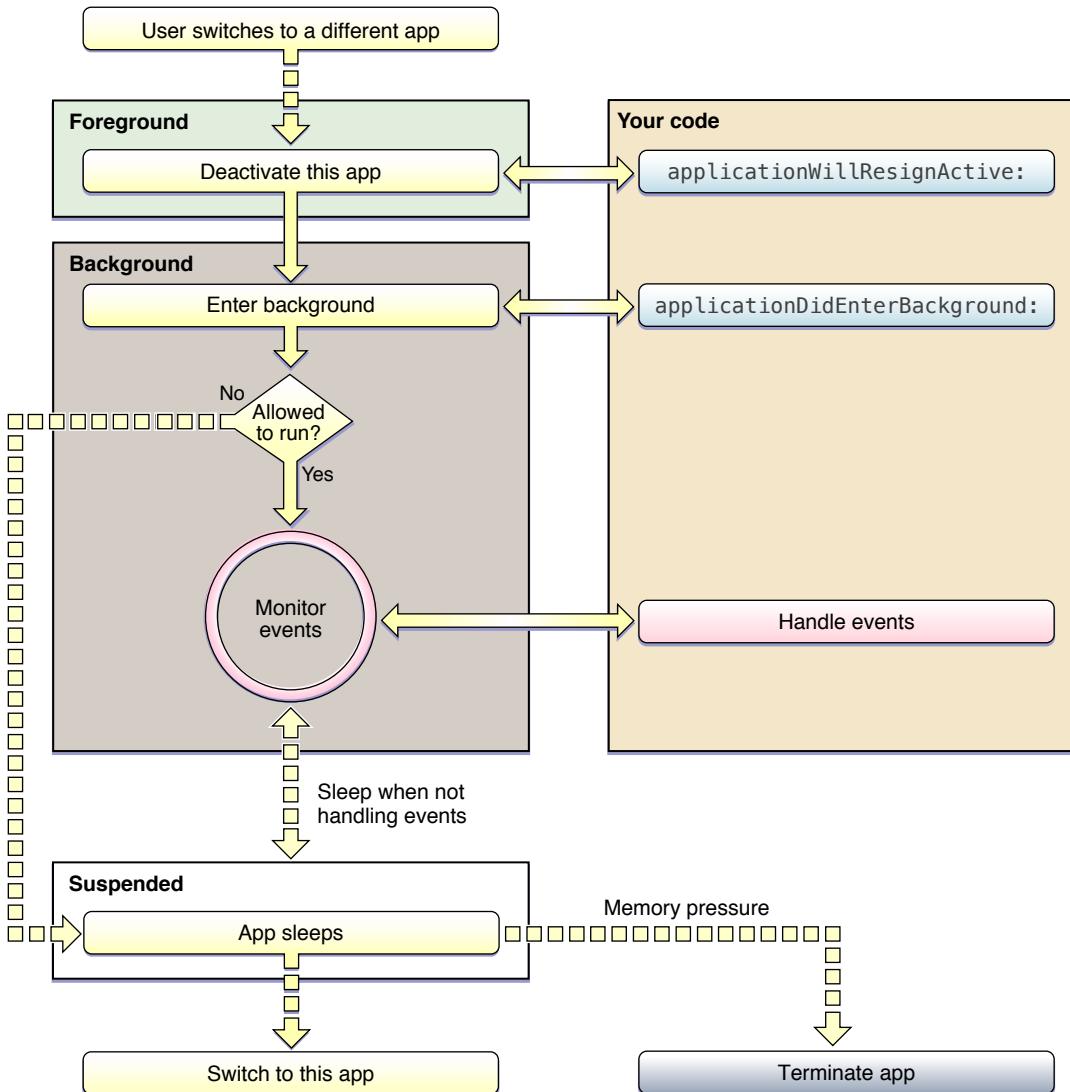
The best way to handle status bar height changes is to use view controllers to manage your views. When installed in your interface, view controllers automatically adjust the height of their managed views when the status bar frame size changes.

If your app does not use view controllers for some reason, you must respond to status bar frame changes manually by registering for the `UIApplicationDidChangeStatusBarFrameNotification` notification. Your handler for this notification should get the status bar height and use it to adjust the height of your app's views appropriately.

## Moving to the Background

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When the user presses the Home button or the system launches another app, the foreground app transitions to the inactive state and then to the background state. These transitions result in calls to the app delegate's `applicationWillResignActive:` and `applicationDidEnterBackground:` methods, as shown in Figure 3-5. After returning from the `applicationDidEnterBackground:` method, most apps move to the suspended state shortly afterward. Apps that request specific background tasks (such as playing music) or that request a little extra execution time from the system may continue to run for a while longer.

**Figure 3-5** Moving from the foreground to the background

**Note:** Apps are moved to the background only on devices that support multitasking and only if those devices are running iOS 4.0 or later. In all other cases, the app is terminated (and thus purged from memory) instead of moved to the background.

### What to Do When Moving to the Background

Apps can use their `applicationDidEnterBackground:` method to prepare for moving to the background state. When moving to the background, all apps should do the following:

- **Prepare to have their picture taken.** When the `applicationDidEnterBackground:` method returns, the system takes a picture of your app's user interface and uses the resulting image for transition animations. If any views in your interface contain sensitive information, you should hide or modify those views before the `applicationDidEnterBackground:` method returns.

- **Save user data and app state information.** All unsaved changes should be written to disk when entering the background. This step is necessary because your app might be quietly killed while in the background for any number of reasons. You can perform this operation from a background thread as needed.
- **Free up as much memory as possible.** For more information about what to do and why this is important, see “[Memory Usage for Background Apps](#)” (page 45).

Your app delegate’s `applicationDidEnterBackground:` method has approximately 5 seconds to finish any tasks and return. In practice, this method should return as quickly as possible. If the method does not return before time runs out, your app is killed and purged from memory. If you still need more time to perform tasks, call the `beginBackgroundTaskWithExpirationHandler:` method to request background execution time and then start any long-running tasks in a secondary thread. Regardless of whether you start any background tasks, the `applicationDidEnterBackground:` method must still exit within 5 seconds.

**Note:** The `UIApplicationDidEnterBackgroundNotification` notification is also sent to let interested parts of your app know that it is entering the background. Objects in your app can use the default notification center to register for this notification.

Depending on the features of your app, there are other things your app should do when moving to the background. For example, any active Bonjour services should be suspended and the app should stop calling OpenGL ES functions. For a list of things your app should do when moving to the background, see “[Being a Responsible Background App](#)” (page 58).

## Memory Usage for Background Apps

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Every app should release as much memory as is practical upon entering the background. The system tries to keep as many apps in memory at the same time as it can, but when memory runs low it terminates suspended apps to reclaim that memory. Apps that consume large amounts of memory while in the background are the first apps to be terminated.

Practically speaking, your app should remove references to objects as soon as they are no longer needed. Removing references allows the automatic reference counting system to release the object and reclaim its memory right away. However, if your app uses caches to improve performance, you can wait and delete those caches during the transition to the background. Some examples of objects that you should allow to be reclaimed include:

- Cached image objects
- Large media or data files that you can load again from disk
- Any other objects that your app does not need and can recreate easily later

To help your app reduce its memory footprint, the system automatically releases many of the objects used behind the scenes to support your app. For example:

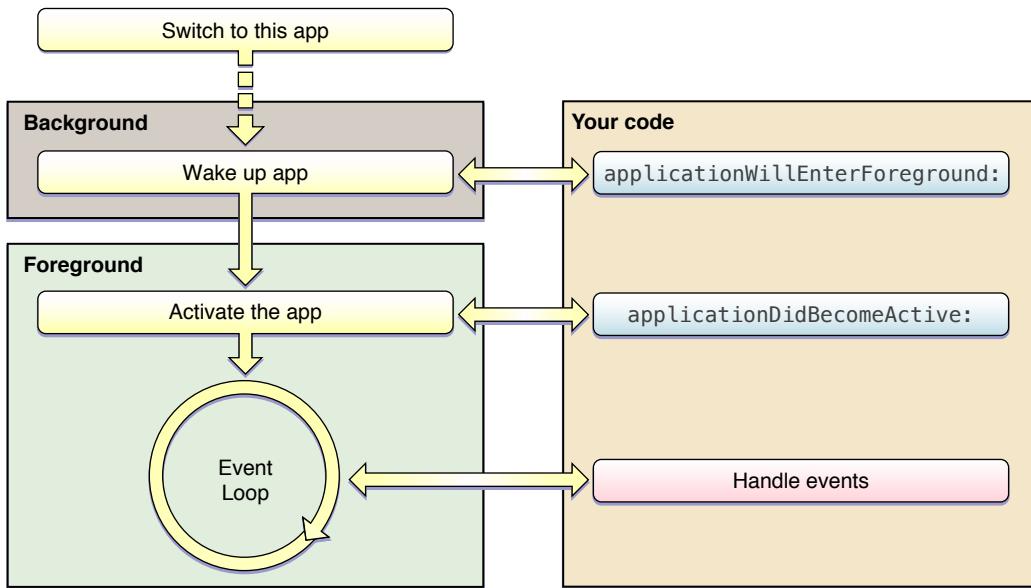
- It releases the backing store for all Core Animation layers, which prevents the contents of those layers from appearing onscreen but does not change the current layer properties. It does not release the layer objects themselves.
- It removes any references to cached images. (If your app does not have a strong reference to the images, they are subsequently removed from memory.)

- It releases some other system-managed data caches.

## Returning to the Foreground

Returning to the foreground is your app's chance to restart the tasks that it stopped when it moved to the background. The steps that occur when moving to the foreground are shown in Figure 3-6. The `applicationWillEnterForeground:` method should undo anything that was done in your `applicationDidEnterBackground:` method, and the `applicationDidBecomeActive:` method should continue to perform the same activation tasks that it would at launch time.

**Figure 3-6** Transitioning from the background to the foreground



**Note:** The `UIApplicationWillEnterForegroundNotification` notification is also available for tracking when your app reenters the foreground. Objects in your app can use the default notification center to register for this notification.

## Processing Queued Notifications at Wakeup Time

An app in the suspended state must be ready to handle any queued notifications when it returns to a foreground or background execution state. A suspended app does not execute any code and therefore cannot process notifications related to orientation changes, time changes, preferences changes, and many others that would affect the app's appearance or state. To make sure these changes are not lost, the system queues many relevant notifications and delivers them to the app as soon as it starts executing code again (either in the foreground or background). To prevent your app from becoming overloaded with notifications when it resumes, the system coalesces events and delivers a single notification (of each relevant type) that reflects the net change since your app was suspended.

Table 3-2 lists the notifications that can be coalesced and delivered to your app. Most of these notifications are delivered directly to the registered observers. Some, like those related to device orientation changes, are typically intercepted by a system framework and delivered to your app in another way.

**Table 3-2** Notifications delivered to waking apps

Event	Notifications
An accessory is connected or disconnected.	<code>EAAccessorDidConnectNotification</code> <code>EAAccessorDidDisconnectNotification</code>
The device orientation changes.	<code>UIDeviceOrientationDidChangeNotification</code> In addition to this notification, view controllers update their interface orientations automatically.
There is a significant time change.	<code>UIApplicationSignificantTimeChangeNotification</code>
The battery level or battery state changes.	<code>UIDeviceBatteryLevelDidChangeNotification</code> <code>UIDeviceBatteryStateDidChangeNotification</code>
The proximity state changes.	<code>UIDeviceProximityStateDidChangeNotification</code>
The status of protected files changes.	<code>UIApplicationProtectedDataWillBecomeUnavailable</code> <code>UIApplicationProtectedDataDidBecomeAvailable</code>
An external display is connected or disconnected.	<code>UIScreenDidConnectNotification</code> <code>UIScreenDidDisconnectNotification</code>
The screen mode of a display changes.	<code>UIScreenModeDidChangeNotification</code>
Preferences that your app exposes through the Settings app changed.	<code>NSUserDefaultsDidChangeNotification</code>
The current language or locale settings changed.	<code>NSCurrentLocaleDidChangeNotification</code>

Queued notifications are delivered on your app's main run loop and are typically delivered before any touch events or other user input. Most apps should be able to handle these events quickly enough that they would not cause any noticeable lag when resumed. However, if your app appears sluggish when it returns from the background state, use Instruments to determine whether your notification handler code is causing the delay.

An app returning to the foreground also receives view-update notifications for any views that were marked dirty since the last update. An app running in the background can still call the `setNeedsDisplay` or `setNeedsDisplayInRect:` methods to request an update for its views. However, because the views are not visible, the system coalesces the requests and updates the views only after the app returns to the foreground.

## Handling Locale Changes Gracefully

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If a user changes the current language while your app is suspended, you can use the `NSCurrentLocaleDidChangeNotification` notification to force updates to any views containing locale-sensitive information, such as dates, times, and numbers when your app returns to the foreground. Of course, the best way to avoid language-related issues is to write your code in ways that make it easy to update views. For example:

- Use the `autoupdatingCurrentLocale` class method when retrieving `NSLocale` objects. This method returns a locale object that updates itself automatically in response to changes, so you never need to recreate it. However, when the locale changes, you still need to refresh views that contain content derived from the current locale.
- Re-create any cached date and number formatter objects whenever the current locale information changes.

For more information about internationalizing your code to handle locale changes, see *Internationalization Programming Topics*.

## Responding to Changes in Your App's Settings

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If your app has settings that are managed by the Settings app, it should observe the `NSUserDefaultsDidChangeNotification` notification. Because the user can modify settings while your app is suspended or in the background, you can use this notification to respond to any important changes in those settings. In some cases, responding to this notification can help close a potential security hole. For example, an email program should respond to changes in the user's account information. Failure to monitor these changes could cause privacy or security issues. Specifically, the current user might be able to send email using the old account information, even if the account no longer belongs to that person.

Upon receiving the `NSUserDefaultsDidChangeNotification` notification, your app should reload any relevant settings and, if necessary, reset its user interface appropriately. In cases where passwords or other security-related information has changed, you should also hide any previously displayed information and force the user to enter the new password.

## App Termination

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Although apps are generally moved to the background and suspended, if any of the following conditions are true, your app is terminated and purged from memory instead:

- The app is linked against a version of iOS earlier than 4.0.
- The app is deployed on a device running a version of iOS earlier than 4.0.
- The current device does not support multitasking; see “[Determining Whether Multitasking Is Available](#)” (page 51).
- The app includes the `UIApplicationExitsOnSuspend` key in its `Info.plist` file; see “[Opting out of Background Execution](#)” (page 59).

If your app is running (either in the foreground or background) at termination time, the system calls your app delegate’s `applicationWillTerminate:` method so that you can perform any required cleanup. You can use this method to save user data or app state information that you would use to restore your app to its current state on a subsequent launch. Your method has approximately 5 seconds to perform any tasks and return. If it does not return in time, the app is killed and removed from memory.

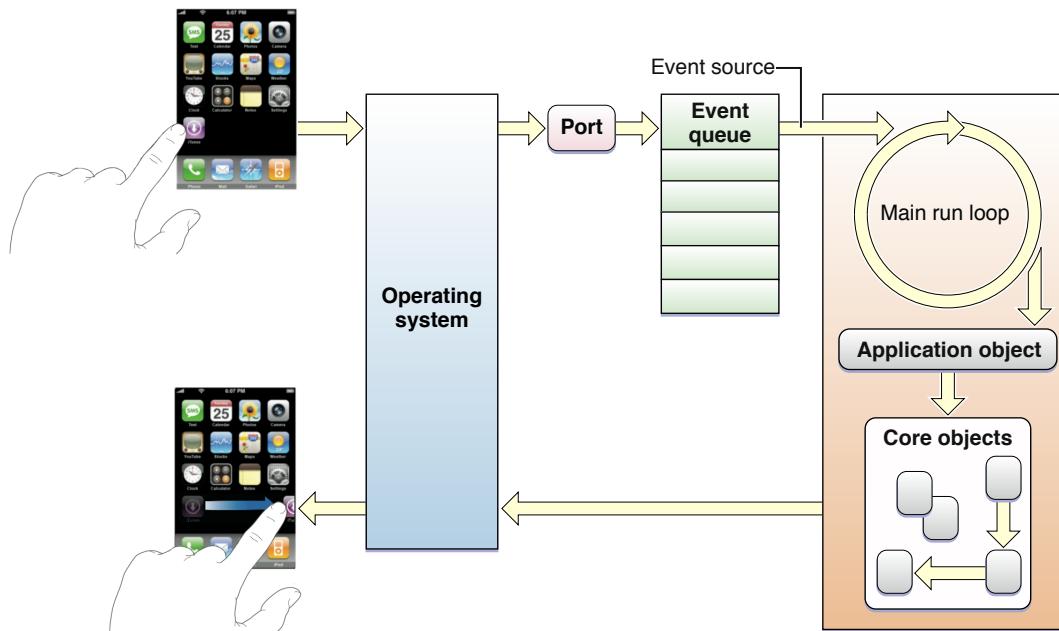
**Important:** The `applicationWillTerminate:` method is not called if your app is currently suspended.

Even if you develop your app using iOS SDK 4 and later, you must still be prepared for your app to be killed without any notification. The user can kill apps explicitly using the multitasking UI. In addition, if memory becomes constrained, the system might remove apps from memory to make more room. Suspended apps are not notified of termination but if your app is currently running in the background state (and not suspended), the system calls the `applicationWillTerminate:` method of your app delegate. Your app cannot request additional background execution time from this method.

## The Main Run Loop

The **main run loop** of your app is responsible for processing all user-related events. The `UIApplication` object sets up the main run loop at launch time and uses it to process events and handle updates to view-based interfaces. As the name suggests, the main run loop executes on the app’s main thread. This behavior ensures that user-related events are processed serially in the order in which they were received.

Figure 3-7 shows the architecture of the main run loop and how user events result in actions taken by your app. As the user interacts with a device, events related to those interactions are generated by the system and delivered to the app via a special port set up by UIKit. Events are queued internally by the app and dispatched one-by-one to the main run loop for execution. The `UIApplication` object is the first object to receive the event and make the decision about what needs to be done. A touch event is usually dispatched to the main window object, which in turn dispatches it to the view in which the touch occurred. Other events might take slightly different paths through various app objects.

**Figure 3-7** Processing events in the main run loop

Many types of events can be delivered in an iOS app. The most common ones are listed in Table 3-3. Many of these event types are delivered using the main run loop of your app, but some are not. For example, accelerometer events are delivered directly to the accelerometer delegate object that you specify. For information about how to handle most types of events—including touch, remote control, motion, accelerometer, and gyroscopic events—see *Event Handling Guide for iOS*.

**Table 3-3** Common types of events for iOS apps

Event type	Delivered to...	Notes
Touch	The view object in which the event occurred	Views are responder objects. Any touch events not handled by the view are forwarded down the responder chain for processing.
Remote control	First responder object	Remote control events are for controlling media playback and are generated by headphones and other accessories.
Motion	First responder object	Motion events reflect specific motion-related events (such as shaking a device) and are handled separately from other accelerometer-based events.
Accelerometer Core Motion	The object you designate	Events related to the accelerometer and gyroscope hardware are delivered to the object you designate.
Redraw	The view that needs the update	Redraw events do not involve an event object but are simply calls to the view to draw itself. The drawing architecture for iOS is described in <i>Drawing and Printing Guide for iOS</i> .

Event type	Delivered to...	Notes
Location	The object you designate	You register to receive location events using the Core Location framework. For more information about using Core Location, see <i>Location Awareness Programming Guide</i> .

Some events, such as touch and remote control events, are handled by your app's responder objects. Responder objects are everywhere in your app. (The `UIApplication` object, your view objects, and your view controller objects are all examples of responder objects.) Most events target a specific responder object but can be passed to other responder objects (via the responder chain) if needed to handle an event. For example, a view that does not handle an event can pass the event to its superview or to a view controller.

Touch events occurring in controls (such as buttons) are handled differently than touch events occurring in many other types of views. There are typically only a limited number of interactions possible with a control, and so those interactions are repackaged into action messages and delivered to an appropriate target object. This target-action design pattern makes it easy to use controls to trigger the execution of custom code in your app.

## Background Execution and Multitasking

In iOS 4 and later, multitasking allows apps to continue running in the background even after the user switches to another app while still preserving battery life as much as possible. Most apps are moved to the suspended state shortly after entering the background. Only apps that provide important services to the user are allowed to continue running for any amount of time.

As much as possible, you are encouraged to avoid executing in the background and let your app be suspended. If you find you need to perform background tasks, here are some guidelines for when that is appropriate:

- You need to implement at least one of several specific user services.
- You need to perform a single finite-length task.
- You need to use notifications to alert the user to some relevant piece of information when your app is not running.

The system keeps suspended apps in memory for as long as possible, removing them only when the amount of free memory gets low. Remaining in memory means that subsequent launches of your app are much faster. At the same time, being suspended means your app does not drain the device's battery as fast.

## Determining Whether Multitasking Is Available

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Apps must be prepared to handle situations where multitasking (and therefore background execution) is not available. Even if your app is specifically built for iOS 4 and later, some devices running iOS 4 may not support multitasking. And multitasking is never available on devices running iOS 3 and earlier. If your app supports these earlier versions of iOS, it must be prepared to run without multitasking.

If the presence or absence of multitasking changes the way your app behaves, check the `multitaskingSupported` property of the `UIDevice` class to determine whether multitasking is available before performing the relevant task. For apps built for iOS 4 and later, this property is always available. However, if your app supports earlier versions of the system, you must check to see whether the property itself is available before accessing it, as shown in Listing 3-2.

#### **Listing 3-2** Checking for background support in earlier versions of iOS

```
UIDevice* device = [UIDevice currentDevice];
BOOL backgroundSupported = NO;
if ([device respondsToSelector:@selector(isMultitaskingSupported)])
    backgroundSupported = device.multitaskingSupported;
```

## Executing a Finite-Length Task in the Background

Apps that are transitioning to the background can request an extra amount of time to finish any important last-minute tasks. To request background execution time, call the `beginBackgroundTaskWithExpirationHandler:` method of the `UIApplication` class. If your app moves to the background while the task is in progress, or if your app was already in the background, this method delays the suspension of your app. This can be important if your app is performing some important task, such as writing user data to disk or downloading an important file from a network server.

The way to use the `beginBackgroundTaskWithExpirationHandler:` method is to call it before starting the task you want to protect. Every call to this method must be balanced by a corresponding call to the `endBackgroundTask:` method to mark the end of the task. Because apps are given only a limited amount of time to finish background tasks, you must call this method before time expires; otherwise the system will terminate your app. To avoid termination, you can also provide an expiration handler when starting a task and call the `endBackgroundTask:` method from there. (You can use the value in the `backgroundTimeRemaining` property of the app object to see how much time is left.)

**Important:** An app can have any number of tasks running at the same time. Each time you start a task, the `beginBackgroundTaskWithExpirationHandler:` method returns a unique identifier for the task. You must pass this same identifier to the `endBackgroundTask:` method when it comes time to end the task.

Listing 3-3 shows how to start a long-running task when your app transitions to the background. In this example, the request to start a background task includes an expiration handler just in case the task takes too long. The task itself is then submitted to a dispatch queue for asynchronous execution so that the `applicationDidEnterBackground:` method can return normally. The use of blocks simplifies the code needed to maintain references to any important variables, such as the background task identifier. The `bgTask` variable is a member variable of the class that stores a pointer to the current background task identifier.

#### **Listing 3-3** Starting a background task at quit time

```
- (void)applicationDidEnterBackground:(UIApplication *)application
{
    UIApplication*      app = [UIApplication sharedApplication];

    bgTask = [app beginBackgroundTaskWithExpirationHandler:^{
        // Clean up any unfinished task business by marking where you.
        // stopped or ending the task outright.
        [app endBackgroundTask:bgTask];
        bgTask = UIBackgroundTaskInvalid;
    }];
}
```

```

    }];

    // Start the long-running task and return immediately.
    dispatch_async(dispatch_get_global_queue(DISPATCH_QUEUE_PRIORITY_DEFAULT,
0), ^{
        // Do the work associated with the task, preferably in chunks.

        [app endBackgroundTask:bgTask];
        bgTask = UIBackgroundTaskInvalid;
    });
}

```

**Note:** Always provide an expiration handler when starting a task, but if you want to know how much time your app has left to run, get the value of the `backgroundTimeRemaining` property of `UIApplication`.

In your own expiration handlers, you can include additional code needed to close out your task. However, any code you include must not take too long to execute because, by the time your expiration handler is called, your app is already very close to its time limit. For this reason, perform only minimal cleanup of your state information and end the task.

## Scheduling the Delivery of Local Notifications

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Notifications are a way for an app that is suspended, is in the background, or is not running to get the user's attention. Apps can use local notifications to display alerts, play sounds, badge the app's icon, or a combination of the three. For example, an alarm clock app might use local notifications to play an alarm sound and display an alert to disable the alarm. When a notification is delivered to the user, the user must decide if the information warrants bringing the app back to the foreground. (If the app is already running in the foreground, local notifications are delivered quietly to the app and not to the user.)

To schedule the delivery of a local notification, create an instance of the `UILocalNotification` class, configure the notification parameters, and schedule it using the methods of the `UIApplication` class. The local notification object contains information about the type of notification to deliver (sound, alert, or badge) and the time (when applicable) at which to deliver it. The methods of the `UIApplication` class provide options for delivering notifications immediately or at the scheduled time.

Listing 3-4 shows an example that schedules a single alarm using a date and time that is set by the user. This example configures only one alarm at a time and cancels the previous alarm before scheduling a new one. (Your own apps can have no more than 128 local notifications active at any given time, any of which can be configured to repeat at a specified interval.) The alarm itself consists of an alert box and a sound file that is played if the app is not running or is in the background when the alarm fires. If the app is active and therefore running in the foreground, the app delegate's `application:didReceiveLocalNotification:` method is called instead.

**Listing 3-4** Scheduling an alarm notification

```

- (void)scheduleAlarmForDate:(NSDate*)theDate
{
    UIApplication* app = [UIApplication sharedApplication];
    NSArray* oldNotifications = [app scheduledLocalNotifications];

    // Clear out the old notification before scheduling a new one.
    if ([oldNotifications count] > 0)

```

```

[app cancelAllLocalNotifications];

// Create a new notification.
UILocalNotification* alarm = [[[UILocalNotification alloc] init] autorelease];
if (alarm)
{
    alarm.fireDate = theDate;
    alarm.timeZone = [NSTimeZone defaultTimeZone];
    alarm.repeatInterval = 0;
    alarm.soundName = @"alarmsound.caf";
    alarm.alertBody = @"Time to wake up!";

    [app scheduleLocalNotification:alarm];
}
}

```

Sound files used with local notifications have the same requirements as those used for push notifications. Custom sound files must be located inside your app's main bundle and support one of the following formats: Linear PCM, MA4, µ-Law, or a-Law. You can also specify the sound name `default` to play the default alert sound for the device. When the notification is sent and the sound is played, the system also triggers a vibration on devices that support it.

You can cancel scheduled notifications or get a list of notifications using the methods of the `UIApplication` class. For more information about these methods, see *UIApplication Class Reference*. For additional information about configuring local notifications, see *Local and Push Notification Programming Guide*.

## Implementing Long-Running Background Tasks

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For tasks that require more execution time to implement, you must request specific permissions to run them in the background without their being suspended. In iOS, only specific app types are allowed to run in the background:

- Apps that play audible content to the user while in the background, such as a music player app
- Apps that keep users informed of their location at all times, such as a navigation app
- Apps that support Voice over Internet Protocol (VoIP)
- Newsstand apps that need to download and process new content
- Apps that receive regular updates from external accessories

Apps that implement these services must declare the services they support and use system frameworks to implement the relevant aspects of those services. Declaring the services lets the system know which services you use, but in some cases it is the system frameworks that actually prevent your application from being suspended.

## Declaring Your App's Supported Background Tasks

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Support for some types of background execution must be declared in advance by the app that uses them. An app declares support for a service using its `Info.plist` file. Add the `UIBackgroundModes` key to your `Info.plist` file and set its value to an array containing one or more of the following strings:

- `audio`—The app plays audible content to the user while in the background. (This content includes streaming audio or video content using AirPlay.)
- `location`—The app keeps users informed of their location, even while it is running in the background.
- `voip`—The app provides the ability for the user to make phone calls using an Internet connection.
- `newsstand-content`—The app is a Newsstand app that downloads and processes magazine or newspaper content in the background.
- `external-accessory`—The app works with a hardware accessory that needs to deliver updates on a regular schedule.

Each of the preceding values lets the system know that your app should be woken up at appropriate times to respond to relevant events. For example, an app that begins playing music and then moves to the background still needs execution time to fill the audio output buffers. Including the `audio` key tells the system frameworks that they should continue playing and make the necessary callbacks to the app at appropriate intervals. If the app does not include this key, any audio being played by the app stops when the app moves to the background.

## Tracking the User’s Location

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There are several ways to track the user’s location in the background, most of which do not actually require your app to run continuously in the background:

- The significant-change location service (Recommended)
- Foreground-only location services
- Background location services

The significant-change location service is highly recommended for apps that do not need high-precision location data. With this service, location updates are generated only when the user’s location changes significantly; thus, it is ideal for social apps or apps that provide the user with noncritical, location-relevant information. If the app is suspended when an update occurs, the system wakes it up in the background to handle the update. If the app starts this service and is then terminated, the system relaunches the app automatically when a new location becomes available. This service is available in iOS 4 and later, and it is available only on devices that contain a cellular radio.

The foreground-only and background location services both use the standard location Core Location service to retrieve location data. The only difference is that the foreground-only location services stop delivering updates if the app is ever suspended, which is likely to happen if the app does not support other background services or tasks. Foreground-only location services are intended for apps that only need location data while they are in the foreground.

An app that provides continuous location updates to the user (even when in the background) can enable background location services by including the `UIBackgroundModes` key (with the `location` value) in its `Info.plist` file. The inclusion of this value in the `UIBackgroundModes` key does not preclude the system from suspending the app, but it does tell the system that it should wake up the app whenever there is new location data to deliver. Thus, this key effectively lets the app run in the background to process location updates whenever they occur.

**Important:** You are encouraged to use the standard services sparingly or use the significant location change service instead. Location services require the active use of an iOS device's onboard radio hardware. Running this hardware continuously can consume a significant amount of power. If your app does not need to provide precise and continuous location information to the user, it is best to minimize the use of location services.

For information about how to use each of the different location services in your app, see *Location Awareness Programming Guide*.

## Playing Background Audio

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An app that plays audio continuously (even while the app is running in the background) can register as a background audio app by including the `UIBackgroundModes` key (with the value `audio`) in its `Info.plist` file. Apps that include this key must play audible content to the user while in the background.

Typical examples of background audio apps include:

- Music player apps
- Apps that support audio or video playback over AirPlay
- VoIP apps

When the `UIBackgroundModes` key contains the `audio` value, the system's media frameworks automatically prevent the corresponding app from being suspended when it moves to the background. As long as it is playing audio or video content, the app continues to run in the background. However, if the app stops playing the audio or video, the system suspends it.

You can use any of the system audio frameworks to initiate the playback of background audio, and the process for using those frameworks is unchanged. (For video playback over AirPlay, you must use the Media Player framework to present your video.) Because your app is not suspended while playing media files, callbacks operate normally while your app is in the background. In your callbacks, though, you should do only the work necessary to provide data for playback. For example, a streaming audio app would need to download the music stream data from its server and push the current audio samples out for playback. You should not perform any extraneous tasks that are unrelated to playback.

Because more than one app may support audio, the system limits which apps can play audio at any given time. The foreground app always has permission to play audio. In addition, one or more background apps may also be allowed to play some audio content depending on the configuration of their audio session objects. You should always configure your app's audio session object appropriately and work carefully with the system frameworks to handle interruptions and other types of audio-related notifications. For information on how to configure audio session objects for background execution, see *Audio Session Programming Guide*.

## Implementing a VoIP App

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A **Voice over Internet Protocol (VoIP)** app allows the user to make phone calls using an Internet connection instead of the device's cellular service. Such an app needs to maintain a persistent network connection to its associated service so that it can receive incoming calls and other relevant data. Rather than keep VoIP apps awake all the time, the system allows them to be suspended and provides facilities for monitoring their sockets for them. When incoming traffic is detected, the system wakes up the VoIP app and returns control of its sockets to it.

To configure a VoIP app, you must do the following:

1. Add the `UIBackgroundModes` key to your app's `Info.plist` file. Set the value of this key to an array that includes the `voip` value.
2. Configure one of the app's sockets for VoIP usage.
3. Before moving to the background, call the `setKeepAliveTimeout:handler:` method to install a handler to be executed periodically. Your app can use this handler to maintain its service connection.
4. Configure your audio session to handle transitions to and from active use.

Including the `voip` value in the `UIBackgroundModes` key lets the system know that it should allow the app to run in the background as needed to manage its network sockets. An app with this key is also relaunched in the background immediately after system boot to ensure that the VoIP services are always available.

Most VoIP apps also need to be configured as background audio apps to deliver audio while in the background. Therefore, you should include both the `audio` and `voip` values to the `UIBackgroundModes` key. If you do not do this, your app cannot play audio while it is in the background. For more information about the `UIBackgroundModes` key, see *Information Property List Key Reference*.

For specific information about the steps you must take to implement a VoIP app, see “[Tips for Developing a VoIP App](#)” (page 95).

## Downloading Newsstand Content in the Background

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A Newsstand app that downloads new magazine or newspaper issues can register to perform those downloads in the background. When your server sends a push notification to indicate that a new issue is available, the system checks to see whether your app has the `UIBackgroundModes` key with the `newsstand-content` value. If it does, the system launches your app, if it is not already running, so that it can initiate the downloading of the new issue.

When you use the Newsstand Kit framework to initiate a download, the system handles the download process for your app. The system continues to download the file even if your app is suspended or terminated. When the download operation is complete, the system transfers the file to your app sandbox and notifies your app. If the app is not running, this notification wakes it up and gives it a chance to process the newly downloaded file. If there are errors during the download process, your app is similarly woken up to handle them.

For information about how to download content using the Newsstand Kit framework, see *Newsstand Kit Framework Reference*.

## Communicating wWith an External Accessory

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Apps that work with external accessories can ask to be woken up if the accessory delivers an update when the app is suspended. This support is important for some types of accessories that deliver data at regular intervals, such as heart-rate monitors. When an app includes the `UIBackgroundModes` key with the `external-accessory` value in its `Info.plist` file, the external accessory framework keeps open any active sessions for the corresponding accessories. (In iOS 4 and earlier, these sessions are closed automatically when the app is suspended.) In addition, new data arriving from the accessory causes the system to wake up the app to process that data. The system also wakes up the app to process accessory connection and disconnection notifications.

Any app that supports the background processing of accessory updates must follow a few basic guidelines:

- Apps must provide an interface that allows the user to start and stop the delivery of accessory update events. That interface should then open or close the accessory session as appropriate.
- Upon being woken up, the app has around 10 seconds to process the data. Ideally, it should process the data as fast as possible and allow itself to be suspended again. However, if more time is needed, the app can use the `beginBackgroundTaskWithExpirationHandler:` method to request additional time; it should do so only when absolutely necessary, though.

## Being a Responsible Background App

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The foreground app always has precedence over background apps when it comes to the use of system resources and hardware. Apps running in the background need to be prepared for this discrepancy and adjust their behavior when running in the background. Specifically, apps moving to the background should follow these guidelines:

- **Do not make any OpenGL ES calls from your code.** You must not create an `EAGLContext` object or issue any OpenGL ES drawing commands of any kind while running in the background. Using these calls causes your app to be killed immediately. Apps must also ensure that any previously submitted commands have completed before moving to the background. For information about how to handle OpenGL ES when moving to and from the background, see “[Implementing a Multitasking-aware OpenGL ES Application](#)” in *OpenGL ES Programming Guide for iOS*.
- **Cancel any Bonjour-related services before being suspended.** When your app moves to the background, and before it is suspended, it should unregister from Bonjour and close listening sockets associated with any network services. A suspended app cannot respond to incoming service requests anyway. Closing out those services prevents them from appearing to be available when they actually are not. If you do not close out Bonjour services yourself, the system closes out those services automatically when your app is suspended.
- **Be prepared to handle connection failures in your network-based sockets.** The system may tear down socket connections while your app is suspended for any number of reasons. As long as your socket-based code is prepared for other types of network failures, such as a lost signal or network transition, this should not lead to any unusual problems. When your app resumes, if it encounters a failure upon using a socket, simply reestablish the connection.
- **Save your app state before moving to the background.** During low-memory conditions, background apps may be purged from memory to free up space. Suspended apps are purged first, and no notice is given to the app before it is purged. As a result, before moving to the background, an app should always save enough state information to reconstitute itself later if necessary. For tips on how to save the state of your user interface, see “[Preserving the State of Your App’s User Interface](#)” (page 92).
- **Release any unneeded memory when moving to the background.** If your app maintains a large in-memory cache of objects (especially images), remove references to those caches when moving to the background. For more information, see “[Memory Usage for Background Apps](#)” (page 45).
- **Stop using shared system resources before being suspended.** Apps that interact with shared system resources such as the Address Book or calendar databases should stop using those resources before being suspended. Priority for such resources always goes to the foreground app. When your app is suspended, if it is found to be using a shared resource, the app is killed.

- **Avoid updating your windows and views.** While in the background, your app's windows and views are not visible, so you should not try to update them. Although creating and manipulating window and view objects in the background does not cause your app to be killed, consider postponing this work until you return to the foreground.
- **Respond to connect and disconnect notifications for external accessories.** For apps that communicate with external accessories, the system automatically sends a disconnection notification when the app moves to the background. The app must register for this notification and use it to close out the current accessory session. When the app moves back to the foreground, a matching connection notification is sent, giving the app a chance to reconnect. For more information on handling accessory connection and disconnection notifications, see *External Accessory Programming Topics*.
- **Clean up resources for active alerts when moving to the background.** In order to preserve context when switching between apps, the system does not automatically dismiss action sheets (`UIActionSheet`) or alert views (`UIAlertView`) when your app moves to the background. It is up to you to provide the appropriate cleanup behavior prior to moving to the background. For example, you might want to cancel the action sheet or alert view programmatically or save enough contextual information to restore the view later (in cases where your app is terminated).

For apps linked against a version of iOS earlier than 4.0, action sheets and alerts are still dismissed at quit time so that your app's cancellation handler has a chance to run.

- **Remove sensitive information from views before moving to the background.** When an app transitions to the background, the system takes a snapshot of the app's main window, which it then presents briefly when transitioning your app back to the foreground. Before returning from your `applicationDidEnterBackground:` method, you should hide or obscure passwords and other sensitive personal information that might be captured as part of the snapshot.
- **Do minimal work while running in the background.** The execution time given to background apps is more constrained than the amount of time given to the foreground app. If your app plays background audio or monitors location changes, you should focus on that task only and defer any nonessential tasks until later. Apps that spend too much time executing in the background can be throttled back by the system or killed.

If you are implementing a background audio app, or any other type of app that is allowed to run in the background, your app responds to incoming messages in the usual way. In other words, the system may notify your app of low-memory warnings when they occur. And in situations where the system needs to terminate apps to free even more memory, the app calls its delegate's `applicationWillTerminate:` method to perform any final tasks before exiting.

## Opting out of Background Execution

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If you do not want your app to run in the background at all, you can explicitly opt out of background by adding the `UIApplicationExitsOnSuspend` key (with the value YES) to your app's `Info.plist` file. When an app opts out, it cycles between the not-running, inactive, and active states and never enters the background or suspended states. When the user presses the Home button to quit the app, the `applicationWillTerminate:` method of the app delegate is called and the app has approximately 5 seconds to clean up and exit before it is terminated and moved back to the not-running state.

Even though opting out of background execution is strongly discouraged, it may be preferable under certain conditions. Specifically, if coding for the background requires adding significant complexity to your app, terminating the app may be a simpler solution. Also, if your app consumes a large amount of memory and

cannot easily release any of it, the system might need to kill your app quickly anyway to make room for other apps. Thus, opting to terminate, instead of switching to the background, might yield the same results and save you development time and effort.

**Note:** Explicitly opting out of background execution is necessary only if your app is linked against iOS SDK 4 and later. Apps linked against earlier versions of the SDK do not support background execution as a rule and therefore do not need to opt out explicitly.

For more information about the keys you can include in your app's `Info.plist` file, see *Information Property List Key Reference*.

## Concurrency and Secondary Threads

The system creates your app's main thread but your app can create additional threads as needed to perform other tasks. The preferred way to create threads is to let the system do it for you by using dispatch queues and operation queues. Queues provide an asynchronous execution model for tasks that you define. When you submit a task to a queue, the system spins up a thread and executes your task on that thread. Letting the system manage the threads simplifies your code and allows the system to manage the threads in the most efficient way available.

You should use queues whenever possible to move work off of your app's main thread. Because the main thread is responsible for processing touch and drawing events, you should never perform lengthy tasks on it. For example, you should never wait for a network response on your app's main thread. It is much better to make the request asynchronously using a queue and process the results when they arrive.

Another good time to move tasks to secondary threads is launch time. Launched apps have a limited amount of time (around 5 seconds) to do their initialization and start processing events. If you have launch-time tasks that can be deferred or executed on a secondary thread, you should move them off the main thread right away and use the main thread only to present your user interface and start handling events.

For more information about using dispatch and operation queues to execute tasks, see *Concurrency Programming Guide*.

# iCloud Storage

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iCloud storage is a set of interfaces and services for sharing data among instances of your app running on different devices. The idea behind iCloud is to provide a single place where your app can write its data. Changes made by one instance of your app are propagated to the user's other devices seamlessly so that the other instances of your app see them too. This creates a more coherent user experience by eliminating the need to synchronize data explicitly between devices or have a computer act as a hub for storing all of the user's files and data.

There are two ways to adopt iCloud storage in your app:

- **iCloud document storage**—Use this feature to store user documents and app data in the user's iCloud account.
- **iCloud key-value data storage**—Use this feature to share small amounts of noncritical configuration data among instances of your app.

Most of the iCloud interfaces are aimed at helping you manage files, not your user interface. Adopting iCloud storage requires some changes to your app's data model and how it tracks and manages files. Depending on your app, it might also require changes to your app's user interface and overall configuration. And if you want to share files between iOS and Mac OS X devices, it might require changing how you construct your file formats too.

**Important:** Access to iCloud is controlled using entitlements, which your app configures through Xcode. If these entitlements are not present, your app is prevented from accessing files and other data in iCloud. For information about how to configure your app's iCloud entitlements, see “[Configuring Your App's iCloud Entitlements](#)” (page 63).

## Design Considerations for iCloud Apps

When adopting iCloud, the first decision you have to make is whether to use document storage or key-value data storage. Document storage is intended for storing your app's data, whether that data is created and managed privately by your app or is created by the user and accessible by other means. Document storage is definitely intended for apps that work with user-facing data, such as user-created documents, but it is also useful for managing the data files your app creates internally too. Key-value storage is intended more for noncritical configuration data that you want to share among the running instances of your app. For example, you might use key-value storage to store preferences and other bits of configuration data that are secondary to your app's behavior. You should avoid using key-value storage to save user-facing data.

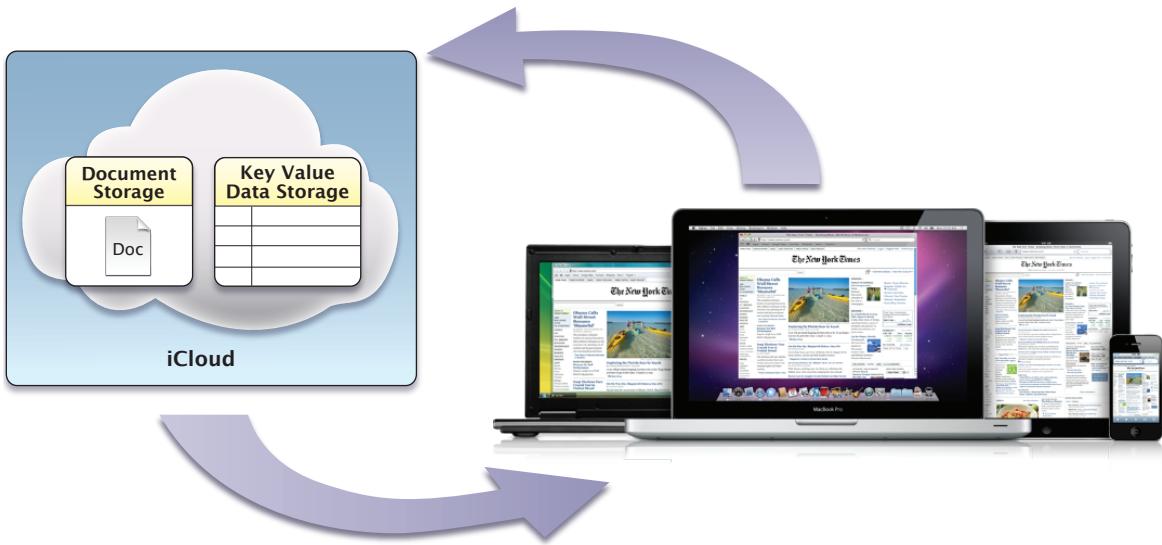


Table 4-1 highlights some of the key usage patterns surrounding iCloud storage and how those patterns differ for document storage and key-value storage. Use this table to help answer some of your basic questions.

**Table 4-1** Differences between document and key-value storage

Attribute	Document storage	Key-value storage
What kind of data can it manage?	Files and directories	Property-list data types only (numbers, strings, booleans)
When would you use it?	Use document storage to manage data that is critical to your app. You almost always use document storage to manage files and data related directly to your app's main data model. Thus, you would use document storage for user documents, private app data files, and any files containing app or user-generated data.	Use key-value storage for things like persistent configuration data that you want to store in the background of your app but that is not critical to your app's functionality. The amount of space in the key-value store is limited to prevent your app from running out of memory.
Are file presenters and file coordinators required?	Yes	No
How do you locate data?	Use a <code>NSMetadataQuery</code> object to search for files.	Use the <code>default NSUbiquitousKeyValueStore</code> object to retrieve the value for a known key.
How do you manage the data?	Manage files and directories using the <code>NSFileManager</code> class. Open, close, read, and write files using standard file system routines.	Set or get keys and values using the <code>NSUbiquitousKeyValueStore</code> object.
How much data can it store?	Limited only by the amount of space in the user's iCloud account.	Limited to a maximum of 64 KB (with a limit of 64 KB).

Attribute	Document storage	Key-value storage
How are conflicts handled?	Your app's file presenters must resolve conflicts manually.	The last value set for the key is always timestamp provided by the device is newest value.
What entitlement is required to use it?	com.apple.developer.ubiquity-container-identifiers	com.apple.developer.ubiquity
When is data synchronized?	iCloud always pulls file metadata and data from a device when changes occur. Devices always pull file metadata but usually do not pull changed data until your app attempts to use the file.	Keys and values are transferred to and intervals.
How do you detect if iCloud is available at launch time?	Call the <code>URLForUbiquityContainerIdentifier:</code> method for one of your registered container directories. If the method returns <code>nil</code> , document storage is not available.	Call the <code>synchronize</code> method of the <code>ValueStore</code> object. If that method returns <code>nil</code> , the <code>ValueStore</code> is not available and there are changes to sync with the user defaults database. If that method returns <code>YES</code> , either not available or there are no changes to sync.
What user interface support is provided?	None. Your app is responsible for deciding what information (if any) to convey about iCloud support. In general, iCloud information should be conveyed seamlessly and involve minimal changes to your user interface.	None. In most cases, you should not need to do anything because key-value data is stored locally or in iCloud.

Another design consideration is how you plan to incorporate iCloud support into your app's user interface. Especially for documents, there may be times when you need to inform the user about the state of a document, such as whether it is downloaded or has version conflicts that need to be resolved. In those situations, you should consider adding some unobtrusive elements to your user interface to convey the appropriate information to the user. For more information about updating your user interface, see [“Updating Your User Interface for iCloud”](#) (page 70).

## Configuring Your App's iCloud Entitlements

Apps that use iCloud must be signed with iCloud-specific entitlements. These entitlements provide a level of security for your app by ensuring that only your apps can access the documents they create. The system also relies on the entitlement values you provide to differentiate your app's documents from other documents in the user's iCloud account.

To enable iCloud entitlements for your iOS app in Xcode:

1. Select your app target in Xcode.
2. Select the Summary tab.
3. In the Entitlements section, enable the Enable Entitlements checkbox.

When you enable entitlements for your app target, Xcode automatically configures both the document storage and key-value data storage entitlements for your app. Each entitlement consists of an entitlement key whose value is one or more container identifier strings. A **container identifier string** identifies one of the iCloud container directories you use to store your app's files. Xcode configures the entitlements in the following way:

- The iCloud Containers field identifies the list of container directories that your app can access in the user's iCloud storage. (This field corresponds to the `com.apple.developer.ubiquity-container-identifiers` entitlement.) The strings you add to this list must correspond to bundle identifiers for apps created by your team. Xcode uses the current app's bundle identifier to specify the first string; you can change this to a different bundle identifier if you want multiple apps to share a main container directory. You can also add additional bundle identifiers for your team's other apps. (The first string must not contain any wildcard characters but subsequent strings may if you do not want to specify every bundle identifier separately.)
- The iCloud Key-Value Store field contains the single container identifier string corresponding to the iCloud key-value data storage for your app. (This field corresponds to the `com.apple.developer.ubiquity-kvstore-identifier` entitlement.)

The bundle identifiers you specify in Xcode do not represent the fully qualified container identifier strings that are written to your entitlements file. A fully qualified container identifier is of the form `<TEAM_ID>. <BUNDLE_IDENTIFIER>`, where `<TEAM_ID>` is the unique ten-character identifier associated with your development team and `<BUNDLE_IDENTIFIER>` is one of the bundle identifiers in the iCloud Containers field. When retrieving a URL for a container directory in your code, you need to pass the fully qualified string to the `URLForUbiquityContainerIdentifier:` method. However, you can also pass `nil` to this method to retrieve the URL for the first container directory in the list.

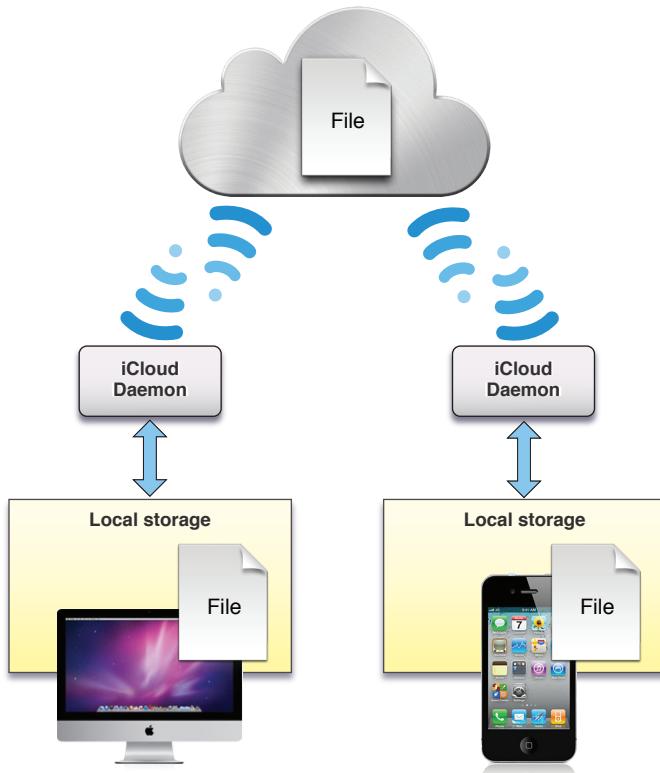
**Note:** You can find the unique `<TEAM_ID>` value for your development team in the Member Center on the Apple Developer website (<http://developer.apple.com/membercenter>). From the Member Center home page, select the Your Account tab and then select Organization Profile from the column on the left of that tab. Your team's identifier is in the Company/Organization ID field.

Apps using iCloud document storage can read and write the contents of multiple container directories by specifying multiple container identifiers in their entitlements file. The iCloud Containers field lets you specify multiple strings. The first string in this field must always be the main container identifier for your app. Any additional strings represent the container identifiers for your other apps. Searches return a merged set of files from all of the available container directories.

For more information about how to configure entitlements for an iOS app, see “Configuring Applications” in *iOS App Development Workflow Guide*.

## Using iCloud Document Storage

iCloud document storage lets you move files and directories to a user's iCloud account and manage them there. Changes made to the file or directory on one device are stored locally and then pushed to iCloud using a local daemon, as shown in Figure 4-1. The transfer of files to and from each device is transparent to your app. Thus, apps simply operate on the file as if it is always there.

**Figure 4-1** Pushing document changes to iCloud

Designing your app to take advantage of iCloud document storage requires some significant changes. Here are the main changes needed:

- Early in your app's execution, call the `URLForUbiquityContainerIdentifier`: method to determine if iCloud is enabled. Calling this method is also necessary to extend your app sandbox to include each of your app's requested container directories; see “[Determining if iCloud Document Storage is Available](#)” (page 66).
- Explicitly incorporate file presenters (such as the `UIDocument` class) into your data layer; see “[Incorporating File Presenters into Your Workflow](#)” (page 66).
- Explicitly move files to iCloud; see “[Manipulating Files and Directories in iCloud](#)” (page 66).
- Be prepared to handle version conflicts for a file; see “[Choosing a Strategy to Respond to Version Conflicts](#)” (page 67).
- Make use of searches to locate files in iCloud; see “[Incorporating Search into Your Infrastructure](#)” (page 68).
- Be prepared to handle cases where files are in iCloud but not fully downloaded to the local device; this might require providing the user with feedback; see “[Determining the Transfer Status of a File or Directory](#)” (page 69).
- Use Core Data if you want to store live databases in iCloud; do not use SQLite.
- If you also have a Mac OS X version of your app, use a common document format for both apps.

Most of the work you do to support iCloud happens in the data layer of your app. Interactions with iCloud occur mostly through the files and directories that your app uses to store data. But you also need to consider the implications that the underlying data changes have on your app’s user interface. Wherever possible, the user should not have to care whether a file is stored locally or in iCloud. The exceptions are in cases where the user experience might be degraded.

## Determining if iCloud Document Storage is Available

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Every user with an Apple ID receives a free iCloud account but some users might choose not to enable iCloud for a given device. Before you try to use any other iCloud interfaces, you must call the `URLForUbiquityContainerIdentifier:` method to determine if iCloud is enabled. This method returns a valid URL when iCloud is enabled (and the specified container directory is available) or `nil` when iCloud is disabled.

The first time you call the `URLForUbiquityContainerIdentifier:` method for a given container directory, iOS extends your application sandbox to include that container directory. Thus, it is important that you call this method at least once to ensure that iCloud is enabled and that your main container directory is accessible. And if your application accesses multiple container directories, you should call the method once for each directory.

## Incorporating File Presenters into Your Workflow

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All files and directories stored in iCloud must be managed by a file presenter object, and all changes you make to those files and directories must occur through a file coordinator object. A **file presenter** is an object that adopts the `NSFilePresenter` protocol. A file presenter’s job is to act as a responsible agent for a given file or directory. Before an external source can change a file, the registered file presenters for that file are notified and given an opportunity to perform any necessary bookkeeping tasks. When your app wants to change a file, it must essentially lock the file by making its changes through an `NSFileCoordinator` object. The **file coordinator** prevents external sources from modifying the file at the same time and delivers relevant notifications to other file presenters.

The simplest way to incorporate file presenters into your app is to use the `UIDocument` class. This class implements the methods of the `NSFilePresenter` protocol and handles all of the file-related management for you. All your app has to do is read and write the document data when told to do so. You can use the `UIDocument` class both for files that contain user-generated content (and thus are displayed directly to the user) and for files that your app creates on behalf of the user and manages without user intervention.

For more information about how to incorporate the `UIDocument` class into your app’s data structures, see *Document-Based Application Programming Guide for iOS*. For information on how to create custom file presenters to manage files and directories, see *File System Programming Guide*.

## Manipulating Files and Directories in iCloud

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Apps use the same technologies to manage files and directories in iCloud that they do for local files and directories. Files and directories in iCloud are still just files and directories. You can open them, create them, move them, copy them, read and write from them, delete them, or any of the other operations you might want to do. The only differences between local files and directories and iCloud files and directories is the URL you use to access them. Instead of URLs being relative to your app’s sandbox, URLs for iCloud files and directories are relative to the corresponding iCloud container directory.

To move a file or directory to iCloud:

1. Create the file or directory locally in your app sandbox.  
While in use, the file or directory must be managed by a file presenter, such as a `UIDocument` object.
2. Use the `URLForUbiquityContainerIdentifier:` method to retrieve a URL for the iCloud container directory in which you want to store the item.
3. Use the container directory URL to build a new URL that specifies the item's location in iCloud.
4. Call the `setUbiquitous:itemAtURL:destinationURL:error:` method of `NSFileManager` to move the item to iCloud. Never call this method from your app's main thread; doing so could block your main thread for an extended period of time or cause a deadlock with one of your app's own file presenters.

When you move a file or directory to iCloud, the system copies that item out of your app sandbox and into a private local directory so that it can be monitored by the iCloud daemon. Even though the file is no longer in your sandbox, your app still has full access to it. Although a copy of the file remains local to the current device, the file is also sent to iCloud so that it can be distributed to other devices. The iCloud daemon handles all of the work of making sure that the local copies are the same. So from the perspective of your app, the file just *is* in iCloud.

All changes you make to a file or directory in iCloud must be made using a file coordinator object. These changes include moving, deleting, copying, or renaming the item. The file coordinator ensures that the iCloud daemon does not change the file or directory at the same time and ensures that other interested parties are notified of the changes you make.

**Note:** When naming files and directories, use the alphanumeric character set as much as possible and avoid special punctuation or other special characters. You should also assume that filenames are case insensitive. Keeping your filenames simple helps ensure that those files can be handled correctly on different types of file systems.

For more information about how to manipulate files and directories, see *File System Programming Guide*.

## Choosing a Strategy to Respond to Version Conflicts

Version conflicts for files in iCloud are inevitable, and so your app needs to have a strategy for handling them. Conflicts occur when two instances of an app change a file locally and both changes are then transferred to iCloud. For example, this can happen when the changes are made while the device is in Airplane mode and cannot transmit changes to iCloud right away. When it does happen, iCloud stores both versions of the file and notifies the apps' file presenters that a conflict has occurred and needs to be resolved.

Apps should always attempt to resolve conflict versions as soon as possible. When a conflict occurs, one file is always designated as the **current file** and any other versions are marked as **conflict versions**. Both the current file and any conflict versions are managed by instances of the `NSFileVersion` class and can be retrieved using class methods of that class.

To resolve a conflict:

1. Get the current file version using the `currentVersionOfItemAtURL:` class method.
2. Get an array of conflict versions using the `unresolvedConflictVersionsOfItemAtURL:` class method.

3. For each file version object, perform whatever actions are needed to resolve the conflict. For example:

- Merge the changed data from the conflicting files, if it is practical to do so.
- Ignore one of the conflicting versions, if you can do so safely or without losing any data.
- Prompt the user to select which version of the file (current or conflict) to keep. This should always be the last option.

4. Update the current file as needed:

- If the current file remains the winner, you do not need to update the current file.
- If a conflict version is chosen as the winner, use a coordinated write operation to overwrite the contents of the current file with the contents of the conflict version.
- If the user chooses to save the conflict version under a different name, create the new file with the contents of the conflict version.

5. Set the `resolved` property of the conflict version objects to YES.

Setting this property to YES causes the conflict version objects (and their corresponding files) to be removed from the user's iCloud storage.

Detecting conflicts depends on whether your app uses `UIDocument` or implements custom file presenters. If your app uses the `UIDocument` class, you detect states by monitoring the value of the `documentState` property and observing the related state change notification. If you implement custom file presenters, whenever a new version is reported, you should check to see whether it is a conflict version.

For more information about handling conflicts in `UIDocument` objects, see *Document-Based Application Programming Guide for iOS*. For information about responding to conflicts in custom file presenters, see *File System Programming Guide*.

## Incorporating Search into Your Infrastructure

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Unlike files that live in your app's sandbox, files in iCloud can be added or removed without your app necessarily knowing it. When the user creates a new file on one device, that file eventually appears on the user's other devices. If the instance of your app running on those other devices is not actively looking for files, there may be a delay in them appearing in your user interface. For this reason, apps should use `NSMetadataQuery` objects to search for items in iCloud container directories. You can leave a metadata query running in order to receive notifications as files are added or removed. You should leave queries running only while your app is in the foreground and should stop them when your app moves to the background.

**Important:** Metadata queries return results only when iCloud is enabled and the corresponding container directories have been created. At launch time, use the `URLForUbiquityContainerIdentifier:` method to determine if iCloud is enabled and your app's supported container directories are available. That method also creates the corresponding directory if it does not yet exist.

Metadata queries search all of the container directories listed in your app's `com.apple.developer.ubiquity-container-identifiers` entitlement and return a merged set of results. If you want the contents of a single container directory, you can alternatively use the `URLForUbiquityContainerIdentifier:` method to get the URL for that directory and obtain a static list of its contents using the `NSFileManager` class.

For information about how to create and configure metadata search queries, see *File Metadata Search Programming Guide*. For information about how to iterate directories using `NSFileManager`, see *File System Programming Guide*.

## Determining the Transfer Status of a File or Directory

Items you write to an iCloud container directory are transferred automatically to the iCloud server as quickly as possible. However, depending on the network and the type of device, a file might not be uploaded to the server or downloaded to a device immediately. In cases where you need to know the state of a file, you can use the `getResourceValue:forKey:error:` method of `NSURL` to retrieve the value for one of the following attributes:

`NSURLIsUbiquitousItemKey`—Indicates whether or not the item is stored in iCloud.

`NSURLUbiquitousItemIsDownloadedKey`—Indicates whether the current version of the item is downloaded and accessible.

`NSURLUbiquitousItemIsDownloadingKey`—Indicates whether the current version of the item is being downloaded and is not yet available.

`NSURLUbiquitousItemPercentDownloadedKey`—For an item being downloaded, indicates what percentage of the changes have already been downloaded. You can use this value to update progress bars.

`NSURLUbiquitousItemIsUploadedKey`—Indicates that locally made changes were successfully uploaded to the iCloud server.

`NSURLUbiquitousItemIsUploadingKey`—Indicates that locally made changes are being uploaded to the iCloud server now.

`NSURLUbiquitousItemPercentUploadedKey`—For an item being uploaded, indicates what percentage of the changes have already been uploaded to the server.

Although the iCloud server aggressively pulls changes your app makes locally, iOS devices typically do not pull changes from the server until you try to access the file. If you try to open a file that is currently being downloaded, iOS blocks the thread that issued the open request until the file is downloaded and available for use. Thus, if you are concerned about potential delays, check the file's current state as needed and possibly update your user interface to reflect that the file is not yet available or is currently downloading.

For more information about the attributes you can request for URLs, see *NSURL Class Reference*.

## Working With Files That Are Not Yet Downloaded

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When a change occurs to a file in iCloud, iOS devices do not automatically download the data associated with that change. Instead, iOS devices download the metadata for the file so that they know that a change exists. The actual data for the file is not downloaded until one of the following happens:

- Your app attempts to open or access the file.
- Your app calls the `startDownloadingUbiquitousItemAtURL:error:` method to download the changes explicitly.

If your app opens a file that is not yet downloaded, the file coordinator used to open the file blocks your app until the file or its changes have been downloaded. Depending on the size of the changes, this might not lead to the best user experience, so it is preferable to check the download status of a file before trying to open it. The `NSURL` class defines properties related to iCloud items, including whether the file is stored in iCloud and whether it is currently downloaded. To obtain the value for one of these keys, use the `getResourceValue:forKey:error:` method of `NSURL`. For example, to determine whether a file was downloaded, you could use code similar to the following:

```
- (BOOL)downloadFileIfNotAvailable:(NSURL*)file {
    NSNumber* isIniCloud = nil;

    if ([file getResourceValue:&isIniCloud forKey:kNSURLIsUbiquitousItemKey
error:nil]) {
        // If the item is in iCloud, see if it is downloaded.
        if ([isIniCloud boolValue]) {
            NSNumber* isDownloaded = nil;
            if ([file getResourceValue:&isDownloaded
forKey:kNSURLUbiquitousItemIsDownloadedKey error:nil]) {
                if ([isDownloaded boolValue])
                    return YES;

                // Download the file.
                NSFileManager* fm = [NSFileManager defaultManager];
                [fm startDownloadingUbiquitousItemAtURL:file error:nil];
                return NO;
            }
        }
    }

    // Return YES as long as an explicit download was not started.
    return YES;
}
```

For more information about the iCloud-related properties available for your URLs, see *NSURL Class Reference*.

## Updating Your User Interface for iCloud

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Any user interface changes you make related to iCloud should be as unobtrusive as possible to the user. The documents you store in iCloud are the same ones you store locally when iCloud is not available. The only difference is their location in the file system. So the bulk of your user interface should look about the same.

Sometimes, though, you might want to modify your user interface for iCloud. Modify your UI:

- **When a user-generated document must be downloaded before it can be used.** Giving the user control over whether to download a document is needed only if your app presents some sort of document browser. For files your app manages privately, download them automatically if they are not available. Any indicators you use should be subtle and provide the user with the option to begin downloading the document. If a download might take more than a few seconds, you might also want to display the current download progress.
- **When there is a version conflict that the user must resolve.** Version conflicts can occur when the same document is modified on two different devices at the same time. (This can occur if one of the devices was not connected to the network when the changes were made.) If your app needs user assistance to resolve the conflict, present a subtle indicator that this is the case. Do not display an alert or any sort of disruptive interface to notify the user that a conflict exists.
- **When you want to give the user the option to enable or disable iCloud usage entirely for your app.** If your app includes a Settings bundle or inline preferences, you could include a preference to toggle whether your app stores content in iCloud at all. For example, an app whose data consists entirely of privately managed files might do this to give the user the choice of how those files are stored.

For tips and guidance about how to design your app's user interface, see *iOS Human Interface Guidelines*.

## Using iCloud in Conjunction with Databases

Using iCloud with a SQLite database is possible only if your app uses Core Data to manage that database. Accessing live database files in iCloud using the SQLite interfaces is not supported and will likely corrupt your database. However, you can create a Core Data store based on SQLite as long as you follow a few extra steps when setting up your Core Data structures. You can also continue to use other types of Core Data stores—that is, stores not based on SQLite—with any special modifications.

When using Core Data with a SQLite store, the actual database file is never transferred to the iCloud sever. Instead, each device maintains its own copy of the SQLite store and synchronizes its contents by writing out changes to log files. It is the log files that are then transferred to and from iCloud and the other devices. On each device, Core Data takes the contents of the log files and uses them to update its local database. The result is that each local database ends up with the exact same set of changes.

Setting up your Core Data store to handle iCloud requires only a little extra effort on your part. The steps you must follow depend on whether you are using a single Core Data store as a central library for your app or whether you are creating separate stores for individual documents.

The following sections assume that you are using a SQLite store to manage your data. SQLite stores are intended for apps that have large amounts of data to manage or want fine-grained change notifications. You do not need to read these sections if you are creating an atomic binary store.

**Important:** For the latest information about using Core Data with iCloud, see *Using Core Data with iCloud Release Notes*.

### Using Core Data to Manage Documents

For apps that manage Core Data stores as individual documents, use instances of the `UIManagedDocument` class to manage individual documents. The `UIManagedDocument` class automatically looks for any managed object models in your application bundle and uses them as the basis for your document data. (You can also

override the `managedObjectModel`<sup>1</sup> property of the class to customize the object models for a given subclass.) Because most of your data is handled by a managed object context, this means that you can often use the `UIManagedDocument` class without subclassing. Behaviors such as saving are handled automatically thanks to the inherited autosave behavior provided for all documents.

When creating new documents, do the following:

1. Create your instance of the `UIManagedDocument` class.
2. Add the `NSPersistentStoreUbiquitousContentNameKey` key to the dictionary in your document's `persistentStoreOptions` property. The value of this key is a unique name that your app can use to identify the document.
3. Add some initial data to the document.
4. Save the document to disk using the `saveToURL:forSaveOperation:completionHandler: method`.

When saving a document, you can either save it directly to iCloud or you can save it to a local directory and move it to iCloud later. To save the document directly to iCloud, specify a URL that is based on a location returned by the `URLForUbiquityContainerIdentifier: method`. If you save the document locally, you can move it to iCloud later using the `setUbiquitous:itemAtURL:destinationURL:error: method`.

When you create a new document, Core Data creates a file package containing the document contents. Among these contents are a `DocumentMetadata.plist` file and a directory containing the SQLite data store. Everything in the file package is transferred to the iCloud server except for the SQLite data store, which remains local to the device.

When opening existing documents that reside in iCloud, do the following:

1. Use an `NSMetadataQuery` object to search for documents in iCloud.

Metadata queries identify all of your Core Data documents, regardless of whether they were created locally or on another device. For documents created on other devices, the only thing present in the document's file package initially is the `DocumentMetadata.plist` file.
2. Open the `DocumentMetadata.plist` file and retrieve the value of the `NSPersistentStoreUbiquitousContentNameKey` key.
3. Create your instance of the `UIManagedDocument` class.
4. Add the `NSPersistentStoreUbiquitousContentNameKey` key to the dictionary in your document's `persistentStoreOptions` property. The value of this key should match the value you retrieve from the `DocumentMetadata.plist` file.
5. Call the `openWithCompletionHandler: method` of the document to open it.

The first time your app opens a Core Data document that was created on another device, Core Data automatically detects the absence of the SQLite store and creates it locally. It then uses the value of the `NSPersistentStoreUbiquitousContentNameKey` key (that you added to the document's `NSPersistentStoreUbiquitousContentNameKey` property) to retrieve the appropriate transaction logs and rebuild the contents of the database. From that point on, you can make changes to the document and save them back to iCloud. The changes you make are stored in a new log file so that they can be incorporated into the SQLite stores on other devices.

When changes for a document are received from iCloud, Core Data automatically folds them into that document's SQLite store and sends your app a `NSPersistentStoreDidImportUbiquitousContentChangesNotification` notification. Apps should always register for this notification and use it to refresh any affected records. If your app does not refresh its local copy of the data, it could save old changes back out to iCloud and create a conflict that would need to be resolved. By incorporating changes when they arrive, your app should be able to avoid such conflicts.

When you want to delete a document, you must delete both the file package for the document and the directory containing the document's transaction logs. Deleting both of these items requires you to perform a coordinated write operation using an `NSFileCoordinator` object. The `DocumentMetadata.plist` file of your document contains a `NSPersistentStoreUbiquitousContentURLKey` key with the URL of the transaction logs directory for your document. For more information on using file coordinators, see *File System Programming Guide*.

For information on how to use Core Data stores to manage the objects in your app, see *Core Data Programming Guide*.

## Using Core Data to Manage a Central Library

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An app that uses a central Core Data store to manage its data should continue to place that data store in its app sandbox directory. Apps with a central data store typically have only one persistent store coordinator object and one persistent store object. As a result, the simplest solution is to leave the Core Data store in your app's sandbox and use iCloud only to synchronize changes.

When creating your SQLite store locally, do the following:

1. Include the `NSPersistentStoreUbiquitousContentNameKey` and `NSPersistentStoreUbiquitousContentURLKey` keys in the options dictionary you pass to the `addPersistentStoreWithType:configuration:URL:options:error:` method when creating your data store.
2. Register for the `NSPersistentStoreDidImportUbiquitousContentChangesNotification` notification and use it to update any changed records.

Because you have only one data store, you can use whatever name you want for the `NSPersistentStoreUbiquitousContentNameKey` key. For the `NSPersistentStoreUbiquitousContentURLKey` key, the URL you provide should be a directory located in one of your iCloud container directories. In other words, the URL should be based on a location returned by the `URLForUbiquityContainerIdentifier:` method. Core Data writes changes to the directory you specify and looks in that directory for changes from other devices. When it detects the changes, it incorporates them into the local SQLite store and notifies your application.

You should always respond to iCloud-related change notifications. These notifications are a way for you to make sure your app is using the updated values. If you continue to use an older version of the data, you could overwrite the newer data or create a version conflict that would need to be resolved later.

For information on how to create a Core Data store, see *Core Data Programming Guide*.

## Specifying a Custom Location for Core Data Transaction Logs

The transaction logs used to store changes for your app's Core Data stores are stored in a special directory in the user's iCloud account. There is only one directory for all of your app's Core Data stores. By default, the directory name is the same as your app's bundle identifier and it is located at the top level of your app's default iCloud container directory—that is, the first container directory listed in your entitlements. If your app is already using that same directory for another purpose, you can change the name of the directory by modifying the options of your Core Data stores.

To specify a custom location for transaction logs in a document-based app, you must modify the dictionary in the `persistentStoreOptions` property of each of your `UIManagedDocument` objects. To this dictionary, add the `NSPersistentStoreUbiquitousContentURLKey` key and set its value to the URL for the directory you want to use instead. The initial part of the URL must be a value returned by the `URLForUbiquityContainerIdentifier:` method for one of your app's container directories. To that URL, add any additional path information you need to specify the custom log directory.

If your app uses a single Core Data store to manage all of its data, add the `NSPersistentStoreUbiquitousContentURLKey` key to the options dictionary you pass to the `addPersistentStoreWithType:configuration:URL:options:error:` method when creating your persistent store. As with the document-based apps, the value for this key is a URL to the location in one of your iCloud container directories where you want to store the transaction logs.

## Using iCloud Key-Value Data Storage

Apps that want to store preferences or small amounts of noncritical configuration data can use the iCloud key-value data store to do so. The key-value data store is similar conceptually to the local user defaults database that you use to store your app's preferences. The difference is that the keys in the iCloud store are shared by all of the instances of your app running on the user's other devices. So if one app changes the value of a key, the other apps see that change and can use it to update their configuration.

**Important:** Apps that use the `NSUbiquitousKeyValueStore` class must request the `com.apple.developer.ubiquity-kvstore-identifier` entitlement. If you configure multiple apps with the same value for this entitlement, all of them share the same key-value data. For more information about configuring iCloud entitlements, see ["Configuring Your App's iCloud Entitlements"](#) (page 63).

To write data to the key-value data store, use the `NSUbiquitousKeyValueStore` class. This class is conceptually similar to the `NSUserDefaults` class in that you use it to save and retrieve simple data types such as numbers, strings, dates, arrays, and so on. The main difference is that the `NSUbiquitousKeyValueStore` class writes that data to iCloud instead of to a local file.

The space available in your app's key-value store is limited to 64 KB. (There is also a per-key limit, which currently is set to 64 KB.) Thus, you can use this storage to record small details but should not use it to store user documents or other large data archives. Instead, store small pieces of data that might improve the user experience for your app. For example, a magazine app might store the current issue and page number that the user is reading. That way, when the user opens the app on another device, that app can open the magazine to the same issue and page that the user was reading.

The `NSUbiquitousKeyValueStore` class must not be used as a replacement for the `NSUserDefaults` class. An app should always write all of its configuration data to disk using the `NSUserDefaults` class, too. It should then write the data it intends to share to the key-value data store using the `NSUbiquitousKeyValueStore` class. This ensures that if iCloud is not available, you still have access to the configuration data you need.

For more information about how to use the key-value store in your app, see *Preferences and Settings Programming Guide*.

## Being a Responsible iCloud App

Apps that take advantage of iCloud storage features should act responsibly when storing data there. The space available in each user's account is limited and is shared by all apps. Users can see how much space is consumed by a given app and choose to delete documents and data associated with your app. For these reasons, it is in your app's interest to be responsible about what files you store. Here are some tips to help you manage documents appropriately:

- Have a good strategy for storing iCloud documents. Whenever possible, give the user a single option to store all data in iCloud.
- Deleting a document removes it from a user's iCloud account and from all of that user's computers and devices. Make sure that users are aware of this fact and confirm any delete operations. If you want to refresh the local copy of a document, use the `evictUbiquitousItemAtURL:error:` method of `NSFileManager` instead of deleting the file.
- When storing documents in iCloud, place them in the `Documents` subdirectory whenever possible. Documents inside a `Documents` directory can be deleted individually by the user to free up space. However, everything outside that directory is treated as data and must be deleted all at once.
- Never store caches or other files that are private to your app in a user's iCloud storage. A user's iCloud account should be used only for storing user-related data and content that cannot be re-created by your app.
- Treat files in iCloud the same way you treat all other files in your app sandbox. The time at which to save a file should be driven by the need of your app and the need to preserve the user's data. You should not change your app to save files more or less frequently for iCloud. iCloud automatically optimizes its transfers to the server to ensure the best possible performance.

## CHAPTER 4

### iCloud Storage

# App-Related Resources

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Aside from the images and media files your app presents on screen, there are some specific resources that iOS itself requires your app to provide. The system uses these resources to determine how to present your app on the user's home screen and, in some cases, how to facilitate interactions with other parts of the system.

## App Store Required Resources

There are several things that you are required to provide in your app bundle before submitting it to the App Store:

- Your app must have an `Info.plist` file. This file contains information that the system needs to interact with your app. Xcode creates a version of this file automatically but most apps need to modify this file in some way. For information on how to configure this file, see “[The Information Property List File](#)” (page 77).
- Your app’s `Info.plist` file must include the `UIRequiredDeviceCapabilities` key. The App Store uses this key to determine whether or not a user can run your app on a specific device. For information on how to configure this key, see “[Declaring the Required Device Capabilities](#)” (page 78).
- Your app must include one or more icons to use when displaying the app. Your icon is what is presented to the user on the iOS device’s home screen. For information about how to specify app icons, see “[App Icons](#)” (page 81).
- Your app must include at least one image to be displayed while your app is launching. The system displays your app’s launch image after launch to provide the user with immediate feedback. For information about launch images, see “[App Launch \(Default\) Images](#)” (page 83).

## The Information Property List File

An app’s information property list (`Info.plist`) file contains critical information about the configuration of the app and must be included in your app bundle. Every new project you create in Xcode has a default `Info.plist` file configured with some basic information about your project. For shipping apps, you should configure this file further to add several important keys.

Your app’s `Info.plist` file must always include the following keys:

- `UIRequiredDeviceCapabilities`—The App Store uses this key to determine the capabilities of your app and to prevent it from being installed on devices that do not support features your app requires. For more information about this key, see “[Declaring the Required Device Capabilities](#)” (page 78).

- `CFBundleIcons`—This is the preferred key for specifying your app’s icon files. Older projects might include the `CFBundleIconFiles` key instead. Both keys have essentially the same purpose but the `CFBundleIcons` key is preferred because it allows you to organize your icons more efficiently. (The `CFBundleIcons` key is also required for Newsstand apps.)
- `UISupportedInterfaceOrientations`—This key is included by Xcode and is set to an appropriate set of values initially. However, you should add or remove values based on the orientations that your app actually supports.

You might also want to include the following keys in your app’s `Info.plist` file, depending on the behavior of your app:

- `UIBackgroundModes`—Include this key if your app supports executing in the background using one of the defined modes; see “[Implementing Long-Running Background Tasks](#)” (page 54).
- `UIFileSharingEnabled`—Include this key if you want to expose the contents of your sandbox’s `Documents` directory in iTunes.
- `UIRequiresPersistentWiFi`—Include this key if your app requires a Wi-Fi connection.
- `UINewsstandApp`—Include this key if your app presents content from the Newsstand app.

The `Info.plist` file itself is a property list file that you can edit manually or using Xcode. Each new Xcode project contains a file called `<project_name>-Info.plist`, where `<project_name>` is the name of your Xcode project. This file is the template that Xcode uses to generate an `Info.plist` file at build time. When you select this file, Xcode displays the property list editor that you can use to add or remove keys or change the value of a key. For information about how to configure the contents of this file, see *Property List Editor Help*.

For details about the keys you can include in the `Info.plist` file, see *Information Property List Key Reference*.

## Declaring the Required Device Capabilities

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If your app requires the presence or absence of specific device capabilities in order to run, you must declare those requirements using the `UIRequiredDeviceCapabilities` key in your app’s `Info.plist` file. At runtime, iOS cannot launch your app unless the declared capabilities are present on the device. Further, the App Store requires this information so that it can generate a list of requirements for user devices and prevent users from downloading apps that they cannot run.

The `UIRequiredDeviceCapabilities` key (supported in iOS 3.0 and later) is normally used to declare the specific capabilities that your app requires. The value of this key is either an array or a dictionary that contains additional keys identifying the corresponding features. If you use an array, the presence of a key indicates that the feature is required; the absence of a key indicates that the feature is not required and that the app can run without it.

If you use a dictionary for the value of the `UIRequiredDeviceCapabilities` key, each key in the dictionary similarly corresponds to one of the targeted features and contains a Boolean value. A value of `true` for a key indicates that the feature is required. However, a value of `false` indicates that the feature must *not* be present on the device. In other words, for features that are optional, you should omit the key entirely rather than including it and setting its value to `false`.

Table 5-1 lists the keys that you can include in the array or dictionary for the `UIRequiredDeviceCapabilities` key. You should include keys only for the features that your app absolutely requires. If your app can do without a specific feature, do not include the corresponding key.

**Table 5-1** Dictionary keys for the `UIRequiredDeviceCapabilities` key

Key	Description
accelerometer	Include this key if your app requires (or specifically prohibits) the presence of accelerometers on the device. Apps use the Core Motion framework to receive accelerometer events. You do not need to include this key if your app detects only device orientation changes.
armv6	Include this key if your app is compiled only for the armv6 instruction set. (iOS 3.1 and later)
armv7	Include this key if your app is compiled only for the armv7 instruction set. (iOS 3.1 and later)
auto-focus-camera	Include this key if your app requires (or specifically prohibits) autofocus capabilities in the device's still camera. Although most developers should not need to include this key, you might include it if your app supports macro photography or requires sharper images in order to perform some sort of image processing.
bluetooth-le	Include this key if your app requires (or specifically prohibits) the presence of Bluetooth low-energy hardware on the device. (iOS 5 and later.)
camera-flash	Include this key if your app requires (or specifically prohibits) the presence of a camera flash for taking pictures or shooting video. Apps use the <code>UIImagePickerController</code> interface to control the enabling of this feature.
front-facing-camera	Include this key if your app requires (or specifically prohibits) the presence of a forward-facing camera. Apps use the <code>UIImagePickerController</code> interface to capture video from the device's camera.
gamekit	Include this key if your app requires (or specifically prohibits) Game Center. (iOS 4.1 and later)
gps	Include this key if your app requires (or specifically prohibits) the presence of GPS (or AGPS) hardware when tracking locations. (You should include this key only if you need the higher accuracy offered by GPS hardware.) If you include this key, you should also include the <code>location-services</code> key. You should require GPS only if your app needs location data more accurate than the cellular or Wi-fi radios might otherwise provide.
gyroscope	Include this key if your app requires (or specifically prohibits) the presence of a gyroscope on the device. Apps use the Core Motion framework to retrieve information from gyroscope hardware.
location-services	Include this key if your app requires (or specifically prohibits) the ability to retrieve the device's current location using the Core Location framework. (This key refers to the general location services feature. If you specifically need GPS-level accuracy, you should also include the <code>gps</code> key.)

Key	Description
magnetometer	Include this key if your app requires (or specifically prohibits) the presence of magnetometer hardware. Apps use this hardware to receive heading-related events through the Core Location framework.
microphone	Include this key if your app uses the built-in microphone or supports accessories that provide a microphone.
opengles-1	Include this key if your app requires (or specifically prohibits) the presence of the OpenGL ES 1.1 interfaces.
opengles-2	Include this key if your app requires (or specifically prohibits) the presence of the OpenGL ES 2.0 interfaces.
peer-peer	Include this key if your app requires (or specifically prohibits) peer-to-peer connectivity over a Bluetooth network. (iOS 3.1 and later)
sms	Include this key if your app requires (or specifically prohibits) the presence of the Messages app. You might require this feature if your app opens URLs with the <code>sms</code> scheme.
still-camera	Include this key if your app requires (or specifically prohibits) the presence of a camera on the device. Apps use the <code>UIImagePickerController</code> interface to capture images from the device's still camera.
telephony	Include this key if your app requires (or specifically prohibits) the presence of the Phone app. You might require this feature if your app opens URLs with the <code>tel</code> scheme.
video-camera	Include this key if your app requires (or specifically prohibits) the presence of a camera with video capabilities on the device. Apps use the <code>UIImagePickerController</code> interface to capture video from the device's camera.
wifi	Include this key if your app requires (or specifically prohibits) access to the networking features of the device.

For detailed information on how to create and edit property lists, see *Information Property List Key Reference*.

## Declaring Your App's Supported Document Types

If your app is able to open existing or custom file types, you must declare the types your app supports. When the user receives attachments in mail, or when another app wants to open a specific type of file using a document interaction controller, the system looks at your declared document types to see whether your app is able to open the file. If it is, that file may be copied to your app sandbox and a URL passed to your app. (URLs are passed to the `application:didFinishLaunchingWithOptions:` or `application:openURL:sourceApplication:annotation:` method of your app delegate.) It is then your app's responsibility to open the file accordingly.

In Xcode, you declare your document (file) types from the Info tab of your target's settings. In the Document Types section of this tab, you can add and delete supported document types and configure the types you have.

A **document type** is your app's way of associating specific types of files with specific information about how your app handles that type of file. A single document type can represent one type of file or multiple types of files. For example, you can define a single document type that represents only PNG images or that represents PNG, JPG, and GIF images. The decision to represent one file type or multiple file types depends on how your app presents the files. If it presents all of the files in the same way—that is, with the same icon and with the same basic code path—then you can use one document type for multiple file types. If the code paths or icons for a given file type are different, you should declare different document types for each.

For each document type, you must provide the following information at a minimum:

- **A name.** This is a localizable string that can be displayed to the user if needed.
- **An icon.** All files associated with a document type share the same icon.
- **The file types.** These are uniform type identifier (UTI) strings that are used to identify the file types. For example, to specify the PNG file type, you would specify the `public.png` UTI. UTIs are the preferred way to specify file types because they are less fragile than filename extensions and other techniques used to identify files.

Although you use Xcode to configure your document types, the information you enter in Xcode is ultimately added to your app's `Info.plist` file as a collection of keys. Document types are declared using the `CFBundleDocumentTypes` key, which is an array of dictionaries. Each dictionary contains the keys that specify the document type's name, icon, file types, and so on. In addition to the basic keys, there are other keys you can associate with your document types. For example, you would use one of these other keys to declare your document type as a file package, which is an opaque directory that is treated by the system as if it were a single file.

For more information on the keys you use to declare your app's document types, see *Information Property List Key Reference*.

## App Icons

Every app must provide an icon to be displayed on a device's Home screen and in the App Store. An app may actually specify several different icons for use in different situations. For example, an app can provide a small icon to use when displaying search results and can provide a high-resolution icon for devices with Retina displays.

To specify the icons for your app, add the `CFBundleIconFiles` key to your app's `Info.plist` file and add the filenames of your icon image to the associated array. The filenames can be anything you want, but all image files must be in the PNG format and reside in the top level of your app bundle. When the system needs an appropriately sized icon, it looks at the files in the `CFBundleIconFiles` array and picks the one whose size most closely matches the intended usage. (If your app runs in iOS 3.1.3 or earlier, you must use specific names for your icon image files; these filenames are described later in this section.)

Table 5-2 lists the dimensions of the icons you can associate with the `CFBundleIconFiles` key, along with the intended usage for each one. For apps that run on devices with Retina displays, two versions of each icon should be provided, with the second one being a high-resolution version of the original. The names of

the two icons should be the same except for the inclusion of the string @2x in the filename of the high-resolution image. You can find out more about specifying and loading high-resolution image resources in *Drawing and Printing Guide for iOS*. For detailed information about the usage and preparation of your icons, see *iOS Human Interface Guidelines*.

**Table 5-2** Sizes for images in the `CFBundleIconFiles` key

Icon	Idiom	Size	Usage
App icon (required)	iPhone	57 x 57 pixels 114 x 114 pixels (@2x)	This is the main icon for apps running on iPhone and iPod touch. The @2x variant of the icon is for use on devices with Retina displays only.
App icon (required)	iPad	72 x 72 pixels	This is the main icon for apps running on iPad.
Settings/Search results icon	iPhone/iPad	29 x 29 pixels 58 x 58 pixels (@2x)	This is the icon displayed in conjunction with search results on iPhone and iPod touch. This icon is also used by the Settings app on all devices. (The @2x variant of the icon is for use on devices with Retina displays only and is not supported on iPad.)
Search results icon	iPad	50 x 50 pixels	This is the icon displayed in conjunction with search results on iPad.

When specifying icon files using the `CFBundleIconFiles` key, it is best to omit the filename extensions of your image files. If you include a filename extension, you must explicitly add the names of all image files (including any high-resolution variants) to the array. When you omit the filename extension, the system automatically detects high-resolution variants of your file, even if they are not included in the array.

**Note:** Do not confuse the `CFBundleIconFiles` key with the `CFBundleIconFile` key. The keys provide similar behaviors, but the plural version is preferred because it allows you to specify an array of image filenames instead of a single filename. The plural version of the key is supported only in iOS 3.2 and later.

If your iPhone app is running in iOS 3.1.3 or earlier, the system does not look for the `CFBundleIconFiles` key. Instead, it looks for icon files with specific names. The `CFBundleIconFiles` key was introduced in iOS 3.2 and is not recognized by earlier versions of the system. Although the sizes of the icons are the same as those in [Table 5-2](#) (page 82), if your app supports deployment on iOS 3.1.3 and earlier, you must use the following filenames when naming your icons:

- `Icon.png`. The name for the app icon on iPhone or iPod touch.
- `Icon-72.png`. The name for the app icon on iPad.
- `Icon-Small.png`. The name for the search results icon on iPhone and iPod touch. This file is also used for the Settings icon on all devices.
- `Icon-Small-50.png`. The name of the search results icon on iPad.

**Important:** The use of fixed filenames for your app icons is for compatibility with earlier versions of iOS only. Even if you use these fixed icon filenames, your app should continue to include the `CFBundleIconFiles` key in its `Info.plist` if it is able to run in iOS 3.2 and later. In iOS 3.2 and earlier, the system looks for icons with the fixed filenames first. In iOS 4 and later, the system looks for icons in the `CFBundleIconFiles` key first.

Developers who distribute their apps using ad hoc distribution must include a 512 x 512 version of their icon and give it the name `iTunesArtwork` (no filename extension). This icon is displayed by iTunes when presenting your app for distribution. Like all other icon files, the `iTunesArtwork` image file must reside at the top level of your app bundle. The file should be the same one you submit to the App Store (typically, a JPEG or PNG file) if you were distributing your app that way.

For more information about the `CFBundleIconFiles` key, see *Information Property List Key Reference*. For information about creating your app icons, see *iOS Human Interface Guidelines*.

## App Launch (Default) Images

When the system launches an app, it temporarily displays a static launch image on the screen. Your app provides this image, with the image contents usually containing a prerendered version of your app's default user interface. The purpose of this image is to give the user immediate feedback that the app launched, but it also gives your app time to initialize itself and prepare its initial set of views for display. When your app is ready to run, the system removes the image and displays your app's windows and views.

Every app must provide at least one launch image. This image is typically in a file named `Default.png` that displays your app's initial screen in a portrait orientation. However, you can also provide other launch images to be used under different launch conditions. All launch images must be PNG files and must reside in the top level of your app's bundle directory. The name of each launch image indicates when it is to be used, and the basic format for launch image filenames is as follows:

`<basename><usage_specific_modifiers><scale_modifier><device_modifier>.png`

The `<basename>` portion of the filename is either the string `Default` or a custom string that you specify using the `UILaunchImageFile` key in your app's `Info.plist` file. The `<scale_modifier>` portion is the optional string `@2x` and should be included only for images intended for use on Retina displays. Other optional modifiers may also be included in the name, and several standard modifiers are discussed in the sections that follow.

Table 5-3 lists the dimensions for launch images in iOS apps. For all dimensions, the image width is listed first, followed by the image height. For precise information about which size launch image to use and how to prepare your launch images, see *iOS Human Interface Guidelines*.

**Table 5-3** Typical launch image dimensions

Device	Portrait	Landscape
iPhone and iPod touch	320 x 480 pixels 640 x 960 pixels (high resolution)	Not supported
iPad	768 x 1004 pixels	1024 x 748 pixels

To demonstrate the naming conventions, suppose your iOS app's Info.plist file included the UILaunchImageFile key with the value MyLaunchImage. The standard resolution version of the launch image would be named MyLaunchImage.png and would be in a portrait orientation (320 x 480). The high-resolution version of the same launch image would be named MyLaunchImage@2x.png. If you did not specify a custom launch image name, these files would need to be named Default.png and Default@2x.png, respectively.

For more information about the UILaunchImageFile key, see *Information Property List Key Reference*.

## Providing Launch Images for Different Orientations

In iOS 3.2 and later, an iPad app can provide both landscape and portrait versions of its launch images. Each orientation-specific launch image must include a special modifier string in its filename. The format for orientation-specific launch image filenames is as follows:

`<basename><orientation_modifier><scale_modifier><device_modifier>.png`

Table 5-4 lists the possible modifiers you can specify for the `<orientation_modifier>` value in your image filenames. As with all launch images, each file must be in the PNG format. These modifiers are supported for launch images used in iPad apps only; they are not supported for apps running on iPhone or iPod touch devices.

**Table 5-4** Launch image orientation modifiers

Modifier	Description
-PortraitUpsideDown	Specifies an upside-down portrait version of the launch image. A file with this modifier takes precedence over a file with the -Portrait modifier for this specific orientation.
-LandscapeLeft	Specifies a left-oriented landscape version of the launch image. A file with this modifier takes precedence over a file with the -Landscape modifier for this specific orientation.
-LandscapeRight	Specifies a right-oriented landscape version of the launch image. A file with this modifier takes precedence over a file with the -Landscape modifier for this specific orientation.
-Portrait	Specifies the generic portrait version of the launch image. This image is used for right-side up portrait orientations and takes precedence over the Default.png image file (or your custom-named replacement for that file). If a file with the -PortraitUpsideDown modifier is not specified, this file is also used for upside-down portrait orientations as well.
-Landscape	Specifies the generic landscape version of the launch image. If a file with the -LandscapeLeft or -LandscapeRight modifier is not specified, this image is used instead. This image takes precedence over the Default.png image file (or your custom-named replacement for that file).
(none)	If you provide a launch image file with no orientation modifier, that file is used when no other orientation-specific launch image is available. For apps running on systems earlier than iOS 3.2, you must name this file Default.png.

For example, if you specify the value MyLaunchImage in the `UILaunchImageFile` key, the custom landscape and portrait launch images for your iPad app would be named `MyLaunchImage-Landscape.png` and `MyLaunchImage-Portrait.png`. If you do not specify a custom launch image filename, you would use the names `Default-Landscape.png` and `Default-Portrait.png`.

No matter which launch image is displayed by the system, your app always launches in a portrait orientation initially and then rotates as needed to the correct orientation. Therefore, your `application:didFinishLaunchingWithOptions:` method should always assume a portrait orientation when setting up your window and views. Shortly after the `application:didFinishLaunchingWithOptions:` method returns, the system sends any necessary orientation-change notifications to your app's window, giving it and your app's view controllers a chance to reorient views using the standard process.

For more information about how your view controllers manage the rotation process, see "Custom View Controllers" in *View Controller Programming Guide for iOS*.

## Providing Device-Specific Launch Images

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Universal apps must provide launch images for both the iPhone and iPad idioms. Because iPhone apps require only one launch image (`Default.png`), whereas iPad apps typically require different images for portrait and landscape orientations, you can usually do without device-specific modifiers. However, if you create multiple launch images for each idiom, the names of device-specific image files are likely to collide. In that situation, you can append a device modifier to filenames to indicate that they are for a specific platform only. The following device modifiers are recognized for launch images in iOS 4.0 and later:

- `~ipad`. The launch image should be loaded on iPad devices only.
- `~iphone`. The launch image should be loaded on iPhone or iPod touch devices only.

Because device modifiers are not supported in iOS 3.2, the minimal set of launch images needed for a universal app (running in iOS 3.2 and later) would need to be named `Default.png` and `Default~iphone.png`. In that case, the `Default.png` file would contain the iPad launch image (for all orientations) and the `Default~iphone.png` file would contain the iPhone version of the image. (To support high-resolution displays, you would also need to include a `Default@2x~iphone.png` launch image.)

**Note:** If you are using the `UILaunchImageFile` key in your `Info.plist` file to specify a custom base name for your launch image files, add device-specific versions as needed to differentiate the launch images on different devices. For example, specify a `UILaunchImageFile~ipad` key to specify a different base name for iPad launch images. Specifying different base names lets a universal app avoid naming conflicts among its launch images. For more information on how to apply device modifiers to keys in the `Info.plist` file, see *Information Property List Key Reference*.

## Providing Launch Images for Custom URL Schemes

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If your app supports one or more custom URL schemes, it can also provide a custom launch image for each URL scheme. When the system launches your app to handle a URL, it displays the launch image associated with the scheme of the given URL. In this case, the format for your launch image filenames is as follows:

`<basename>-<url_scheme><scale_modifier><device_modifier>.png`

The `<url_scheme>` modifier is a string representing the name of your URL scheme name. For example, if your app supports a URL scheme with the name `myscheme`, the system looks for an image with the name `Default-myscheme.png` (or `Default-myscheme@2x.png` for Retina displays) in the app's bundle. If the app's `Info.plist` file includes the `UILaunchImageFile` key, the base name portion changes from `Default` to the custom string you provide in that key.

**Note:** You can combine a URL scheme modifier with orientation modifiers. If you do this, the format for the filename is `<basename>-<url_scheme><orientation_modifier><scale_modifier><device_modifier>.png`. For more information about the launch orientation modifiers, see “[Protecting Data Using On-Disk Encryption](#)” (page 94).

In addition to including the launch images at the top level of your bundle, you can also include localized versions of your launch images in your app's language-specific project subdirectories. For more information on localizing resources in your app, see [Table 6-2](#) (page 99).

## The Settings Bundle

Apps that want to display preferences in the Settings app must include a Settings bundle resource. A **Settings bundle** is a specially formatted bundle that sits at the top of your app's bundle directory and contains the data needed to display your app's preferences. Figure 5-1 shows an example of custom preferences displayed for an app.

**Figure 5-1** Custom preferences displayed by the Settings app



**Note:** Because changing preferences in the Settings app requires leaving your app, you should use a Settings bundle only for preferences that the user changes infrequently. Frequently changed settings should be included directly inside your app.

Xcode provides support for creating a Settings bundle resource and adding it to your app. Inside the Settings bundle, you place one or more property list files and any images associated with your preferences. Each property-list file contains special keys and values that tell the Settings app how to display different pages of your preferences. Changes to your app's preferences are stored in the user defaults database and are accessible to your app using an `NSUserDefaults` object.

For detailed information about how to create a Settings bundle, see *Preferences and Settings Programming Guide*.

## Localized Resource Files

Because iOS apps are distributed in many countries, localizing your app's content can help you reach many more customers. Users are much more likely to use an app when it is localized for their native language. When you factor your user-facing content into resource files, localizing that content is a relatively simple process.

Before you can localize your content, you must internationalize your app in order to facilitate the localization process. Internationalizing your app involves factoring out any user-facing content into localizable resource files and providing language-specific project (`.lproj`) directories for storing that content. It also means using appropriate technologies (such as date and number formatters) when working with language-specific and locale-specific content.

For a fully internationalized app, the localization process creates new sets of language-specific resource files for you to add to your project. A typical iOS app requires localized versions of the following types of resource files:

- Storyboard files (or nib files)—Storyboards can contain text labels and other content that need to be localized. You might also want to adjust the position of interface items to accommodate changes in text length. (Similarly, nib files can contain text that needs to be localized or layout that needs to be updated.)
- Strings files—Strings files (so named because of their `.strings` filename extension) contain localized text that you plan to display in your app.
- Image files—You should avoid localizing images unless the images contain culture-specific content. And you should never store text directly in your image files. Instead, store text in a strings file and composite that text with your image-based content at runtime..
- Video and audio files—You should avoid localizing multimedia files unless they contain language-specific or culture-specific content. For example, you would want to localize a video file that contained a voice-over track.

For information about the internationalization and localization process, see *Internationalization Programming Topics*. For information about the proper way to use resource files in your app, see *Resource Programming Guide*.

## CHAPTER 5

### App-Related Resources

# Advanced App Tricks

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Many app-related tasks depend on the type of app you are trying to create. This chapter shows you how to implement some of the common behaviors found in iOS apps.

## Creating a Universal App

A universal app is a single app that is optimized for iPhone, iPod touch, and iPad devices. Providing a single binary that adapts to the current device offers the best user experience but, of course, involves extra work on your part. Because of the differences in device screen sizes, most of your window, view, and view controller code for iPad is likely to differ from the code for iPhone and iPod touch. In addition, there are things you must do to ensure your app runs correctly on each device type.

Xcode provides built-in support for configuring universal apps. When you create a new project, you can select whether you want to create a device-specific project or a universal project. After you create your project, you can change the supported set of devices for your app target using the Summary pane. When changing from a single-device project to a universal project, you must fill in the information for the device type for which you are adding support.

The following sections highlight the changes you must make to an existing app to ensure that it runs smoothly on any type of device.

## Updating Your Info.plist Settings

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Most of the existing keys in a universal app's `Info.plist` file should remain the same. However, for any keys that require different values on iPhone versus iPad devices, you can add device modifiers to the key name. When reading the keys of your `Info.plist` file, the system interprets each key using the following format:

`key_root - <platform>~<device>`

In this format, the `key_root` portion represents the original name of the key. The `<platform>` and `<device>` portions are both optional endings that you can use for keys that are specific to a platform or device. For apps that run only on iOS, you can omit the platform string. (The `iphoneos` platform string is used to distinguish apps written for iOS from those written for Mac OS X.) To apply a key to a specific device, use one of the following values:

- `iphone`—The key applies to iPhone devices.
- `ipod`—The key applies to iPod touch devices.
- `ipad`—The key applies to iPad devices.

For example, to indicate that you want your app to launch in a portrait orientation on iPhone and iPod touch devices but in landscape-right on iPad, you would configure your `Info.plist` with the following keys:

```
<key>UIInterfaceOrientation</key>
<string>UIInterfaceOrientationPortrait</string>
<key>UIInterfaceOrientation~ipad</key>
<string>UIInterfaceOrientationLandscapeRight</string>
```

Notice that in the preceding example, there is an iPad-specific key and a default key without any device modifiers. Continue to use the default key to specify the most common (or default) value and add a specific version with a device-specific modifier when you need to change that value. This guarantees that there is always a value available for the system to examine. For example, if you were to replace the default key with an iPhone-specific and iPad-specific version of the `UIInterfaceOrientation` key, the system would not know the preferred starting orientation for iPod devices.

For more information about the keys you can include in your `Info.plist` file, see *Information Property List Key Reference*

## Implementing Your View Controllers and Views

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The largest amount of effort that goes into creating universal apps is designing your user interface. Because of the different screen sizes, apps often need completely separate versions of their interface for each device idiom. This means creating new view hierarchies but might also mean creating completely different view controller objects to manage those views.

For views, the main modification is to redesign your view layouts to support the larger screen. Simply scaling existing views may work but often does not yield the best results. Your new interface should make use of the available space and take advantage of new interface elements where appropriate. Doing so is more likely to result in an interface that feels more natural to the user—and not just an iPhone app on a larger screen.

For view controllers, follow these guidelines:

- Consider defining separate view controller classes for iPhone and iPad devices. Using separate view controllers is often easier than trying to create one view controller that supports both platforms. If there is a significant amount of shared code, you could always put the shared code in a base class and then implement custom subclasses to address device-specific issues.
- If you use a single view controller class for both platforms, your code must support both iPhone and iPad screen sizes. (For an app that uses nib files, this might mean choosing which nib file to load based on the current device idiom.) Similarly, your view controller code must be able to handle differences between the two platforms.

For views, follow these guidelines:

- Consider using separate sets of views for iPhone and iPad devices. For custom views, this means defining different versions of your class for each device.
- If you choose to use the same custom view for both devices, make sure your `drawRect:` and `layoutSubviews` methods especially work properly on both devices.

For information about the view controllers you can use in your apps, see *View Controller Programming Guide for iOS*.

## Adding Runtime Checks for Newer Symbols

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Any app that supports a range of iOS versions must use runtime checks to protect code that uses symbols introduced in newer versions of the operating system. Thus, if you use the iOS 4.2 SDK to develop apps that run in iOS 3.1 and later, runtime checks allow you to use newer features when they are available and to follow alternate code paths when they are not. Failure to include such checks results in crashes when your app tries to use symbols that are not available.

There are several types of checks that you can make:

- Apps that link against iOS SDK 4.2 and later can use the weak linking support introduced in that version of the SDK. This support lets you check for the existence of a given Class object to determine whether you can use that class. For example:

```
if ([UIPrintInteractionController class]) {
    // Create an instance of the class and use it.
}
else {
    // The print interaction controller is not available.
}
```

To use this feature, you must build your app using LLVM and Clang and the app's deployment target must be set to iOS 3.1 or later.

- Apps that link against iOS SDK 4.1 and earlier must use the `NSClassFromString` function to see whether a class is defined. If the function returns a value other than `nil`, you may use the class. For example:

```
Class splitVCClass = NSClassFromString(@"UISplitViewController");
if (splitVCClass)
{
    UISplitViewController* mySplitViewController = [[splitVCClass alloc] init];
    // Configure the split view controller.
}
```

- To determine whether a method is available on an existing class, use the `instancesRespondToSelector: class` method.
- To determine whether a C-based function is available, perform a Boolean comparison of the function name to `NULL`. If the result is `YES`, you can use the function. For example:

```
if (UIGraphicsBeginPDFPage != NULL)
{
    UIGraphicsBeginPDFPage();
}
```

For more information and examples of how to write code that supports multiple deployment targets, see *SDK Compatibility Guide*.

## Using Runtime Checks to Create Conditional Code Paths

---

If your code needs to follow a different path depending on the underlying device type, use the `userInterfaceIdiom` property of `UIDevice` to determine which path to take. This property provides an indication of the style of interface to create: iPad or iPhone. Because this property is available only in iOS 3.2

and later, apps that support earlier versions of iOS need to check for the availability of this property before accessing it. Of course, the simplest way to check this property is to use the `UI_USER_INTERFACE_IDIOM` macro, which performs the necessary runtime checks for you.

```
if (UI_USER_INTERFACE_IDIOM() == UIUserInterfaceIdiomPad) {  
    // The device is an iPad running iOS 3.2 or later.  
}  
else {  
    // The device is an iPhone or iPod touch.  
}
```

## Updating Your Resource Files

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Because resource files are generally used to implement your app's user interface, you need to make the following changes:

- In addition to the `Default.png` file displayed when your app launches on iPhone devices, you must add new launch images for iPad devices as described in “[Providing Launch Images for Different Orientations](#)” (page 84).
- If you use images, you may need to add larger (or higher-resolution) versions to support iPad devices.
- If you use nib files, you need to provide a new set of nib files for iPad devices.
- You must size your app icons appropriately for iPad, as described in “[App Icons](#)” (page 81).

When using different resource files for each platform, you can conditionally load those resources just as you would conditionally execute code. For more information about how to use runtime checks, see “[Using Runtime Checks to Create Conditional Code Paths](#)” (page 91).

## Preserving the State of Your App’s User Interface

An app can save the state of its user interface by walking its view controller hierarchy and saving information about each view controller to disk. Walking the view controllers is fast and enables you to gather enough information to restore your app to its previous state. As you walk your view controller hierarchy, you need to save the following information at a minimum:

- The currently visible view controller
- The structural arrangement of your view controllers
- Information about each view controller, including the class name of the view controller, which you use to recreate the view controller during the next launch cycle, and references to the data being managed by the view controller.

One approach to saving this information is to build a property list that is structured to match the organization of your view controllers. In this property list, you save information about each view controller in a dictionary object. The keys of the dictionary identify properties of the view controller, such as its class name and pointers to any relevant data objects. For container view controllers, such as navigation and tab bar controllers, the dictionary should also contain an array with the dictionaries for any child view controllers.

Practically speaking, your app should save information only about those view controllers that are not part of your app's default user interface. That is, when an app launches, it normally loads a main nib file or creates an initial set of views and view controllers. This initial set of view controllers provides the interface that users see when they first launch the app. Because these objects are always created, you may not need to save them in your property list.

When your app's `applicationDidEnterBackground:` or  `applicationWillTerminate:` method is called, build your property list and save it as an app preference. Then, in your `application:didFinishLaunchingWithOptions:` method, load the property list from preferences and use it to create and configure any additional view controllers you need.

## Launching in Landscape Mode

Apps that use only landscape orientations for their interface must explicitly ask the system to launch the app in that orientation. Normally, iOS apps launch in portrait mode initially and rotate their interface to match the device orientation as needed. For apps that support both portrait and landscape orientations, always configure your views for portrait mode and then let your view controllers handle any rotations. If, however, your app supports landscape but not portrait orientations, perform the following tasks to make it launch in landscape mode initially:

- Add the `UIInterfaceOrientation` key to your app's `Info.plist` file and set the value of this key to either `UIInterfaceOrientationLandscapeLeft` or `UIInterfaceOrientationLandscapeRight`.
- Lay out your views in landscape mode and make sure that their autoresizing options are set correctly.
- Override your view controller's `shouldAutorotateToInterfaceOrientation:` method and return YES for the left or right landscape orientations and NO for portrait orientations.

**Important:** Apps should always use view controllers to manage their window-based content.

The `UIInterfaceOrientation` key in the `Info.plist` file tells iOS that it should configure the orientation of the app status bar (if one is displayed) as well as the orientation of views managed by any view controllers at launch time. In iOS 2.1 and later, view controllers respect this key and set their view's initial orientation to match. Using this key is equivalent to calling the `setStatusBarOrientation:animated:` method of `UIApplication` early in the execution of your `applicationDidFinishLaunching:` method.

**Note:** To launch a view controller-based app in landscape mode in versions of iOS before 2.1, you need to apply a 90-degree rotation to the transform of the app's root view in addition to all the preceding steps.

## Installing App-Specific Data Files at First Launch

You can use your app's first launch cycle to set up any data or configuration files required to run. App-specific data files should be created in the Library/Application Support/<bundleID>/ directory of your app sandbox, where <bundleID> is your app's bundle identifier. You can further subdivide this directory to organize your data files as needed. You can also create files in other directories, such as the Documents directory, depending on your needs.

If your app's bundle contains data files that you plan to modify, you must copy those files out of the app bundle and modify the copies. You must not modify any files inside your app bundle. Because iOS apps are code signed, modifying files inside your app bundle invalidates your app's signature and prevents your app from launching in the future. Copying those files to the Application Support directory (or another writable directory in your sandbox) and modifying them there is the only way to use such files safely.

For more information about the directories of the iOS app sandbox and the proper location for files, see *File System Programming Guide*.

## Protecting Data Using On-Disk Encryption

In iOS 4 and later, apps can use the data protection feature to add a level of security to their on-disk data. Data protection uses the built-in encryption hardware present on specific devices (such as the iPhone 3GS and iPhone 4) to store files in an encrypted format on disk. While the user's device is locked, protected files are inaccessible even to the app that created them. The user must explicitly unlock the device (by entering the appropriate passcode) at least once before your app can access one of its protected files.

Data protection is available on most iOS devices and is subject to the following requirements:

- The file system on the user's device must support data protection. This is true for newer devices, but for some earlier devices, the user might have to reformat the device's disk and restore any content from a backup.
- The user must have an active passcode lock set for the device.

To protect a file, your app must add an extended attribute to the file indicating the level of desired protection. Add this attribute using either the `NSData` class or the `NSFileManager` class. When writing new files, you can use the `writeToFile:options:error:` method of `NSData` with the appropriate protection value as one of the write options. For existing files, you can use the `setAttributes:ofItemAtPath:error:` method of `NSFileManager` to set or change the value of the `NSFileProtectionKey`. When using these methods, your app can specify one of the following protection levels for the file:

- No protection—The file is not encrypted on disk. You can use this option to remove data protection from an accessible file. Specify the `NSDataWritingFileProtectionNone` option (`NSData`) or the `NSFileProtectionNone` attribute (`NSFileManager`).

- Complete—The file is encrypted and inaccessible while the device is locked. Specify the `NSDataWritingFileProtectionComplete` option (`NSData`) or the `NSFileProtectionComplete` attribute (`NSFileManager`).
- Complete unless already open—The file is encrypted. A closed file is inaccessible while the device is locked. After the user unlocks the device, your app can open the file and continue to use it even if the user locks the device again. Specify the `NSDataWritingFileProtectionCompleteUnlessOpen` option (`NSData`) or the `NSFileProtectionCompleteUnlessOpen` attribute (`NSFileManager`).
- Complete until first login—The file is encrypted and inaccessible until after the device has booted and the user has unlocked it once. Specify the `NSDataWritingFileProtectionCompleteUntilFirstUserAuthentication` option (`NSData`) or the `NSFileProtectionCompleteUntilFirstUserAuthentication` attribute (`NSFileManager`).

If you protect a file, your app must be prepared to lose access to that file. When complete file protection is enabled, even your app loses the ability to read and write the file's contents when the user locks the device. Your app has several options for tracking when access to protected files might change, though:

- The app delegate can implement the `applicationProtectedDataWillBecomeUnavailable:` and `applicationProtectedDataDidBecomeAvailable:` methods.
- Any object can register for the `UIApplicationProtectedDataWillBecomeUnavailable` and `UIApplicationProtectedDataDidBecomeAvailable` notifications.
- Any object can check the value of the `protectedDataAvailable` property of the shared `UIApplication` object to determine whether files are currently accessible.

For new files, it is recommended that you enable data protection before writing any data to them. If you are using the `writeToFile:options:error:` method to write the contents of an `NSData` object to disk, this happens automatically. For existing files, adding data protection replaces an unprotected file with a new protected version.

## Tips for Developing a VoIP App

A **Voice over Internet Protocol (VoIP)** app allows the user to make phone calls using an Internet connection instead of the device's cellular service. Such an app needs to maintain a persistent network connection to its associated service so that it can receive incoming calls and other relevant data. Rather than keep VoIP apps awake all the time, the system allows them to be suspended and provides facilities for monitoring their sockets for them. When incoming traffic is detected, the system wakes up the VoIP app and returns control of its sockets to it.

There are several requirements for implementing a VoIP app:

1. Add the `UIBackgroundModes` key to your app's `Info.plist` file. Set the value of this key to an array that includes the `voip` string.
2. Configure one of the app's sockets for VoIP usage.
3. Before moving to the background, call the `setKeepAliveTimeout:handler:` method to install a handler to be executed periodically. Your app can use this handler to maintain its service connection.

4. Configure your audio session to handle transitions to and from active use.
5. To ensure a better user experience on iPhone, use the Core Telephony framework to adjust your behavior in relation to cell-based phone calls; see *Core Telephony Framework Reference*.
6. To ensure good performance for your VoIP app, use the System Configuration framework to detect network changes and allow your app to sleep as much as possible.

Including the `voip` value in the `UIBackgroundModes` key lets the system know that it should allow the app to run in the background as needed to manage its network sockets. This key also permits your app to play background audio (although including the `audio` value for the `UIBackgroundModes` key is still encouraged). An app with this key is also relaunched in the background immediately after system boot to ensure that the VoIP services are always available. For more information about the `UIBackgroundModes` key, see *Information Property List Key Reference*.

## Configuring Sockets for VoIP Usage

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In order for your app to maintain a persistent connection while it is in the background, you must tag your app's main communication socket specifically for VoIP usage. Tagging this socket tells the system that it should take over management of the socket when your app is suspended. The handoff itself is totally transparent to your app. And when new data arrives on the socket, the system wakes up the app and returns control of the socket so that the app can process the incoming data.

You need to tag only the socket you use for communicating with your VoIP service. This is the socket you use to receive incoming calls or other data relevant to maintaining your VoIP service connection. Upon receipt of incoming data, the handler for this socket needs to decide what to do. For an incoming call, you likely want to post a local notification to alert the user to the call. For other noncritical data, though, you might just process the data quietly and allow the system to put your app back into the suspended state.

In iOS, most sockets are managed using streams or other high-level constructs. To configure a socket for VoIP usage, the only thing you have to do beyond the normal configuration is add a special key that tags the interface as being associated with a VoIP service. Table 6-1 lists the stream interfaces and the configuration for each.

**Table 6-1** Configuring stream interfaces for VoIP usage

Interface	Configuration
<code>NSInputStream</code> and <code>NSOutputStream</code>	For Cocoa streams, use the <code>setProperty:forKey:</code> method to add the <code>NSStreamNetworkServiceType</code> property to the stream. The value of this property should be set to <code>NSStreamNetworkServiceTypeVoIP</code> .
<code>NSURLRequest</code>	When using the URL loading system, use the <code>setNetworkServiceType:</code> method of your <code>NSMutableURLRequest</code> object to set the network service type of the request. The service type should be set to <code>NSURLNetworkServiceTypeVoIP</code> .
<code>CFReadStreamRef</code> and <code>CFWriteStreamRef</code>	For Core Foundation streams, use the <code>CFReadStreamSetProperty</code> or <code>CFWriteStreamSetProperty</code> function to add the <code>KCFStreamNetworkServiceType</code> property to the stream. The value for this property should be set to <code>KCFStreamNetworkServiceTypeVoIP</code> .

**Note:** When configuring your sockets, you need to configure only your main signaling channel with the appropriate service type key. You do not need to include this key when configuring your voice channels.

Because VoIP apps need to stay running in order to receive incoming calls, the system automatically relaunches the app if it exits with a nonzero exit code. (This type of exit could happen when there is memory pressure and your app is terminated as a result.) However, terminating the app also releases all of its sockets, including the one used to maintain the VoIP service connection. Therefore, when the app is launched, it always needs to create its sockets from scratch.

For more information about configuring Cocoa stream objects, see *Stream Programming Guide for Cocoa*. For information about using URL requests, see *URL Loading System Programming Guide*. And for information about configuring streams using the CFNetwork interfaces, see *CFNetwork Programming Guide*.

## Installing a Keep-Alive Handler

To prevent the loss of its connection, a VoIP app typically needs to wake up periodically and check in with its server. To facilitate this behavior, iOS lets you install a special handler using the `setKeepAliveTimeout:handler:` method of `UIApplication`. You typically install this handler in the `applicationDidEnterBackground:` method of your app delegate. Once installed, the system calls your handler at least once before the timeout interval expires, waking up your app as needed to do so.

Your keep-alive handler executes in the background and should return as quickly as possible. Handlers are given a maximum of 10 seconds to perform any needed tasks and return. If a handler has not returned after 10 seconds, or has not requested extra execution time before that interval expires, the system suspends the app.

When installing your handler, specify the largest timeout value that is practical for your app's needs. The minimum allowable interval for running your handler is 600 seconds, and attempting to install a handler with a smaller timeout value will fail. Although the system promises to call your handler block before the timeout value expires, it does not guarantee the exact call time. To improve battery life, the system typically groups the execution of your handler with other periodic system tasks, thereby processing all tasks in one quick burst. As a result, your handler code must be prepared to run earlier than the actual timeout period you specified.

## Configuring Your App's Audio Session

As with any background audio app, the audio session for a VoIP app must be configured properly to ensure the app works smoothly with other audio-based apps. Because audio playback and recording for a VoIP app are not used all the time, it is especially important that you create and configure your app's audio session object only when it is needed. For example, you would create the audio session to notify the user of an incoming call or while the user was actually on a call. As soon as the call ends, you would then release the audio session and give other audio apps the opportunity to play their audio.

For information about how to configure and manage an audio session for a VoIP app, see *Audio Session Programming Guide*.

## Using the Reachability Interfaces to Improve the User Experience

Because VoIP apps rely heavily on the network, they should use the reachability interfaces of the System Configuration framework to track network availability and adjust their behavior accordingly. The reachability interfaces allow an app to be notified whenever network conditions change. For example, a VoIP app could close its network connections when the network becomes unavailable and recreate them when it becomes available again. The app could also use those kinds of changes to keep the user apprised about the state of the VoIP connection.

To use the reachability interfaces, you must register a callback function with the framework and use it to track changes. To register a callback function:

1. Create a `SCNetworkReachabilityRef` structure for your target remote host.
2. Assign a callback function to your structure (using the `SCNetworkReachabilitySetCallback` function) that processes changes in your target's reachability status.
3. Add that target to an active run loop of your app (such as the main run loop) using the `SCNetworkReachabilityScheduleWithRunLoop` function.

Adjusting your app's behavior based on the availability of the network can also help improve the battery life of the underlying device. Letting the system track the network changes means that your app can let itself go to sleep more often.

For more information about the reachability interfaces, see *System Configuration Framework Reference*.

## Communicating with Other Apps

Apps that support custom URL schemes can use those schemes to receive messages. Some apps use URL schemes to initiate specific requests. For example, an app that wants to show an address in the Maps app can use a URL to launch that app and display the address. You can implement your own URL schemes to facilitate similar types of communications in your apps.

Apple provides built-in support for the `http`, `mailto`, `tel`, and `sms` URL schemes. It also supports `http`-based URLs targeted at the Maps, YouTube, and iPod apps. The handlers for these schemes are fixed and cannot be changed. If your URL type includes a scheme that is identical to one defined by Apple, the Apple-provided app is launched instead of your app.

**Note:** If more than one third-party app registers to handle the same URL scheme, there is currently no process for determining which app will be given that scheme.

To communicate with an app using a custom URL, create an `NSURL` object with some properly formatted content and pass that object to the `openURL:` method of the shared `UIApplication` object. The `openURL:` method launches the app that registered to receive URLs of that type and passes it the URL. At that point, control passes to the new app.

The following code fragment illustrates how one app can request the services of another app ("todolist" in this example is a hypothetical custom scheme registered by an app):

```
NSURL *myURL = [NSURL
URLWithString:@"todolist://www.acme.com?Quarterly%20Report#200806231300"];
[[UIApplication sharedApplication] openURL:myURL];
```

If your app defines a custom URL scheme, it should implement a handler for that scheme as described in “[Implementing Custom URL Schemes](#)” (page 99). For more information about the system-supported URL schemes, including information about how to format the URLs, see *Apple URL Scheme Reference*.

## Implementing Custom URL Schemes

If your app can receive specially formatted URLs, you should register the corresponding URL schemes with the system. A custom URL scheme is a mechanism through which third-party apps can communicate with each other. Apps often use custom URL schemes to vend services to other apps. For example, the Maps app supports URLs for displaying specific map locations.

### Registering Custom URL Schemes

To register a URL type for your app, include the `CFBundleURLTypes` key in your app’s `Info.plist` file. The `CFBundleURLTypes` key contains an array of dictionaries, each of which defines a URL scheme the app supports. Table 6-2 describes the keys and values to include in each dictionary.

**Table 6-2** Keys and values of the `CFBundleURLTypes` property

Key	Value
<code>CFBundleURLName</code>	A string containing the abstract name of the URL scheme. To ensure uniqueness, it is recommended that you specify a reverse-DNS style of identifier, for example, <code>com.acme.myscheme</code> . The string you specify is also used as a key in your app’s <code>InfoPlist.strings</code> file. The value of the key is the human-readable scheme name.
<code>CFBundleURLSchemes</code>	An array of strings containing the URL scheme names—for example, <code>http</code> , <code>mailto</code> , <code>tel</code> , and <code>sms</code> .

Figure 6-1 shows the `Info.plist` file of an app that supports a custom scheme for creating “to-do” items. The `URL types` entry corresponds to the `CFBundleURLTypes` key added to the `Info.plist` file. Similarly, the “URL identifier” and “URL Schemes” entries correspond to the `CFBundleURLName` and `CFBundleURLSchemes` keys.

**Figure 6-1** Defining a custom URL scheme in the Info.plist file

Key	Value
▼ Information Property List	(12 items)
Localization native develo	en
Bundle display name	\${PRODUCT_NAME}
Executable file	\${EXECUTABLE_NAME}
Icon file	
Bundle identifier	com.acme.\${PRODUCT_NAME}
InfoDictionary version	6.0
Bundle name	\${PRODUCT_NAME}
Bundle OS Type code	APPL
Bundle creator OS Type co	????
Bundle version	1.0
Main nib file base name	MainWindow
▼ URL types	(1 item)
▼ Item 1	(2 items)
URL identifier	com.acme.ToDoList
▼ URL Schemes	(1 item)
Item 1	todolist

## Handling URL Requests

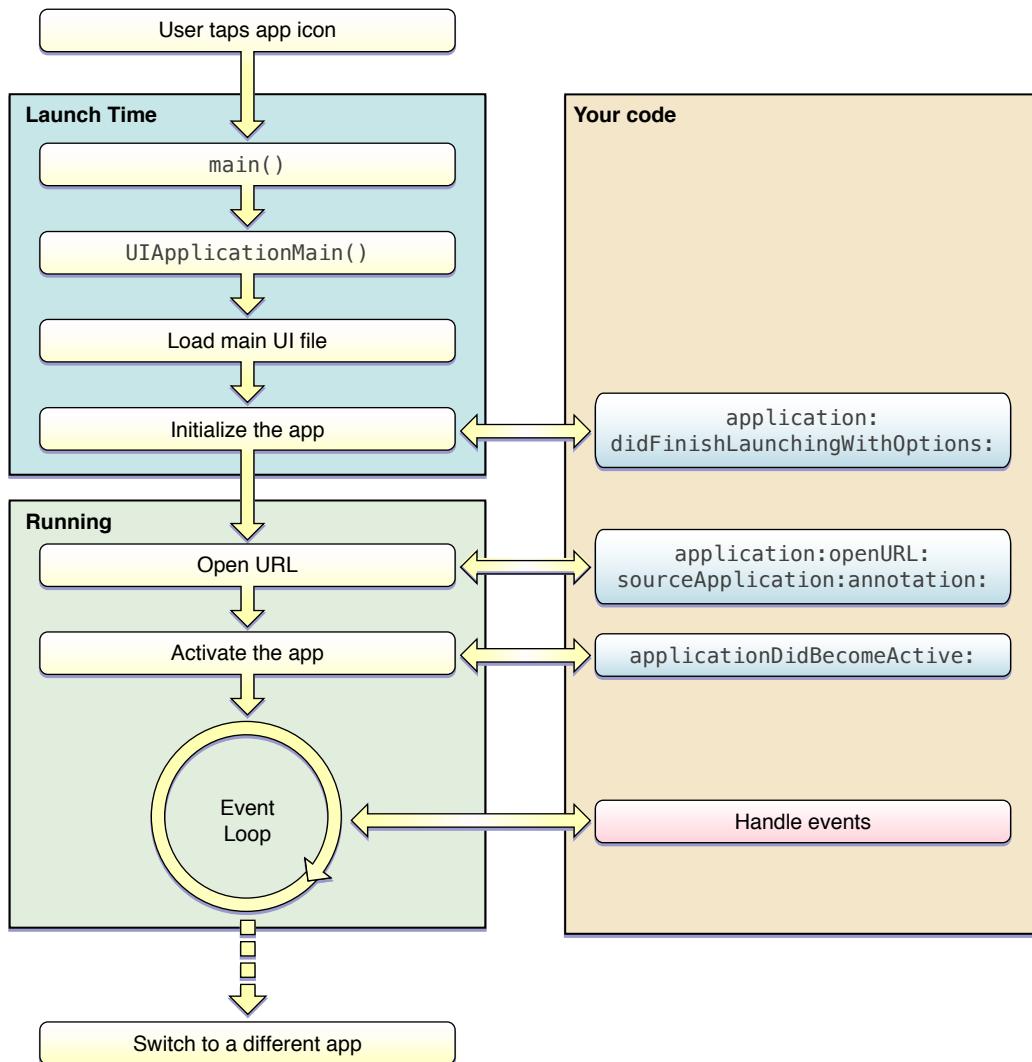
---

An app that has its own custom URL scheme must be able to handle URLs passed to it. All URLs are passed to your app delegate, either at launch time or while your app is running or in the background. To handle incoming URLs, your delegate should implement the following methods:

- Use the `application:didFinishLaunchingWithOptions:` method to retrieve information about the URL and decide whether you want to open it. This method is called only when your app is launched.
- In iOS 4.2 and later, use the `application:openURL:sourceApplication:annotation:` method to open the file.
- In iOS 4.1 and earlier, use the `application:handleOpenURL:` method to open the file.

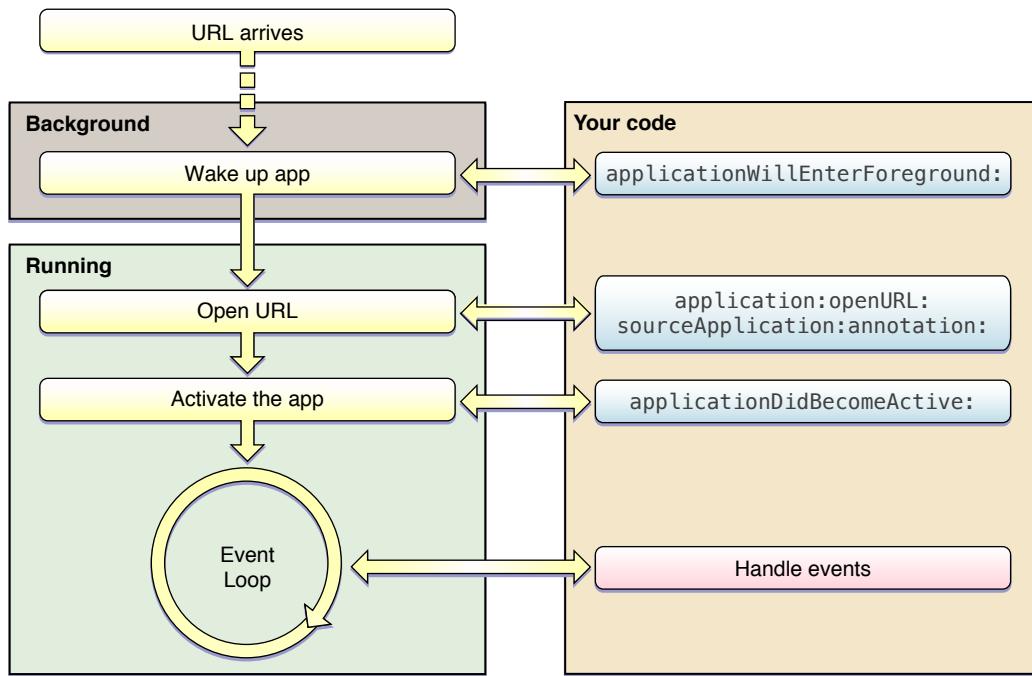
If your app is not running when a URL request arrives, it is launched and moved to the foreground so that it can open the URL. The implementation of your `application:didFinishLaunchingWithOptions:` method should retrieve the URL from its options dictionary and determine whether the app can open it. If it can, return YES and let your `application:openURL:sourceApplication:annotation:` (or `application:handleOpenURL:`) method handle the actual opening of the URL. Figure 6-2 shows the modified launch sequence for an app that is asked to open a URL.

**Figure 6-2** Launching an app to open a URL



If your app is running but is in the background or suspended when a URL request arrives, it is moved to the foreground to open the URL. Shortly thereafter, the system calls the delegate's `application:openURL:sourceApplication:annotation:` method to check the URL and open it. If your delegate does not implement this method (or the current system version is iOS 4.1 or earlier), the system calls your delegate's `application:handleOpenURL:` method instead. Figure 6-3 shows the modified process for moving an app to the foreground to open a URL.

**Figure 6-3** Waking a background app to open a URL



**Note:** Apps that support custom URL schemes can specify different launch images to be displayed when launching the app to handle a URL. For more information about how to specify these launch images, see [“Providing Launch Images for Custom URL Schemes”](#) (page 85).

All URLs are passed to your app in an `NSURL` object. It is up to you to define the format of the URL, but the `NSURL` class conforms to the RFC 1808 specification and therefore supports most URL formatting conventions. Specifically, the class includes methods that return the various parts of a URL as defined by RFC 1808, including the user, password, query, fragment, and parameter strings. The “protocol” for your custom scheme can use these URL parts for conveying various kinds of information.

In the implementation of `application:handleOpenURL:` shown in Listing 6-1, the passed-in URL object conveys app-specific information in its query and fragment parts. The delegate extracts this information—in this case, the name of a to-do task and the date the task is due—and with it creates a model object of the app. This example assumes that the user is using a Gregorian calendar. If your app supports non-Gregorian calendars, you need to design your URL scheme accordingly and be prepared to handle those other calendar types in your code.

**Listing 6-1 Handling a URL request based on a custom scheme**

```

- (BOOL)application:(UIApplication *)application handleOpenURL:(NSURL *)url {
    if ([[url scheme] isEqualToString:@"todolist"]) {
        ToDoItem *item = [[ToDoItem alloc] init];
        NSString *taskName = [url query];
        if (!taskName || ![self isValidTaskString:taskName]) { // must have a
            task name
            [item release];
            return NO;
        }
        taskName = [taskName
stringByReplacingPercentEscapesUsingEncoding:NSUTF8StringEncoding];

        item.todoTask = taskName;
        NSString *dateString = [url fragment];
        if (!dateString || [dateString isEqualToString:@"today"]) {
            item.dateDue = [NSDate date];
        } else {
            if (![self isValidDateString:dateString]) {
                [item release];
                return NO;
            }
            // format: yyyyymmddhhmm (24-hour clock)
            NSString *curStr = [dateString substringWithRange:NSMakeRange(0,
4)];
            NSInteger yeardigit = [curStr integerValue];
            curStr = [dateString substringWithRange:NSMakeRange(4, 2)];
            NSInteger monthdigit = [curStr integerValue];
            curStr = [dateString substringWithRange:NSMakeRange(6, 2)];
            NSInteger daydigit = [curStr integerValue];
            curStr = [dateString substringWithRange:NSMakeRange(8, 2)];
            NSInteger hourdigit = [curStr integerValue];
            curStr = [dateString substringWithRange:NSMakeRange(10, 2)];
            NSInteger minuttedigit = [curStr integerValue];

            NSDateComponents *dateComps = [[NSDateComponents alloc] init];
            [dateComps setYear:yeardigit];
            [dateComps setMonth:monthdigit];
            [dateComps setDay:daydigit];
            [dateComps setHour:hourdigit];
            [dateComps setMinute:minuttedigit];
            NSCalendar *calendar = [[NSCalendar alloc]
initWithCalendarIdentifier:NSGregorianCalendar
                                autorelease];
            NSDate *itemDate = [calendar dateFromComponents:dateComps];
            if (!itemDate) {
                [dateComps release];
                [item release];
                return NO;
            }
            item.dateDue = itemDate;
            [dateComps release];
        }
        [(NSMutableArray *)self.list addObject:item];
        [item release];
        return YES;
    }
}

```

```
    }
    return NO;
}
```

Be sure to validate the input you get from URLs passed to your app; see “[Validating Input And Interprocess Communication](#)” in *Secure Coding Guide* to find out how to avoid problems related to URL handling. To learn about URL schemes defined by Apple, see *Apple URL Scheme Reference*.

## Showing and Hiding the Keyboard

The appearance of the keyboard is tied to the responder status of views. If a view is able to become the first responder, the system shows the keyboard whenever that view actually becomes the first responder. When the user taps another view that does not support becoming the first responder, the system hides the keyboard if it is currently visible. In UIKit, only views that support text entry can become the first responder. Other views must override the `canBecomeFirstResponder` method and return YES if they want the keyboard to be shown.

When a view becomes first responder, the keyboard is shown by default, but you can replace the keyboard for views that support custom forms of input. Every responder object has an `inputView` property that contains the view to be displayed when the responder becomes the first responder. When this property is nil, the system displays the standard keyboard. When this property is not nil, the system displays the view you provide instead.

Normally, user taps dictate which view becomes the first responder in your app, but you can force a view to become the first responder too. Calling the `becomeFirstResponder` method on any responder object causes that object to try to become the first responder. If that responder object is able to become the first responder, the custom input view (or the standard keyboard) is shown automatically.

For more information about using the keyboard, see *Text, Web, and Editing Programming Guide for iOS*.

## Turning Off Screen Locking

If an iOS-based device does not receive touch events for a specified period of time, the system turns off the screen and disables the touch sensor. Locking the screen is an important way to save power. As a result, you should generally leave this feature enabled. However, for an app that does not rely on touch events, such as a game that uses the accelerometers for input, disable screen locking to prevent the screen from going dark while the app is running. However, even in this case, disable screen locking only while the user is actively engaged with the app. For example, if the user pauses a game, reenable screen locking to allow the screen to turn off.

To disable screen locking, set the `idleTimerDisabled` property of the shared `UIApplication` object to YES. Be sure to reset this property to NO when your app does not need to prevent screen locking.

# Performance Tuning

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At each step in the development of your app, you should consider the implications of your design choices on the overall performance of your app. The operating environment for iOS apps is more constrained than that for Mac OS X apps. The following sections describe the factors you should consider throughout the development process.

## Make App Backups More Efficient

Backups occur wirelessly via iCloud or when the user syncs the device with iTunes. During backups, files are transferred from the device to the user's computer or iCloud account. The location of files in your app sandbox determines whether or not those files are backed up and restored. If your application creates many large files that change regularly and puts them in a location that is backed up, backups could be slowed down as a result. As you write your file-management code, you need to be mindful of this fact.

### What Is Backed Up?

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You do not have to prepare your app in any way for backup and restore operations. Devices with an active iCloud account have their app data backed up to iCloud at appropriate times. And for devices that are plugged into a computer, iTunes performs an incremental backup of the app's data files. However, iCloud and iTunes do not back up the contents of the following directories:

- *<Application\_Home>/AppName.app*
- *<Application\_Home>/Library/Caches*
- *<Application\_Home>/tmp*

To prevent the syncing process from taking a long time, be selective about where you place files inside your app's home directory. Apps that store large files can slow down the process of backing up to iTunes or iCloud. These apps can also consume a large amount of a user's available storage, which may encourage the user to delete the app or disable backup of that app's data to iCloud. With this in mind, you should store app data according to the following guidelines:

- Data that can be downloaded again or regenerated should be stored in the *<Application\_Home>/Library/Caches* directory. Examples of files you should put in the *Caches* directory include (but are not limited to) database cache files and downloadable content, such as that used by magazine, newspaper, and map apps.
- Data that is used only temporarily should be stored in the *<Application\_Home>/tmp* directory. Remember to delete those files when you are done with them so that they do not continue to consume space on the user's device.

- Documents and data that are user-generated or that cannot otherwise be recreated by your app, should be stored in the `<Application_Home>/Documents` directory

Although iTunes backs up the app bundle itself, it does not do this during every sync operation. Apps purchased directly from a device are backed up when that device is next synced with iTunes. Apps are not backed up during subsequent sync operations, though, unless the app bundle itself has changed (because the app was updated, for example).

For additional guidance about how you should use the directories in your app, see *File System Programming Guide*.

## Files Saved During App Updates

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When a user downloads an app update, iTunes installs the update in a new app directory. It then moves the user's data files from the old installation over to the new app directory before deleting the old installation. Files in the following directories are guaranteed to be preserved during the update process:

- `<Application_Home>/Documents`
- `<Application_Home>/Library`

Although files in other user directories may also be moved over, you should not rely on them being present after an update.

## Use Memory Efficiently

Because the iOS virtual memory model does not include disk swap space, apps are more limited in the amount of memory they have available for use. Using large amounts of memory can seriously degrade system performance and potentially cause the system to terminate your app. In addition, apps running under multitasking must share system memory with all other running apps. Therefore, make it a high priority to reduce the amount of memory used by your app.

There is a direct correlation between the amount of free memory available and the relative performance of your app. Less free memory means that the system is more likely to have trouble fulfilling future memory requests. If that happens, the system can always remove suspended apps, code pages, or other nonvolatile resources from memory. However, removing those apps and resources from memory may be only a temporary fix, especially if they are needed again a short time later. Instead, minimize your memory use in the first place, and clean up the memory you do use in a timely manner.

The following sections provide more guidance on how to use memory efficiently and how to respond when there is only a small amount of available memory.

## Observe Low-Memory Warnings

When the system dispatches a low-memory warning to your app, respond immediately. iOS notifies all running apps whenever the amount of free memory dips below a safe threshold. (It does not notify suspended apps.) If your app receives this warning, it must free up as much memory as possible. The best types of memory to release are caches and image objects that can be recreated later if needed.

UIKit provides several ways to receive low-memory warnings, including the following:

- Implement the `applicationDidReceiveMemoryWarning:` method of your app delegate.
- Override the `didReceiveMemoryWarning` method in your custom `UIViewController` subclass.
- Register to receive the `UIApplicationDidReceiveMemoryWarningNotification` notification.

Upon receiving any of these warnings, your handler method should respond by immediately freeing up any unneeded memory. For example, the default behavior of the `UIViewController` class is to purge its view if that view is not currently visible; subclasses can supplement the default behavior by purging additional data structures. An app that maintains a cache of images might respond by releasing any images that are not currently onscreen.

If your data model includes known purgeable resources, you can have a corresponding manager object register for the `UIApplicationDidReceiveMemoryWarningNotification` notification and release its purgeable resources directly. Handling this notification directly avoids the need to route all memory warning calls through the app delegate.

**Note:** You can test your app's behavior under low-memory conditions using the Simulate Memory Warning command in iOS Simulator.

## Reduce Your App's Memory Footprint

Starting off with a low footprint gives you more room for expanding your app later. Table 7-1 lists some tips on how to reduce your app's overall memory footprint.

**Table 7-1**    Tips for reducing your app's memory footprint

Tip	Actions to take
Eliminate memory leaks.	Because memory is a critical resource in iOS, your app should have no memory leaks. You can use the Instruments app to track down leaks in your code, both in Simulator and on actual devices. For more information on using Instruments, see <i>Instruments User Guide</i> .
Make resource files as small as possible.	Files reside on disk but must be loaded into memory before they can be used. Property list files and images can be made smaller with some very simple actions. To reduce the space used by property list files, write those files out in a binary format using the <code>NSPropertyListSerialization</code> class. For images, compress all image files to make them as small as possible. (To compress PNG images—the preferred image format for iOS apps—use the <code>pngcrush</code> tool.)

Tip	Actions to take
Use Core Data or SQLite for large data sets.	<p>If your app manipulates large amounts of structured data, store it in a Core Data persistent store or in a SQLite database instead of in a flat file. Both Core Data and SQLite provide efficient ways to manage large data sets without requiring the entire set to be in memory all at once.</p> <p>The Core Data framework was introduced in iOS 3.0.</p>
Load resources lazily.	<p>You should never load a resource file until it is actually needed. Prefetching resource files may seem like a way to save time, but this practice actually slows down your app right away. In addition, if you end up not using the resource, loading it wastes memory for no good purpose.</p>
Build your program using the Thumb option.	<p>Adding the <code>-mthumb</code> compiler flag can reduce the size of your code by up to 35%. However, if your app contains floating-point-intensive code modules and you are building your app for ARMv6, you should disable the Thumb option. If you are building your code for ARMv7, you should leave Thumb enabled.</p>

## Allocate Memory Wisely

Table 7-2 lists tips for improving memory usage in your app.

**Table 7-2** Tips for allocating memory

Tip	Actions to take
Reduce your use of autoreleased objects.	<p>If your app does not use automatic reference counting (ARC) to manage its memory, release objects directly (using the <code>release</code> method) instead of indirectly (using the <code>autorelease</code> method) whenever possible. Releasing objects directly reclaims the memory occupied by the object immediately. Conversely, objects released using the <code>autorelease</code> method stay in memory until you explicitly drain the current autorelease pool or until the next iteration of the current run loop. Thus, creating large numbers of autoreleased objects during one iteration of a run loop can greatly increase memory pressure.</p>
Impose size limits on resources.	<p>Avoid loading a large resource file when a smaller one will do. Instead of using a high-resolution image, use one that is appropriately sized for iOS-based devices. If you must use large resource files, find ways to load only the portion of the file that you need at any given time. For example, rather than load the entire file into memory, use the <code>mmap</code> and <code>munmap</code> functions to map portions of the file into and out of memory. For more information about mapping files into memory, see <i>File-System Performance Guidelines</i>.</p>
Avoid unbounded problem sets.	<p>Unbounded problem sets might require an arbitrarily large amount of data to compute. If the set requires more memory than is available, your app may be unable to complete the calculations. Your apps should avoid such sets whenever possible and work on problems with known memory limits.</p>

For detailed information on how to allocate memory in iOS apps and for more information on autorelease pools, see “Cocoa Objects” in *Cocoa Fundamentals Guide*.

## Move Work off the Main Thread

Be sure to limit the type of work you do on the main thread of your app. The main thread is where your app handles touch events and other user input. To ensure that your app is always responsive to the user, you should never use the main thread to perform long-running or potentially unbounded tasks, such as tasks that access the network. Instead, you should always move those tasks onto background threads. The preferred way to do so is to use Grand Central Dispatch (GCD) or operation objects to perform tasks asynchronously.

Moving tasks into the background leaves your main thread free to continue processing user input, which is especially important when your app is starting up or quitting. During these times, your app is expected to respond to events in a timely manner. If your app's main thread is blocked at launch time, the system could kill the app before it even finishes launching. If the main thread is blocked at quitting time, the system could similarly kill the app before it has a chance to write out crucial user data.

For more information about using GCD, operation objects, and threads, see *Concurrency Programming Guide*.

## Floating-Point Math Considerations

The processors found in iOS-based devices are capable of performing floating-point calculations in hardware. If you have an existing program that performs calculations using a software-based fixed-point math library, you should consider modifying your code to use floating-point math instead. Hardware-based floating-point computations are typically much faster than their software-based fixed-point equivalents.

**Important:** If you build your app for ARMv6 and your code uses floating-point math extensively, compile that code without the `-mthumb` compiler option. The Thumb option can reduce the size of code modules, but it can also degrade the performance of floating-point code. If you build your app for ARMv7, you should always enable the Thumb option.

In iOS 4 and later, you can also use the functions of the Accelerate framework to perform complex mathematical calculations. This framework contains high-performance vector-accelerated libraries for digital signal processing and linear algebra mathematics. You can apply these libraries to problems involving audio and video processing, physics, statistics, cryptography, and complex algebraic equations.

## Reduce Power Consumption

Power consumption on mobile devices is always an issue. The power management system in iOS conserves power by shutting down any hardware features that are not currently being used. You can help improve battery life by optimizing your use of the following features:

- The CPU
- Wi-Fi, Bluetooth, and baseband (EDGE, 3G) radios
- The Core Location framework
- The accelerometers

- The disk

The goal of your optimizations should be to do the most work you can in the most efficient way possible. You should always optimize your app's algorithms using Instruments. But even the most optimized algorithm can still have a negative impact on a device's battery life. You should therefore consider the following guidelines when writing your code:

- Avoid doing work that requires polling. Polling prevents the CPU from going to sleep. Instead of polling, use the `NSRunLoop` or `NSTimer` classes to schedule work as needed.
- Leave the `idleTimerDisabled` property of the shared `UIApplication` object set to `NO` whenever possible. The idle timer turns off the device's screen after a specified period of inactivity. If your app does not need the screen to stay on, let the system turn it off. If your app experiences side effects as a result of the screen being turned off, you should modify your code to eliminate the side effects rather than disable the idle timer unnecessarily.
- Coalesce work whenever possible to maximize idle time. It generally takes less power to perform a set of calculations all at once than it does to perform them in small chunks over an extended period of time. Doing small bits of work periodically requires waking up the CPU more often and getting it into a state where it can perform your tasks.
- Avoid accessing the disk too frequently. For example, if your app saves state information to the disk, do so only when that state information changes, and coalesce changes whenever possible to avoid writing small changes at frequent intervals.
- Do not draw to the screen faster than is needed. Drawing is an expensive operation when it comes to power. Do not rely on the hardware to throttle your frame rates. Draw only as many frames as your app actually needs.
- If you use the `UIAccelerometer` class to receive regular accelerometer events, disable the delivery of those events when you do not need them. Similarly, set the frequency of event delivery to the smallest value that is suitable for your needs. For more information, see *Event Handling Guide for iOS*.

The more data you transmit to the network, the more power must be used to run the radios. In fact, accessing the network is the most power-intensive operation you can perform. You can minimize that time by following these guidelines:

- Connect to external network servers only when needed, and do not poll those servers.
- When you must connect to the network, transmit the smallest amount of data needed to do the job. Use compact data formats, and do not include excess content that simply is ignored.
- Transmit data in bursts rather than spreading out transmission packets over time. The system turns off the Wi-Fi and cell radios when it detects a lack of activity. When it transmits data over a longer period of time, your app uses much more power than when it transmits the same amount of data in a shorter amount of time.
- Connect to the network using the Wi-Fi radios whenever possible. Wi-Fi uses less power and is preferred over cellular radios.
- If you use the Core Location framework to gather location data, disable location updates as soon as you can and set the distance filter and accuracy levels to appropriate values. Core Location uses the available GPS, cell, and Wi-Fi networks to determine the user's location. Although Core Location works hard to

minimize the use of these radios, setting the accuracy and filter values gives Core Location the option to turn off hardware altogether in situations where it is not needed. For more information, see *Location Awareness Programming Guide*.

The Instruments app includes several instruments for gathering power-related information. You can use these instruments to gather general information about power consumption and to gather specific measurements for hardware such as the Wi-Fi and Bluetooth radios, GPS receiver, display, and CPU. For more information about using these instruments, see *Instruments User Guide*.

## Tune Your Code

iOS comes with several apps for tuning the performance of your app. Most of these tools run on Mac OS X and are suitable for tuning some aspects of your code while it runs in iOS Simulator. For example, you can use Simulator to eliminate memory leaks and make sure your overall memory usage is as low as possible. You can also remove any computational hotspots in your code that might be caused by an inefficient algorithm or a previously unknown bottleneck.

After you have tuned your code in Simulator, you should then use the Instruments app to further tune your code on a device. Running your code on an actual device is the only way to tune your code fully. Because Simulator runs in Mac OS X, it has the advantage of a faster CPU and more usable memory, so its performance is generally much better than the performance on an actual device. And using Instruments to trace your code on an actual device may point out additional performance bottlenecks that need tuning.

For more information on using Instruments, see *Instruments User Guide*.

## Improve File Access Times

Minimize the amount of data you write to the disk. File operations are relatively slow and involve writing to the flash drive, which has a limited lifespan. Some specific tips to help you minimize file-related operations include:

- Write only the portions of the file that changed, and aggregate changes when you can. Avoid writing out the entire file just to change a few bytes.
- When defining your file format, group frequently modified content together to minimize the overall number of blocks that need to be written to disk each time.
- If your data consists of structured content that is randomly accessed, store it in a Core Data persistent store or a SQLite database, especially if the amount of data you are manipulating could grow to more than a few megabytes.

Avoid writing cache files to disk. The only exception to this rule is when your app quits and you need to write state information that can be used to put your app back into the same state when it is next launched.

## Tune Your Networking Code

The networking stack in iOS includes several interfaces for communicating over the radio hardware of iOS devices. The main programming interface is the CFNetwork framework, which builds on top of BSD sockets and opaque types in the Core Foundation framework to communicate with network entities. You can also use the `NSStream` classes in the Foundation framework and the low-level BSD sockets found in the Core OS layer of the system.

For information about how to use the CFNetwork framework for network communication, see *CFNetwork Programming Guide* and *CFNetwork Framework Reference*. For information about using the `NSStream` class, see *Foundation Framework Reference*.

### Tips for Efficient Networking

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Implementing code to receive or transmit data across the network is one of the most power-intensive operations on a device. Minimizing the amount of time spent transmitting or receiving data helps improve battery life. To that end, you should consider the following tips when writing your network-related code:

- For protocols you control, define your data formats to be as compact as possible.
- Avoid using chatty protocols.
- Transmit data packets in bursts whenever you can.

Cellular and Wi-Fi radios are designed to power down when there is no activity. Depending on the radio, though, doing so can take several seconds. If your app transmits small bursts of data every few seconds, the radios may stay powered up and continue to consume power, even when they are not actually doing anything. Rather than transmit small amounts of data more often, it is better to transmit a larger amount of data once or at relatively large intervals.

When communicating over the network, packets can be lost at any time. Therefore, when writing your networking code, you should be sure to make it as robust as possible when it comes to failure handling. It is perfectly reasonable to implement handlers that respond to changes in network conditions, but do not be surprised if those handlers are not called consistently. For example, the Bonjour networking callbacks may not always be called immediately in response to the disappearance of a network service. The Bonjour system service immediately invokes browsing callbacks when it receives a notification that a service is going away, but network services can disappear without notification. This situation might occur if the device providing the network service unexpectedly loses network connectivity or the notification is lost in transit.

### Using Wi-Fi

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If your app accesses the network using the Wi-Fi radios, you must notify the system of that fact by including the `UIRequiresPersistentWiFi` key in the app's `Info.plist` file. The inclusion of this key lets the system know that it should display the network selection dialog if it detects any active Wi-Fi hot spots. It also lets the system know that it should not attempt to shut down the Wi-Fi hardware while your app is running.

To prevent the Wi-Fi hardware from using too much power, iOS has a built-in timer that turns off the hardware completely after 30 minutes if no running app has requested its use through the `UIRequiresPersistentWiFi` key. If the user launches an app that includes the key, iOS effectively disables the timer for the duration of the app's life cycle. As soon as that app quits or is suspended, however, the system reenables the timer.

**Note:** Note that even when `UIRequiresPersistentWiFi` has a value of `true`, it has no effect when the device is idle (that is, screen-locked). The app is considered inactive, and although it may function on some levels, it has no Wi-Fi connection.

For more information on the `UIRequiresPersistentWiFi` key and the keys of the `Info.plist` file, see [Figure 6-1](#) (page 100).

## The Airplane Mode Alert

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If your app launches while the device is in airplane mode, the system may display an alert to notify the user of that fact. The system displays this alert only when all of the following conditions are met:

- Your app's information property list (`Info.plist`) file contains the `UIRequiresPersistentWiFi` key and the value of that key is set to `true`.
- Your app launches while the device is currently in airplane mode.
- Wi-Fi on the device has not been manually reenabled after the switch to airplane mode.

## CHAPTER 7

### Performance Tuning

# The iOS Environment

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The iOS environment affects several aspects of how you design your app. Understanding some key aspects should help you when writing your code.

## Specialized System Behaviors

The iOS system is based on the same technologies used by Mac OS X, namely the Mach kernel and BSD interfaces. Thus, iOS apps run in a UNIX-based system and have full support for threads, sockets, and many of the other technologies typically available at that level. However, there are places where the behavior of iOS differs from that of Mac OS X.

### The Virtual Memory System

To manage program memory, iOS uses essentially the same virtual memory system found in Mac OS X. In iOS, each program still has its own virtual address space, but unlike Mac OS X, the amount of usable virtual memory is constrained by the amount of physical memory available. This is because iOS does not support paging to disk when memory gets full. Instead, the virtual memory system simply releases read-only memory pages, such as code pages, when it needs more space. Such pages can always be loaded back into memory later if they are needed again.

If memory continues to be constrained, the system may send low-memory notifications to any running apps, asking them to free up additional memory. All apps should respond to this notification and do their part to help relieve the memory pressure. For information on how to handle such notifications in your app, see “[Observe Low-Memory Warnings](#)” (page 107).

### The Automatic Sleep Timer

One way iOS saves battery power is through the automatic sleep timer. When the system does not detect touch events for an extended period of time, it dims the screen initially and eventually turns it off altogether.

If you are creating an app that does not use touch inputs, such as a game that relies on the accelerometers, you can disable the automatic sleep timer to prevent the screen from dimming. You should use this timer sparingly and reenable it as soon as possible to conserve power. Only apps that display visual content and do not rely on touch inputs should ever disable the timer. Audio apps or apps that do not need to present visual content should not disable the timer.

The process for disabling the timer is described in “[Turning Off Screen Locking](#)” (page 104). For additional tips on how to save power in your app, see “[Reduce Power Consumption](#)” (page 109).

## Multitasking Support

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In iOS 4 and later, **multitasking** allows apps to run in the background even when they are not visible on the screen. Most background apps reside in memory but do not actually execute any code. These apps are suspended by the system shortly after entering the background to preserve battery life. Apps can ask the system for background execution time in a number of ways, though.

For an overview of multitasking and what you need to do to support it, see [“Background Execution and Multitasking”](#) (page 51).

## Security

The security infrastructure in iOS is there to protect your app’s data and the system as a whole. Security breaches can and will happen, so the first line of defense in iOS is to minimize the damage caused by such breaches by securing each app separately in its own sandbox. But iOS provides other technologies, such as encryption and certificate support, to help you protect your data at an even more fundamental level.

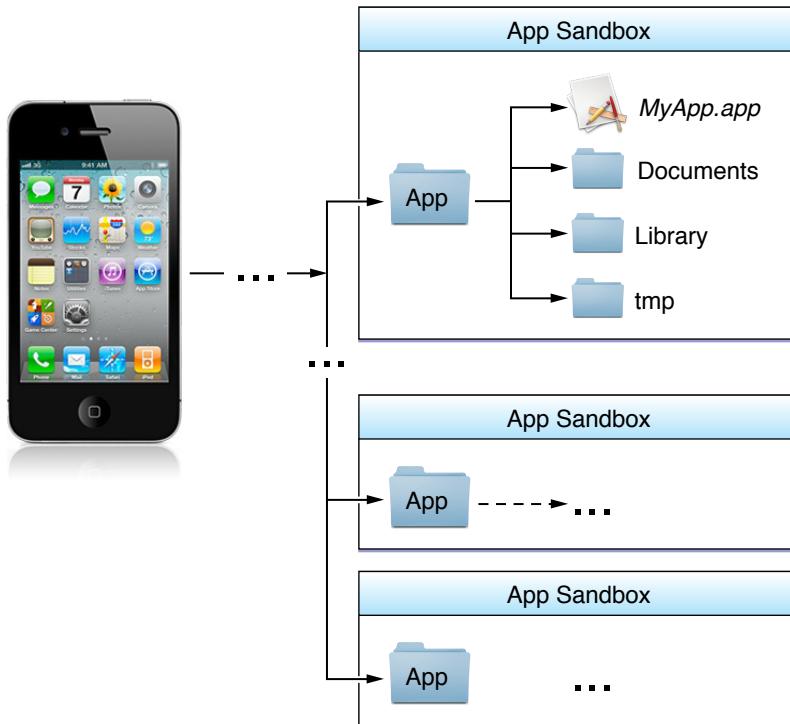
For an introduction to security and how it impacts the design of your app, see *Security Overview*.

## The App Sandbox

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For security reasons, iOS places each app (including its preferences and data) in a sandbox at install time. A sandbox is a set of fine-grained controls that limit the app’s access to files, preferences, network resources, hardware, and so on. As part of the sandboxing process, the system installs each app in its own sandbox directory, which acts as the home for the app and its data.

To help apps organize their data, each sandbox directory contains several well-known subdirectories for placing files. Figure A-1 shows the basic layout of a sandbox directory. For detailed information about the sandbox directory and what belongs in each of its subdirectories, see *File System Programming Guide*.

**Figure A-1** Sandbox directories in iOS

**Important:** The purpose of a sandbox is to limit the damage that a compromised app can cause to the system. Sandboxes do not prevent attacks from happening to a particular app and it is still your responsibility to code defensively to prevent attacks. For example, if your app does not validate user input and there is an exploitable buffer overflow in your input-handling code, an attacker could still hijack your app or cause it to crash. The sandbox only prevents the hijacked app from affecting other apps and other parts of the system.

## Keychain Data

A **keychain** is a secure, encrypted container for passwords and other secrets. The keychain is intended for storing small amounts of sensitive data that are specific to your app. It is not intended as a general-purpose mechanism for encrypting and storing data.

Keychain data for an app is stored outside of the app's sandbox. When the user backs up app data using iTunes, the keychain data is also backed up. Before iOS 4.0, keychain data could only be restored to the device from which the backup was made. In iOS 4.0 and later, a keychain item that is password protected can be restored to a different device only if its accessibility is not set to `kSecAttrAccessibleAlwaysThisDeviceOnly` or any other value that restricts it to the current device. Upgrading an app does not affect that app's keychain data.

For more on the iOS keychain, see “Keychain Services Concepts” in *Keychain Services Programming Guide*.

## APPENDIX A

### The iOS Environment

# Document Revision History

This table describes the changes to *iOS App Programming Guide*.

Date	Notes
2011-10-12	Added information about features introduced in iOS 5.0.
	Reorganized book and added more design-level information.
	Added high-level information about iCloud and how it impacts the design of applications.
2011-02-24	Added information about using AirPlay in the background.
2010-12-13	Made minor editorial changes.
2010-11-15	Incorporated additional iPad-related design guidelines into this document.
	Updated the information about how keychain data is preserved and restored.
2010-08-20	Fixed several typographical errors and updated the code sample on initiating background tasks.
2010-06-30	Updated the guidance related to specifying application icons and launch images.
	Changed the title from <i>iPhone Application Programming Guide</i> .
2010-06-14	Reorganized the book so that it focuses on the design of the core parts of your application.
	Added information about how to support multitasking in iOS 4 and later. For more information, see “ <a href="#">Core App Objects</a> ” (page 21).
	Updated the section describing how to determine what hardware is available.
	Added information about how to support devices with high-resolution screens.
	Incorporated iPad-related information.
2010-02-24	Made minor corrections.
2010-01-20	Updated the “Multimedia Support” chapter with improved descriptions of audio formats and codecs.
2009-10-19	Moved the iPhone specific Info.plist keys to <i>Information Property List Key Reference</i> .
	Updated the “Multimedia Support” chapter for iOS 3.1.

## REVISION HISTORY

### Document Revision History

Date	Notes
2009-06-17	Added information about using the compass interfaces.
	Moved information about OpenGL support to <i>OpenGL ES Programming Guide for iOS</i> .
	Updated the list of supported Info.plist keys.
2009-05-14	Updated for iOS 3.0.
	Added code examples to "Copy and Paste Operations" in the Event Handling chapter.
	Added a section on keychain data to the Files and Networking chapter.
	Added information about how to display map and email interfaces.
	Made various small corrections.
2009-01-06	Fixed several typos and clarified the creation process for child pages in the Settings application.
2008-11-12	Added guidance about floating-point math considerations
	Updated information related to what is backed up by iTunes.
2008-10-15	Reorganized the contents of the book.
	Moved the high-level iOS information to <i>iOS Technology Overview</i> .
	Moved information about the standard system URL schemes to <i>Apple URL Scheme Reference</i> .
	Moved information about the development tools and how to configure devices to <i>iOS App Development Workflow Guide</i> .
	Created the Core Application chapter, which now introduces the application architecture and covers much of the guidance for creating iPhone applications.
	Added a Text and Web chapter to cover the use of text and web classes and the manipulation of the onscreen keyboard.
	Created a separate chapter for Files and Networking and moved existing information into it.
	Changed the title from <i>iPhone OS Programming Guide</i> .
2008-07-08	New document that describes iOS and the development process for iPhone applications.