

Multimedia Programming Guide



Developer

Contents

About Audio and Video 4

Organization of This Document 4

Using Audio 5

The Basics: Audio Codecs, Supported Audio Formats, and Audio Sessions 6

iOS Hardware and Software Audio Codecs 7

Audio Sessions 9

Playing Audio 11

Playing Audio Items with iPod Library Access 12

Playing UI Sound Effects or Invoking Vibration Using System Sound Services 12

Playing Sounds Easily with the AVAudioPlayer Class 15

Playing Sounds with Control Using Audio Queue Services 17

Playing Sounds with Positioning Using OpenAL 21

Recording Audio 21

Recording with the AVAudioRecorder Class 22

Recording with Audio Queue Services 24

Parsing Streamed Audio 25

Audio Unit Support in iOS 26

Best Practices for iOS Audio 27

Tips for Using Audio 27

Preferred Audio Formats in iOS 28

Using Video 30

Recording and Editing Video 30

Playing Video Files 31

Document Revision History 34

Figures, Tables, and Listings

Using Audio 5

Figure 1-1	Using iPod library access	12
Table 1-1	Audio playback formats and codecs	7
Table 1-2	Audio recording formats and codecs	8
Table 1-3	Features provided by the audio session APIs	9
Table 1-4	Handling audio interruptions	11
Table 1-5	System-supplied audio units	26
Table 1-6	Audio tips	27
Listing 1-1	Creating a sound ID object	13
Listing 1-2	Playing a system sound	14
Listing 1-3	Triggering vibration	14
Listing 1-4	Configuring an AVAudioPlayer object	15
Listing 1-5	Implementing an AVAudioPlayer delegate method	16
Listing 1-6	Controlling an AVAudioPlayer object	17
Listing 1-7	Creating an audio queue object	18
Listing 1-8	Setting the playback level directly	20
Listing 1-9	The AudioQueueLevelMeterState structure	21
Listing 1-10	Setting up the audio session and the sound file URL	22
Listing 1-11	A record/stop method using the AVAudioRecorder class	23

Using Video 30

Figure 2-1	Media player interface with transport controls	31
Listing 2-1	Playing full-screen movies	31

About Audio and Video

Whether multimedia features are central or incidental to your application, iPhone, iPod touch, and iPad users expect high quality. When presenting video content, take advantage of the device's high-resolution screen and high frame rates. When designing the audio portion of your application, keep in mind that compelling sound adds immeasurably to a user's overall experience.

You can take advantage of the iOS multimedia frameworks for adding features like:

- High-quality audio recording, playback, and streaming
- Immersive game sounds
- Live voice chat
- Playback of content from a user's iPod library
- Video playback and recording on supported devices

In iOS 4.0 and later, the AV Foundation framework gives you fine-grained control over inspecting, editing, and presenting audio-visual assets.

Organization of This Document

This document contains the following chapters:

- [“Using Audio”](#) (page 5) shows how to use the system's audio technologies to play and record audio.
- [“Using Video”](#) (page 30) shows how to use the system's video technologies to play and capture video.

Using Audio

Important: This document contains information that used to be in *iOS App Programming Guide*. The information in this document has *not* been updated specifically for iOS 4.0.

iOS offers a rich set of tools for working with sound in your application. These tools are arranged into frameworks according to the features they provide, as follows:

- Use the **Media Player framework** to play songs, audio books, or audio podcasts from a user's iPod library. For details, see *Media Player Framework Reference*, *iPod Library Access Programming Guide*, and the *AddMusic* sample code project.
- Use the **AV Foundation framework** to play and record audio using a simple Objective-C interface. For details, see *AV Foundation Framework Reference* and the *avTouch* sample code project.
- Use the **Audio Toolbox framework** to play audio with synchronization capabilities, access packets of incoming audio, parse audio streams, convert audio formats, and record audio with access to individual packets. For details, see *Audio Toolbox Framework Reference* and the *SpeakHere* sample code project.
- Use the **Audio Unit framework** to connect to and use audio processing plug-ins. For details, see *Audio Unit Hosting Guide for iOS*.
- Use the **OpenAL framework** to provide positional audio playback in games and other applications. iOS supports OpenAL 1.1. For information on OpenAL, see the [OpenAL](#) website, *OpenAL FAQ for iPhone OS*, and the *oalTouch* sample code project.

To allow your code to use the features of an audio framework, add that framework to your Xcode project, link against it in any relevant targets, and add an appropriate `#import` statement near the top of relevant source files. For example, to provide access to the AV Foundation framework in a source file, add a `#import <AVFoundation/AVFoundation.h>` statement near the top of the file. For detailed information on how to add frameworks to your project, see "Files in Projects" in *Xcode Project Management Guide*.

Important: To use the features of the Audio Unit framework, add the *Audio Toolbox* framework to your Xcode project and link against it in any relevant targets. Then add a `#import <AudioToolbox/AudioToolbox.h>` statement near the top of relevant source files.

This section on sound provides a quick introduction to implementing iOS audio features, as listed here:

- To play songs, audio podcasts, and audio books from a user's iPod library, see [“Playing Audio Items with iPod Library Access”](#) (page 12).
- To play and record audio in the fewest lines of code, use the AV Foundation framework. See [“Playing Sounds Easily with the AVAudioPlayer Class”](#) (page 15) and [“Recording with the AVAudioRecorder Class”](#) (page 22).
- To provide full-featured audio playback including stereo positioning, level control, and simultaneous sounds, use OpenAL. See [“Playing Sounds with Positioning Using OpenAL”](#) (page 21).
- To provide lowest latency audio, especially when doing simultaneous input and output (such as for a VoIP application), use the I/O unit or the Voice Processing I/O unit. See [“Audio Unit Support in iOS”](#) (page 26).
- To play sounds with the highest degree of control, including support for synchronization, use Audio Queue Services. See [“Playing Sounds with Control Using Audio Queue Services”](#) (page 17). Audio Queue Services also supports recording and provides access to incoming audio packets, as described in [“Recording with Audio Queue Services”](#) (page 24).
- To parse audio streamed from a network connection, use Audio File Stream Services. See [“Parsing Streamed Audio”](#) (page 25).
- To play user-interface sound effects, or to invoke vibration on devices that provide that feature, use System Sound Services. See [“Playing UI Sound Effects or Invoking Vibration Using System Sound Services”](#) (page 12).

Be sure to read the next section, [“The Basics: Audio Codecs, Supported Audio Formats, and Audio Sessions”](#) (page 6), for critical information on how audio works in iOS. Also read [“Best Practices for iOS Audio”](#) (page 27), which offers guidelines and lists the audio and file formats to use for best performance and best user experience.

When you're ready to dig deeper, the [iOS Dev Center](#) contains guides, reference books, sample code, and more. For in-depth explanations of audio development in iOS, see *Core Audio Overview*, *Audio Session Programming Guide*, *Audio Queue Services Programming Guide*, *Audio Unit Hosting Guide for iOS*, and *iPod Library Access Programming Guide*.

The Basics: Audio Codecs, Supported Audio Formats, and Audio Sessions

To get oriented toward iOS audio development, it's important to understand a few critical things about the hardware and software architecture of iOS devices—described in this section.

iOS Hardware and Software Audio Codecs

To ensure optimum performance and quality, you need to pick the right audio format and audio codec type. Starting in iOS 3.0, most audio formats can use software-based encoding (for recording) and decoding (for playback). Software codecs support simultaneous playback of multiple sounds, but may entail significant CPU overhead.

Hardware-assisted decoding provides excellent performance—but does not support simultaneous playback of multiple sounds. If you need to maximize video frame rate in your application, minimize the CPU impact of your audio playback by using uncompressed audio or the IMA4 format, or use hardware-assisted decoding of your compressed audio assets.

For best-practice advice on picking an audio format, see [“Preferred Audio Formats in iOS”](#) (page 28).

Table 1-1 describes the playback audio codecs available on iOS devices.

Table 1-1 Audio playback formats and codecs

Audio decoder/playback format	Hardware-assisted decoding	Software-based decoding
AAC (MPEG-4 Advanced Audio Coding)	Yes	Yes, starting in iOS 3.0
ALAC (Apple Lossless)	Yes	Yes, starting in iOS 3.0
HE-AAC (MPEG-4 High Efficiency AAC)	Yes	-
iLBC (Internet Low Bitrate Codec, another format for speech)	-	Yes
IMA4 (IMA/ADPCM)	-	Yes
Linear PCM (uncompressed, linear pulse-code modulation)	-	Yes
MP3 (MPEG-1 audio layer 3)	Yes	Yes, starting in iOS 3.0
μ-law and a-law	-	Yes

When using hardware-assisted decoding, the device can play *only a single instance* of one of the supported formats at a time. For example, if you are playing a stereo MP3 sound using the hardware codec, a second simultaneous MP3 sound will use software decoding. Similarly, you cannot simultaneously play an AAC and an ALAC sound using hardware. If the iPod application is playing an AAC or MP3 sound in the background, it has claimed the hardware codec; your application then plays AAC, ALAC, and MP3 audio using software decoding.

To play multiple sounds with best performance, or to efficiently play sounds while the iPod is playing in the background, use linear PCM (uncompressed) or IMA4 (compressed) audio.

To learn how to check at runtime which hardware and software codecs are available on a device, read the discussion for the `kAudioFormatProperty_HardwareCodecCapabilities` constant in *Audio Format Services Reference* and read Technical Q&A QA1663, “Determining the availability of the AAC hardware encoder at runtime.”

To summarize how iOS supports audio formats for single or multiple playback:

- **Linear PCM and IMA4 (IMA/ADPCM)** You can play multiple linear PCM or IMA4 sounds simultaneously in iOS without incurring CPU resource problems. The same is true for the iLBC speech-quality format, and for the μ -law and a-law compressed formats. When using compressed formats, check the sound quality to ensure it meets your needs.
- **AAC, HE-AAC, MP3, and ALAC (Apple Lossless)** Playback for AAC, HE-AAC, MP3, and ALAC sounds can use efficient hardware-assisted decoding on iOS devices, but these codecs all share a single hardware path. The device can play only a single instance of one of these formats at a time using hardware-assisted decoding.

The single hardware path for AAC, HE-AAC, MP3, and ALAC playback has implications for “play along” style applications, such as a virtual piano. If the user is playing a song in one of these three formats in the iPod application, then your application—to play along over that audio—will employ software decoding.

Table 1-2 describes the recording audio codecs available on iOS devices.

Table 1-2 Audio recording formats and codecs

Audio encoder/recording format	Hardware-assisted encoding	Software-based encoding
AAC (MPEG-4 Advanced Audio Coding)	Yes, starting in iOS 3.1 for iPhone 3GS and iPod touch (2nd generation) Yes, starting in iOS 3.2 for iPad	Yes, starting in iOS 4.0 for iPhone 3GS and iPod touch (2nd generation)
ALAC (Apple Lossless)	-	Yes
iLBC (internet Low Bitrate Codec, for speech)	-	Yes
IMA4 (IMA/ADPCM)	-	Yes
Linear PCM (uncompressed, linear pulse-code modulation)	-	Yes

Audio encoder/recording format	Hardware-assisted encoding	Software-based encoding
μ-law and a-law	-	Yes

Audio Sessions

The iOS audio session APIs let you define your application’s general audio behavior and design it to work well within the larger audio context of the device it’s running on. These APIs are described in *Audio Session Services Reference* and *AVAudioSession Class Reference*. Using these APIs, you can specify such behaviors as:

- Whether or not your audio should be silenced by the Silent switch (on iPhone, this is called the *Ring/Silent switch*)
- Whether or not your audio should stop upon screen lock
- Whether other audio, such as from the iPod, should continue playing or be silenced when your audio starts

The audio session APIs also let you respond to user actions, such as the plugging in or unplugging of headsets, and to events that use the device’s sound hardware, such as Clock and Calendar alarms and incoming phone calls.

The audio session APIs provide three programmatic features, described in Table 1-3.

Table 1-3 Features provided by the audio session APIs

Audio session feature	Description
Setting categories	A category is a key that identifies a set of audio behaviors for your application. By setting a category, you indicate your audio intentions to iOS, such as whether your audio should continue when the screen locks. There are six categories, described in “Responding to Interruptions”. You can fine-tune the behavior of some categories, as explained in “Use Modes to Specialize the Category” in <i>Audio Session Programming Guide</i> .
Handling interruptions and route changes	Your audio session posts messages when your audio is interrupted, when an interruption ends, and when the hardware audio route changes. These messages let you respond gracefully to changes in the larger audio environment—such as an interruption due to an incoming phone call. For details, see “Handling Audio Hardware Route Changes” and “Audio Guidelines By App Type”.

Audio session feature	Description
Optimizing for hardware characteristics	You can query the audio session to discover characteristics of the device your application is running on, such as hardware sample rate, number of hardware channels, and whether audio input is available. For details, see “Optimizing for Device Hardware”.

There are two interfaces for working with the audio session:

- A streamlined, objective-C interface that gives you access to the core audio session features and is described in *AVAudioSession Class Reference* and *AVAudioSessionDelegate Protocol Reference*.
- A C-based interface that provides comprehensive access to all basic and advanced audio session features and is described in *Audio Session Services Reference*.

You can mix and match audio session code from AV Foundation and Audio Session Services—the interfaces are completely compatible.

An audio session comes with some default behavior that you can use to get started in development. However, except for certain special cases, the default behavior is unsuitable for a shipping application that uses audio.

For example, when using the default audio session, audio in your application stops when the Auto-Lock period times out and the screen locks. If you want to ensure that playback continues with the screen locked, include the following lines in your application’s initialization code:

```

NSError *setCategoryErr = nil;
NSError *activationErr = nil;
[[AVAudioSession sharedInstance]
    setCategory: AVAudioSessionCategoryPlayback
    error: &setCategoryErr];
[[AVAudioSession sharedInstance]
    setActive: YES
    error: &activationErr];

```

The `AVAudioSessionCategoryPlayback` category ensures that playback continues when the screen locks. Activating the audio session puts the specified category into effect.

How you handle the interruption caused by an incoming phone call or Clock or Calendar alarm depends on the audio technology you are using, as shown in Table 1-4.

Table 1-4 Handling audio interruptions

Audio technology	How interruptions work
AV Foundation framework	<p>The <code>AVAudioPlayer</code> and <code>AVAudioRecorder</code> classes provide delegate methods for interruption start and end. Implement these methods to update your user interface and optionally, after interruption ends, to resume paused playback. The system automatically pauses playback or recording upon interruption, and reactivates your audio session when you resume playback or recording.</p> <p>If you want to save and restore playback position between application launches, save playback position on interruption as well as on application quit.</p>
Audio Queue Services, I/O audio unit	<p>These technologies put your application in control of handling interruptions. You are responsible for saving playback or recording position and reactivating your audio session after interruption ends. Implement the <code>AVAudioSession</code> interruption delegate methods or write an interruption listener callback function.</p>
OpenAL	<p>When using OpenAL for playback, implement the <code>AVAudioSession</code> interruption delegate methods or write an interruption listener callback function—as when using Audio Queue Services. However, the delegate or callback must additionally manage the OpenAL context.</p>
System Sound Services	<p>Sounds played using System Sound Services go silent when an interruption starts. They can automatically be used again if the interruption ends. Applications cannot influence the interruption behavior for sounds that use this playback technology.</p>

Every iOS application—with rare exception—should actively manage its audio session. For a complete explanation of how to do this, read *Audio Session Programming Guide*. To ensure that your application conforms to Apple recommendations for audio session behavior, read “Sound” in *iOS Human Interface Guidelines* in *iOS Human Interface Guidelines*.

Playing Audio

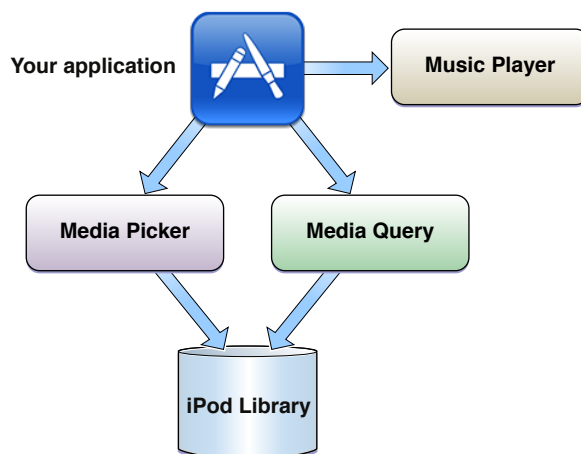
This section introduces you to playing sounds in iOS using iPod library access, System Sound Services, Audio Queue Services, the AV Foundation framework, and OpenAL.

Playing Audio Items with iPod Library Access

Starting in iOS 3.0, iPod library access lets your application play a user's songs, audio books, and audio podcasts. The API design makes basic playback very simple while also supporting advanced searching and playback control.

As shown in Figure 1-1, your application has two ways to retrieve media items. The media item picker, shown on the left, is an easy-to-use, pre-packaged view controller that behaves like the built-in iPod application's music selection interface. For many applications, this is sufficient. If the picker doesn't provide the specialized access control you want, the media query interface will. It supports predicate-based specification of items from the iPod library.

Figure 1-1 Using iPod library access



As depicted in the figure to the right of your application, you then play the retrieved media items using the music player provided by this API.

For a complete explanation of how to add media item playback to your application, see *iPod Library Access Programming Guide*. For a code example, see the *AddMusic* sample code project.

Playing UI Sound Effects or Invoking Vibration Using System Sound Services

To play user-interface sound effects (such as button clicks), or to invoke vibration on devices that support it, use System Sound Services. This compact interface is described in *System Sound Services Reference*. You can find sample code in the *Audio UI Sounds (SysSound)* sample in the [iOS Dev Center](#).

Note: Sounds played with System Sound Services are not subject to configuration using your audio session. As a result, you cannot keep the behavior of System Sound Services audio in line with other audio behavior in your application. This is the most important reason to avoid using System Sound Services for any audio apart from its intended uses.

The `AudioServicesPlaySystemSound` function lets you very simply play short sound files. The simplicity carries with it a few restrictions. Your sound files must be:

- No longer than 30 seconds in duration
- In linear PCM or IMA4 (IMA/ADPCM) format
- Packaged in a `.caf`, `.aif`, or `.wav` file

In addition, when you use the `AudioServicesPlaySystemSound` function:

- Sounds play at the current system audio volume, with no programmatic volume control available
- Sounds play immediately
- Looping and stereo positioning are unavailable
- Simultaneous playback is unavailable: You can play only one sound at a time

The similar `AudioServicesPlayAlertSound` function plays a short sound as an alert. If a user has configured their device to vibrate in Ring Settings, calling this function invokes vibration in addition to playing the sound file.

Note: System-supplied alert sounds and system-supplied user-interface sound effects are not available to your application. For example, using the `kSystemSoundID_UserPreferredAlert` constant as a parameter to the `AudioServicesPlayAlertSound` function will not play anything.

To play a sound with the `AudioServicesPlaySystemSound` or `AudioServicesPlayAlertSound` function, first create a sound ID object, as shown in Listing 1-1.

Listing 1-1 Creating a sound ID object

```
// Get the main bundle for the app
CFBundleRef mainBundle = CFBundleGetMainBundle ();

// Get the URL to the sound file to play. The file in this case
// is "tap.aif"
```

```
soundFileURLRef = CFBundleCopyResourceURL (
    mainBundle,
    CFSTR ("tap"),
    CFSTR ("aif"),
    NULL
);

// Create a system sound object representing the sound file
AudioServicesCreateSystemSoundID (
    soundFileURLRef,
    &soundFileObject
);
```

Then play the sound, as shown in Listing 1-2.

Listing 1-2 Playing a system sound

```
- (IBAction) playSystemSound {
    AudioServicesPlaySystemSound (self.soundFileObject);
}
```

In typical use, which includes playing a sound occasionally or repeatedly, retain the sound ID object until your application quits. If you know that you will use a sound only once—for example, in the case of a startup sound—you can destroy the sound ID object immediately after playing the sound, freeing memory.

Applications running on iOS devices that support vibration can trigger that feature using System Sound Services. You specify the vibrate option with the `kSystemSoundID_Vibrate` identifier. To trigger it, use the `AudioServicesPlaySystemSound` function, as shown in Listing 1-3.

Listing 1-3 Triggering vibration

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

- (void) vibratePhone {
    AudioServicesPlaySystemSound (kSystemSoundID_Vibrate);
}
```

If your application is running on an iPod touch, this code does nothing.

Playing Sounds Easily with the `AVAudioPlayer` Class

The `AVAudioPlayer` class provides a simple Objective-C interface for playing sounds. If your application does not require stereo positioning or precise synchronization, and if you are not playing audio captured from a network stream, Apple recommends that you use this class for playback.

Using an audio player you can:

- Play sounds of any duration
- Play sounds from files or memory buffers
- Loop sounds
- Play multiple sounds simultaneously (although not with precise synchronization)
- Control relative playback level for each sound you are playing
- Seek to a particular point in a sound file, which supports application features such as fast forward and rewind
- Obtain audio power data that you can use for audio level metering

The `AVAudioPlayer` class lets you play sound in any audio format available in iOS, as described in [Table 1-1](#) (page 7). For a complete description of this class's interface, see *AVAudioPlayer Class Reference*.

To configure an audio player:

1. Assign a sound file to the audio player.
2. Prepare the audio player for playback, which acquires the hardware resources it needs.
3. Designate an audio player delegate object, which handles interruptions as well as the playback-completed event.

The code in Listing 1-4 illustrates these steps. It would typically go into an initialization method of the controller class for your application. (In production code, you'd include appropriate error handling.)

Listing 1-4 Configuring an `AVAudioPlayer` object

```
// in the corresponding .h file:
// @property (nonatomic, retain) AVAudioPlayer *player;

// in the .m file:
@synthesize player; // the player object
```

```
NSString *soundFilePath =
    [[NSBundle mainBundle] pathForResource:@"sound"
                                         ofType:@"wav"];

NSURL *fileURL = [[NSURL alloc] initWithURLWithPath: soundFilePath];

AVAudioPlayer *newPlayer =
    [[AVAudioPlayer alloc] initWithContentsOfURL: fileURL
                                         error: nil];

[fileURL release];

self.player = newPlayer;
[newPlayer release];

[player prepareToPlay];
[player setDelegate: self];
```

The delegate (which can be your controller object) handles interruptions and updates the user interface when a sound has finished playing. The delegate methods for the `AVAudioPlayer` class are described in *AVAudioPlayerDelegate Protocol Reference*. Listing 1-5 shows a simple implementation of one delegate method. This code updates the title of a Play/Pause toggle button when a sound has finished playing.

Listing 1-5 Implementing an `AVAudioPlayer` delegate method

```
- (void) audioPlayerDidFinishPlaying: (AVAudioPlayer *) player
    successfully: (BOOL) completed {
    if (completed == YES) {
        [self.button setTitle: @"Play" forState: UIControlStateNormal];
    }
}
```

To play, pause, or stop an `AVAudioPlayer` object, call one of its playback control methods. You can test whether or not playback is in progress by using the `playing` property. Listing 1-6 shows a basic play/pause toggle method that controls playback and updates the title of a `UIButton` object.

Listing 1-6 Controlling an AVAudioPlayer object

```
- (IBAction) playOrPause: (id) sender {

    // if already playing, then pause
    if (self.player.playing) {
        [self.button setTitle: @"Play" forState: UIControlStateHighlighted];
        [self.button setTitle: @"Play" forState: UIControlStateNormal];
        [self.player pause];

    // if stopped or paused, start playing
    } else {
        [self.button setTitle: @"Pause" forState: UIControlStateHighlighted];
        [self.button setTitle: @"Pause" forState: UIControlStateNormal];
        [self.player play];
    }
}
```

The `AVAudioPlayer` class uses the Objective-C declared properties feature for managing information about a sound—such as the playback point within the sound’s timeline, and for accessing playback options—such as volume and looping. For example, you can set the playback volume for an audio player as shown here:

```
[self.player setVolume: 1.0];    // available range is 0.0 through 1.0
```

For more information on the `AVAudioPlayer` class, see *AVAudioPlayer Class Reference*.

Playing Sounds with Control Using Audio Queue Services

Audio Queue Services adds playback capabilities beyond those available with the `AVAudioPlayer` class. Using Audio Queue Services for playback lets you:

- Precisely schedule when a sound plays, allowing synchronization
- Precisely control volume on a buffer-by-buffer basis
- Play audio that you have captured from a stream using Audio File Stream Services

Audio Queue Services lets you play sound in any audio format available in iOS, as described in [Table 1-1](#) (page 7). You can also use this technology for recording, as explained in [“Recording Audio”](#) (page 21).

For detailed information on using this technology, see *Audio Queue Services Programming Guide* and *Audio Queue Services Reference*. For sample code, see the *SpeakHere* sample.

Creating an Audio Queue Object

To create an audio queue object for playback, perform these three steps:

1. Create a data structure to manage information needed by the audio queue, such as the audio format for the data you want to play.
2. Define a callback function for managing audio queue buffers. The callback uses Audio File Services to read the file you want to play. (In iOS 2.1 and later, you can also use Extended Audio File Services to read the file.)
3. Instantiate the playback audio queue using the `AudioQueueNewOutput` function.

Listing 1-7 illustrates these steps using ANSI C. (In production code, you'd include appropriate error handling.) The *SpeakHere* sample project shows these same steps in the context of a C++ program.

Listing 1-7 Creating an audio queue object

```
static const int kNumberBuffers = 3;
// Create a data structure to manage information needed by the audio queue
struct myAQStruct {
    AudioFileID                mAudioFile;
    CAStreamBasicDescription    mDataFormat;
    AudioQueueRef              mQueue;
    AudioQueueBufferRef         mBuffers[kNumberBuffers];
    SInt64                     mCurrentPacket;
    UInt32                     mNumPacketsToRead;
    AudioStreamPacketDescription *mPacketDescs;
    bool                       mDone;
};
// Define a playback audio queue callback function
static void AQTestBufferCallback(
    void                *inUserData,
    AudioQueueRef       inAQ,
    AudioQueueBufferRef inCompleteAQBuffer
) {
```

```
myAQStruct *myInfo = (myAQStruct *)inUserData;
if (myInfo->mDone) return;
UInt32 numBytes;
UInt32 nPackets = myInfo->mNumPacketsToRead;

AudioFileReadPackets (
    myInfo->mAudioFile,
    false,
    &numBytes,
    myInfo->mPacketDescs,
    myInfo->mCurrentPacket,
    &nPackets,
    inCompleteAQBuffer->mAudioData
);
if (nPackets > 0) {
    inCompleteAQBuffer->mAudioDataByteSize = numBytes;
    AudioQueueEnqueueBuffer (
        inAQ,
        inCompleteAQBuffer,
        (myInfo->mPacketDescs ? nPackets : 0),
        myInfo->mPacketDescs
    );
    myInfo->mCurrentPacket += nPackets;
} else {
    AudioQueueStop (
        myInfo->mQueue,
        false
    );
    myInfo->mDone = true;
}
}

// Instantiate an audio queue object
AudioQueueNewOutput (
    &myInfo.mDataFormat,
    AQTestBufferCallback,
```

```
    &myInfo,  
    CFRunLoopGetCurrent(),  
    kCFRunLoopCommonModes,  
    0,  
    &myInfo.mQueue  
);
```

Controlling the Playback Level

Audio queue objects give you two ways to control playback level.

To set playback level directly, use the `AudioQueueSetParameter` function with the `kAudioQueueParam_Volume` parameter, as shown in Listing 1-8. Level change takes effect immediately.

Listing 1-8 Setting the playback level directly

```
Float32 volume = 1;    // linear scale, range from 0.0 through 1.0  
AudioQueueSetParameter (  
    myAQstruct.audioQueueObject,  
    kAudioQueueParam_Volume,  
    volume  
);
```

You can also set playback level for an audio queue buffer by using the `AudioQueueEnqueueBufferWithParameters` function. This lets you assign audio queue settings that are, in effect, carried by an audio queue buffer as you enqueue it. Such changes take effect when the buffer begins playing.

In both cases, level changes for an audio queue remain in effect until you change them again.

Indicating Playback Level

You can obtain the current playback level from an audio queue object by:

1. Enabling metering for the audio queue object by setting its `kAudioQueueProperty_EnableLevelMetering` property to `true`
2. Querying the audio queue object's `kAudioQueueProperty_CurrentLevelMeter` property

The value of this property is an array of `AudioQueueLevelMeterState` structures, one per channel. Listing 1-9 shows this structure:

Listing 1-9 The `AudioQueueLevelMeterState` structure

```
typedef struct AudioQueueLevelMeterState {  
    Float32    mAveragePower;  
    Float32    mPeakPower;  
}; AudioQueueLevelMeterState;
```

Playing Multiple Sounds Simultaneously

To play multiple sounds simultaneously, create one playback audio queue object for each sound. For each audio queue, schedule the first buffer of audio to start at the same time using the `AudioQueueEnqueueBufferWithParameters` function.

Starting in iOS 3.0, nearly all supported audio formats can be used for simultaneous playback—namely, all those that can be played using software decoding, as described in [Table 1-1](#) (page 7). For the most processor-efficient multiple playback, use linear PCM (uncompressed) or IMA4 (compressed) audio.

Playing Sounds with Positioning Using OpenAL

The open-sourced OpenAL audio API, available in iOS in the OpenAL framework, provides an interface optimized for positioning sounds in a stereo field during playback. Playing, positioning, and moving sounds works just as it does on other platforms. OpenAL also lets you mix sounds. OpenAL uses the I/O unit for playback, resulting in the lowest latency.

For all of these reasons, OpenAL is your best choice for playing sounds in game applications on iOS-based devices. However, OpenAL is also a good choice for general iOS application audio playback needs.

OpenAL 1.1 support in iOS is built on top of Core Audio. For more information, see *OpenAL FAQ for iPhone OS*. For sample code, see *oalTouch*.

Recording Audio

iOS supports audio recording using the `AVAudioRecorder` class and Audio Queue Services. These interfaces do the work of connecting to the audio hardware, managing memory, and employing codecs as needed. You can record audio in any of the formats listed in [Table 1-2](#) (page 8).

Recording takes place at a system-defined input level in iOS. The system takes input from the audio source that the user has chosen—the built-in microphone or, if connected, the headset microphone or other input source.

Recording with the AVAudioRecorder Class

The easiest way to record sound in iOS is with the `AVAudioRecorder` class, described in *AVAudioRecorder Class Reference*. This class provides a highly-streamlined, Objective-C interface that makes it easy to provide sophisticated features like pausing/resuming recording and handling audio interruptions. At the same time, you retain complete control over recording format.

To prepare for recording using an audio recorder:

1. Specify a sound file URL.
2. Set up the audio session.
3. Configure the audio recorder's initial state.

Application launch is a good time to do this part of the setup, as shown in Listing 1-10. Variables such as `soundFileURL` and `recording` in this example are declared in the class interface. (In production code, you would include appropriate error handling.)

Listing 1-10 Setting up the audio session and the sound file URL

```
- (void) viewDidLoad {

    [super viewDidLoad];

    NSString *tempDir = NSTemporaryDirectory ();
    NSString *soundFilePath =
        [tempDir stringByAppendingString: @"sound.caf"];

    NSURL *newURL = [[NSURL alloc] initWithFileURLWithPath: soundFilePath];
    self.soundFileURL = newURL;
    [newURL release];

    AVAudioSession *audioSession = [AVAudioSession sharedInstance];
    audioSession.delegate = self;
    [audioSession setActive: YES error: nil];
}
```

```
    recording = NO;
    playing = NO;
}
```

To handle interruptions and the completion of recording, add the `AVAudioSessionDelegate` and `AVAudioRecorderDelegate` protocol names to the interface declaration for your implementation. If your application also does playback, also adopt the `AVAudioPlayerDelegate` Protocol Reference protocol.

To implement a record method, you can use code such as that shown in Listing 1-11. (In production code, you would include appropriate error handling.)

Listing 1-11 A record/stop method using the `AVAudioRecorder` class

```
- (IBAction) recordOrStop: (id) sender {

    if (recording) {

        [soundRecorder stop];
        recording = NO;
        self.soundRecorder = nil;

        [recordOrStopButton setTitle: @"Record" forState:
                                         UIControlStateNormal];
        [recordOrStopButton setTitle: @"Record" forState:
                                         UIControlStateHighlighted];
        [[AVAudioSession sharedInstance] setActive: NO error: nil];

    } else {

        [[AVAudioSession sharedInstance]
         setCategory: AVAudioSessionCategoryRecord
         error: nil];

        NSDictionary *recordSettings =
            [[NSDictionary alloc] initWithObjectsAndKeys:
```

```
        [NSNumber numberWithInt: 44100.0], AVSampleRateKey,
        [NSNumber numberWithInt: kAudioFormatAppleLossless], AVFormatIDKey,
        [NSNumber numberWithInt: 1], AVNumberOfChannelsKey,
        [NSNumber numberWithInt: AVAudioQualityMax],
            AVEncoderAudioQualityKey,
        nil];

    AVAudioRecorder *newRecorder =
        [[AVAudioRecorder alloc] initWithURL: soundFileURL
            settings: recordSettings
            error: nil];

    [recordSettings release];
    self.soundRecorder = newRecorder;
    [newRecorder release];

    soundRecorder.delegate = self;
    [soundRecorder prepareToRecord];
    [soundRecorder record];
    [recordOrStopButton setTitle: @"Stop" forState: UIControlStateNormal];
    [recordOrStopButton setTitle: @"Stop" forState: UIControlStateHighlighted];

    recording = YES;
}
}
```

For more information on the `AVAudioRecorder` class, see *AVAudioRecorder Class Reference*.

Recording with Audio Queue Services

To set up for recording with audio with Audio Queue Services, your application instantiates a recording audio queue object and provides a callback function. The callback stores incoming audio data in memory for immediate use or writes it to a file for long-term storage.

Just as with playback, you can obtain the current recording audio level from an audio queue object by querying its `kAudioQueueProperty_CurrentLevelMeter` property, as described in [“Indicating Playback Level”](#) (page 20).

For detailed examples of how to use Audio Queue Services to record audio, see “Recording Audio” in *Audio Queue Services Programming Guide*. For sample code, see the *SpeakHere* sample.

Parsing Streamed Audio

To play streamed audio content, such as from a network connection, use Audio File Stream Services in concert with Audio Queue Services. Audio File Stream Services parses audio packets and metadata from common audio file container formats in a network bitstream. You can also use it to parse packets and metadata from on-disk files.

In iOS, you can parse the same audio file and bitstream formats that you can in Mac OS X, as follows:

- MPEG-1 Audio Layer 3, used for .mp3 files
- MPEG-2 ADTS, used for the .aac audio data format
- AIFC
- AIFF
- CAF
- MPEG-4, used for .m4a, .mp4, and .3gp files
- NeXT
- WAVE

Having retrieved audio packets, you can play back the recovered sound in any of the formats supported in iOS, as listed in [Table 1-1](#) (page 7).

For best performance, network streaming applications should use data from Wi-Fi connections. iOS lets you determine which networks are reachable and available through its System Configuration framework and its `SCNetworkReachabilityRef` opaque type, described in *SCNetworkReachability Reference*. For sample code, see the *Reachability* sample in the [iOS Dev Center](#).

To connect to a network stream, use interfaces from Core Foundation, such as the one described in *CFHTTPMessage Reference*. Parse the network packets to recover audio packets using Audio File Stream Services. Then buffer the audio packets and send them to a playback audio queue object.

Audio File Stream Services relies on interfaces from Audio File Services, such as the `AudioFramePacketTranslation` structure and the `AudioFilePacketTableInfo` structure. These are described in *Audio File Services Reference*.

For more information on using streams, refer to *Audio File Stream Services Reference*.

Audio Unit Support in iOS

iOS provides a set of audio processing plug-ins, known as *audio units*, that you can use in any application. The interfaces in the Audio Unit framework let you open, connect, and use these audio units.

To use the features of the Audio Unit framework, add the *Audio Toolbox* framework to your Xcode project and link against it in any relevant targets. Then add a `#import <AudioToolbox/AudioToolbox.h>` statement near the top of relevant source files. For detailed information on how to add frameworks to your project, see “Files in Projects” in *Xcode Project Management Guide*.

Table 1-5 lists the audio units provided in iOS.

Table 1-5 System-supplied audio units

Audio unit	Description
iPod Equalizer unit	The iPod EQ unit, of type <code>kAudioUnitSubType_AUiPodEQ</code> , provides a simple, preset-based equalizer you can use in your application. For a demonstration of how to use this audio unit, see the sample code project <i>Mixer iPodEQ AUGraph Test</i> .
3D Mixer unit	The 3D Mixer unit, of type <code>kAudioUnitSubType_AU3DMixerEmbedded</code> , lets you mix multiple audio streams, specify stereo output panning, manipulate playback rate, and more. OpenAL is built on top of this audio unit and provides a higher-level API well suited for game apps.
Multichannel Mixer unit	The Multichannel Mixer unit, of type <code>kAudioUnitSubType_MultiChannelMixer</code> , lets you mix multiple mono or stereo audio streams to a single stereo stream. It also supports left/right panning for each input. For a demonstration of how to use this audio unit, see the sample code project <i>Audio Mixer (MixerHost)</i> .
Remote I/O unit	The Remote I/O unit, of type <code>kAudioUnitSubType_RemoteIO</code> , connects to audio input and output hardware and supports realtime I/O. For demonstrations of how to use this audio unit, see the sample code project <i>aurioTouch</i> .
Voice Processing I/O unit	The Voice Processing I/O unit, of type <code>kAudioUnitSubType_VoiceProcessingIO</code> , has the characteristics of the I/O unit and adds echo suppression and other features for two-way communication.
Generic Output unit	The Generic Output unit, of type <code>kAudioUnitSubType_GenericOutput</code> , supports converting to and from linear PCM format; can be used to start and stop a graph.

Audio unit	Description
Converter unit	The Converter unit, of type <code>kAudioUnitSubType_AUConverter</code> , lets you convert audio data from one format to another. You typically obtain the features of this audio unit by using the Remote I/O unit, which incorporates a Converter unit.

For more information on using system audio units, see *Audio Unit Hosting Guide for iOS*. For reference documentation, see *Audio Unit Framework Reference* and *Audio Unit Processing Graph Services Reference*. The iOS Dev Center provides two sample-code projects that demonstrate use of system audio units: *aurioTouch* and *iPhoneMultichannelMixerTest*.

Best Practices for iOS Audio

This section lists some important tips for using audio in iOS and describes the best audio data formats for various uses.

Tips for Using Audio

Table 1-6 lists some important tips to keep in mind when using audio in iOS.

Table 1-6 Audio tips

Tip	Action
Use compressed audio appropriately	For AAC, MP3, and ALAC (Apple Lossless) audio, decoding can take place using hardware-assisted codecs. While efficient, this is limited to one audio stream at a time. If you need to play multiple sounds simultaneously, store those sounds using the IMA4 (compressed) or linear PCM (uncompressed) format.
Convert to the data format and file format you need	The <code>afconvert</code> tool in Mac OS X lets you convert to a wide range of audio data formats and file types. See “Preferred Audio Formats in iOS” (page 28) and the <code>afconvert</code> man page.
Evaluate audio memory issues	When playing sound with Audio Queue Services, you write a callback that sends short segments of audio data to audio queue buffers. In some cases, loading an entire sound file to memory for playback, which minimizes disk access, is best. In other cases, loading just enough data at a time to keep the buffers full is best. Test and evaluate which strategy works best for your application.

Tip	Action
Reduce audio file sizes by limiting sample rates, bit depths, and channels	<p>Sample rate and the number of bits per sample have a direct impact on the size of your audio files. If you need to play many such sounds, or long-duration sounds, consider reducing these values to reduce the memory footprint of the audio data. For example, rather than use 44.1 kHz sampling rate for sound effects, you could use a 32 kHz (or possibly lower) sample rate and still provide reasonable quality.</p> <p>Using monophonic (single-channel) audio instead of stereo (two channel) reduces file size. For each sound asset, consider whether mono could suit your needs.</p>
Pick the appropriate technology	<p>Use OpenAL when you want a convenient, high-level interface for positioning sounds in a stereo field or when you need low latency playback. To parse audio packets from a file or a network stream, use Audio File Stream Services. For simple playback of single or multiple sounds, use the <code>AVAudioPlayer</code> class. For recording to a file, use the <code>AVAudioRecorder</code> class. For audio chat, use the Voice Processing I/O unit. To play audio resources synced from a user's iTunes library, use iPod Library Access. When your sole audio need is to play alerts and user-interface sound effects, use Core Audio's System Sound Services. For other audio applications, including playback of streamed audio, precise synchronization, and access to packets of incoming audio, use Audio Queue Services.</p>
Code for low latency	<p>For the lowest possible playback latency, use OpenAL or use the I/O unit directly.</p>

Preferred Audio Formats in iOS

For uncompressed (highest quality) audio, use 16-bit, little endian, linear PCM audio data packaged in a CAF file. You can convert an audio file to this format in Mac OS X using the `afconvert` command-line tool, as shown here:

```
/usr/bin/afconvert -f caff -d LEI16 {INPUT} {OUTPUT}
```

The `afconvert` tool lets you convert to a wide range of audio data formats and file types. See the `afconvert` man page, and enter `afconvert -h` at a shell prompt, for more information.

For compressed audio when playing one sound at a time, and when you don't need to play audio simultaneously with the iPod application, use the AAC format packaged in a CAF or m4a file.

For less memory usage when you need to play multiple sounds simultaneously, use IMA4 (IMA/ADPCM) compression. This reduces file size but entails minimal CPU impact during decompression. As with linear PCM data, package IMA4 data in a CAF file.

Using Video

Important: This document contains information that used to be in *iOS App Programming Guide*. The information in this document has not been updated specifically for iOS 4.0.

Recording and Editing Video

Starting in iOS 3.0, you can record video, with included audio, on supported devices. To display the video recording interface, create and push a `UIImagePickerController` object, just as for displaying the still-camera interface.

To record video, you must first check that the camera source type (`UIImagePickerControllerSourceTypeCamera`) is available and that the movie media type (`kUTTypeMovie`) is available for the camera. Depending on the media types you assign to the `mediaTypes` property, the picker can directly display the still camera or the video camera, or a selection interface that lets the user choose.

Using the `UIImagePickerControllerDelegate` protocol, register as a delegate of the image picker. Your delegate object receives a completed video recording by way of the `imagePickerController:didFinishPickingMediaWithInfo:` method.

On supported devices, you can also pick previously-recorded videos from a user's photo library.

For more information on using the image picker class, see *UIImagePickerController Class Reference*. For information on trimming recorded videos, see *UIVideoEditorController Class Reference* and *UIVideoEditorControllerDelegate Protocol Reference*.

In iOS 4.0 and later, you can record from a device's camera and display the incoming data live on screen. You use `AVCaptureSession` to manage data flow from inputs represented by `AVCaptureInput` objects (which mediate input from an `AVCaptureDevice`) to outputs represented by `AVCaptureOutput`.

In iOS 4.0 and later, you can edit, assemble, and compose video using existing assets or with new raw materials. Assets are represented by `AVAsset`, which you can inspect asynchronously for better performance. You use `AVMutableComposition` to compose media from one or more sources, then `AVAssetExportSession` to encode output of a composition for delivery.

Playing Video Files

Important: The information in this section currently reflects the usage of the Media Player framework in iOS 3.1 and earlier. Please see the headers for information about changes to this framework in iOS 4.0.

iOS supports the ability to play back video files directly from your application using the Media Player framework, described in *Media Player Framework Reference*. Video playback is supported in full screen mode only and can be used by game developers who want to play short animations or by any developers who want to play media files. When you start a video from your application, the media player interface takes over, fading the screen to black and then fading in the video content. You can play a video with or without user controls for adjusting playback. Enabling some or all of these controls (shown in Figure 2-1) gives the user the ability to change the volume, change the playback point, or start and stop the video. If you disable all of these controls, the video plays until completion.

Figure 2-1 Media player interface with transport controls



To initiate video playback, you must know the URL of the file you want to play. For files your application provides, this would typically be a pointer to a file in your application's bundle; however, it can also be a pointer to a file on a remote server. Use this URL to instantiate a new instance of the `MPMoviePlayerController` class. This class presides over the playback of your video file and manages user interactions, such as user taps in the transport controls (if shown). To start playback, call the `play` method described in *MPMediaPlayback Protocol Reference*.

Listing 2-1 shows a sample method that plays back the video at a specified URL. The `play` method is an asynchronous call that returns control to the caller while the movie plays. The movie controller loads the movie in a full-screen view, and animates the movie into place on top of the application's existing content. When playback is finished, the movie controller sends a notification received by the application controller object, which releases the movie controller now that it is no longer needed.

Listing 2-1 Playing full-screen movies

```
-(void) playMovieAtURL: (NSURL*) theURL {
```

```
MPMoviePlayerController* theMovie =
    [[MPMoviePlayerController alloc] initWithContentURL: theURL];

theMovie.scalingMode = MPMovieScalingModeAspectFill;
theMovie.movieControlMode = MPMovieControlModeHidden;

// Register for the playback finished notification
[[NSNotificationCenter defaultCenter]
    addObserver: self
    selector: @selector(myMovieFinishedCallback:)
    name: MPMoviePlayerPlaybackDidFinishNotification
    object: theMovie];

// Movie playback is asynchronous, so this method returns immediately.
[theMovie play];
}

// When the movie is done, release the controller.
-(void) myMovieFinishedCallback: (NSNotification*) aNotification
{
    MPMoviePlayerController* theMovie = [aNotification object];

    [[NSNotificationCenter defaultCenter]
        removeObserver: self
        name: MPMoviePlayerPlaybackDidFinishNotification
        object: theMovie];

    // Release the movie instance created in playMovieAtURL:
    [theMovie release];
}
```

For a list of supported video formats, see *iOS Technology Overview*.

In iOS 4.0 and later, you can play video using `AVPlayer` in conjunction with an `AVPlayerLayer` or an `AVSynchronizedLayer` object. You can use `AVAudioMix` and `AVVideoComposition` to customize the audio and video parts of playback respectively. You can also use `AVCaptureVideoPreviewLayer` to display video as it is being captured by an input device.

Document Revision History

This table describes the changes to *Multimedia Programming Guide*.

Date	Notes
2014-02-11	Removed link to openAL.org website.
2010-09-01	Clarified usage of <code>AudioServicesPlaySystemSound</code> function in “ Playing UI Sound Effects or Invoking Vibration Using System Sound Services ” (page 12).
2010-05-27	Updated Table 1-2 (page 8) for iOS 4.0 by clarifying support for AAC encoding.



Apple Inc.
Copyright © 2014 Apple Inc.
All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, mechanical, electronic, photocopying, recording, or otherwise, without prior written permission of Apple Inc., with the following exceptions: Any person is hereby authorized to store documentation on a single computer for personal use only and to print copies of documentation for personal use provided that the documentation contains Apple's copyright notice.

No licenses, express or implied, are granted with respect to any of the technology described in this document. Apple retains all intellectual property rights associated with the technology described in this document. This document is intended to assist application developers to develop applications only for Apple-labeled computers.

Apple Inc.
1 Infinite Loop
Cupertino, CA 95014
408-996-1010

Apple, the Apple logo, iPad, iPhone, iPod, iPod touch, iTunes, Mac, Mac OS, Objective-C, OS X, and Xcode are trademarks of Apple Inc., registered in the U.S. and other countries.

NeXT is a trademark of NeXT Software, Inc., registered in the U.S. and other countries.

iOS is a trademark or registered trademark of Cisco in the U.S. and other countries and is used under license.

Even though Apple has reviewed this document, APPLE MAKES NO WARRANTY OR REPRESENTATION, EITHER EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT, ITS QUALITY, ACCURACY, MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE. AS A RESULT, THIS DOCUMENT IS PROVIDED "AS IS," AND YOU, THE READER, ARE ASSUMING THE ENTIRE RISK AS TO ITS QUALITY AND ACCURACY.

IN NO EVENT WILL APPLE BE LIABLE FOR DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECT OR INACCURACY IN THIS DOCUMENT, even if advised of the possibility of such damages.

THE WARRANTY AND REMEDIES SET FORTH ABOVE ARE EXCLUSIVE AND IN LIEU OF ALL OTHERS, ORAL OR WRITTEN, EXPRESS OR IMPLIED. No Apple dealer, agent, or employee is authorized to make any modification, extension, or addition to this warranty.

Some states do not allow the exclusion or limitation of implied warranties or liability for incidental or consequential damages, so the above limitation or exclusion may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.