Distributing Tone Sequences

The tone sequences that you create using the special MMAPI tone sequence format can be distributed using the same file format in a binary mode. This means that the sequence of a tone is dumped into a binary file with the extension of `jts` (Java Tone Sequence). This file can then be downloaded or loaded into any MMAPI-compliant device, and the device will be able to play the tone. To help with the recognition of these files by Web servers and Web browsers, the JTS files have the MIME type of audio/x-tone-seq associated with them.

Creating JTS Files

To create these binary files, you'll need to dump your tone sequence into a file. However, you can't do this within the MIDlet environment because there is no provision to write to a file easily.

The `RingToneConverter` comes to the rescue again by providing a method called `dumpSequence()`, which provides the hexadecimal representation of the tone sequence for you to take and create a binary file out of. To get this representation, simply use `rtc.dumpSequence()` to print the sequence on the standard out. The hex dump sequence for the "Happy Birthday to You" tone is shown here:

```
FE 01 FD 1F 48 04 FF 02
48 02 FF 02 4A 08 FF 02
48 08 FF 02 4D 08 FF 02
4C 10 FF 04 48 04 FF 02
48 02 FF 02 4A 08 FF 02
48 08 FF 02 4F 08 FF 02
4D 10 FF 08 48 04 FF 02
48 02 FF 02 54 08 FF 02
51 08 FF 02 4D 08 FF 02
4C 08 FF 02 4A 08 FF 02
52 04 FF 02 52 02 FF 02
51 08 FF 02 4D 08 FF 02
4F 08 FF 02 4D 10
```

Now, to convert this hexadecimal representation into a binary file, you need to create a Java class that will read this representation from a file, convert it back into a byte array, and write the byte array out to a binary file with the extension of `jts`. Listing 6-6 shows such a class called `CreateJTSFileFromHexString`. Store the hexadecimal representation just shown in a file called `happybday_hex.txt` and compile and run `CreateJTSFileFromHexString` with this file as a parameter.

Listing 6-6. *A Class to Create a Binary JTS File from a Hex Representation*

```
package com.apress.chapter6;

import java.io.*;

public class CreateJTSFileFromHexString {

  public static void main(String[] args) {
```


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```
if(args[0] == null) System.err.println("Usage: java <filename>");

// initialize streams that we will need
FileReader fr = null;
BufferedReader br = null;
ByteArrayOutputStream bos = null;
FileOutputStream fos = null;

try {
  // the argument must be the file containing tone format in hex string
  File hexStringFile = new File(args[0]);

  // create text-based readers on it
  fr = new FileReader(hexStringFile);
  br = new BufferedReader(fr);

  String lineRead;
  String hexString = "";

  // read the file, a line at a time into the hexString variable
  while((lineRead = br.readLine()) != null) {
     hexString += lineRead;
  }

  // remove the spaces within this hexString
  StringBuffer buf = new StringBuffer();
  for(int i = 0; i < hexString.length(); i++) {
    if(!Character.isWhitespace(hexString.charAt(i)))
      buf.append(hexString.charAt(i));
  }

  // the final hexString with spaces removed
  hexString = buf.toString();

  // now write the hexString out to a file as a byte array making it a
  // binary file
  byte[] txtInByte = new byte[hexString.length()/2];
  int j = 0;
  for (int i = 0; i < hexString.length(); i += 2)
  {
    txtInByte[j++] =
      (byte)Integer.parseInt(hexString.substring(i, i + 2), 16);
  }

  // the byte array created, write it to a ByteArrayOutputStream
```

```
      bos = new ByteArrayOutputStream();
      bos.write(txtInByte, 0, txtInByte.length);

      // and create a physical file with the extension jts containing this data
      fos = new FileOutputStream(
        new File(args[0].substring(0, args[0].indexOf(".")) + ".jts"));
      bos.writeTo(fos);

    } catch (Exception e) {
      System.err.println(e);
    } finally {
      try {
        if(fos != null) fos.close();
        if(bos != null) bos.close();
        if(br != null) br.close();
        if(fr != null) fr.close();
      } catch(Exception e) {
        System.err.println(e);
      }
    }
  }

}
```

Remember that this is a normal Java file and not a Java ME class. So this will need to be run in its own Java SE environment, as was the case with Listing 6-2, `NoteCalculator`.

The output will be a file named `happybday_hex.jts`. This is a binary file that cannot be viewed in a text editor. However, this file contains the tone sequence for "Happy Birthday to You" in the MMAPI format and can now be distributed and played.

Playing Tone Sequences Stored in Files

Because MMAPI recognizes the `jts` extension files, you can now create `Player` instances that can load these files using locator strings. So now it's possible to create a `Player` instance that loads a tone sequence as a `jts` extension file from a Web site, using the `createPlayer(String locator)` method. First, let's load a JTS file stored in a JAR file. Listing 6-7 shows the code for the `DistributedToneMIDlet` that will load and play the `happybday_hex.jts` file, created in the previous section, from its JAR file.

Listing 6-7. *Loading and Playing JTS File from JAR File*

```
package com.apress.chapter6;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import javax.microedition.media.control.*;

public class DistributedToneMIDlet extends MIDlet {
```

```
  private Player tonePlayer;

  public DistributedToneMIDlet() {
    try {
      tonePlayer = Manager.createPlayer(getClass().getResourceAsStream(
          "/media/misc/happybday_hex.jts"), "audio/x-tone-seq");
    } catch(Exception e) {
      System.err.println(e);
    }
  }

  public void startApp() {
    try {
      if(tonePlayer != null)
        tonePlayer.start();
    } catch(Exception e) {
      System.err.println(e);
    }
  }

  public void pauseApp() {
  }

  public void destroyApp(boolean unconditional) {
  }
}
```

As you can see, this code is not very special. In fact, it's almost identical to the code in Listing 3-1 in Chapter 3, where you learned to play a simple wav file, with changes made for the different content types. Notice that you didn't even need to get the `ToneControl` and set the sequence on it. By creating a tone-playing instance like this, most of the other things that you learned about earlier are abstracted nicely.

To play the same sequence on a Web site, all you need to do is replace it with the corresponding `createPlayer(String locator)` method that takes the location of the Web site as a parameter. An example is shown here:

```
tonePlayer = Manager.createPlayer(
  "http://www.mmapibook.com/resources/media/tones/chapter6/happybday_hex.jts");
```

The extension of the file will let MMAPI's `Manager` class know that it needs to create a `TonePlayer` and set its sequence to the sequence specified in the JTS file. If there are any errors in the JTS file, you will get an error similar to "bad jts file. Error no <no>." Most of these errors occur if the JTS file hasn't been created correctly, so if you've followed the steps so far, these errors will not occur.

Summary

MMAPI identifies the fact that even the simplest of devices offer the developer and the user some capability of tone generation. MMAPI provides the ability to generate simple tones in its most simple form using the `Manager` class. Of course, if the device supports the full set of the MMAPI implementation, it provides an even richer set of tone-generation, modification, and playback capabilities.

This chapter showed you how to take advantage of this capability in MMAPI. You also learned how to play simple, single tones and to create and distribute more complex tones and tone sequences. You also learned a simple lesson in music theory, which was essential to understanding some of the concepts behind tone generation.

The next chapter covers the basics of MIDI and how MMAPI is capable of handling it.

CHAPTER 7

Managing MIDI Using MIDIControl, TempoControl, and PitchControl

Contrary to popular belief, Musical Instrument Digital Interface (MIDI) is not a representation of music. Rather, it's a communication protocol, designed to transmit information about music digitally across disparate musical systems. Instead of describing audio data directly, MIDI represents it by using events that take place when a sound from an electronic synthesizer is made. This event information is what constitutes a MIDI data/file.

In this chapter, you'll learn about the support MMAPI provides for playing and controlling MIDI. You'll also learn about the different MIDI specifications that are supported and how the different aspects of the specification map to the actual implementation. Extensive examples with `MIDIControl` allow you to use `MIDIControl` effectively. You'll also learn how to play and manipulate MIDI files, without using `MIDIControl`, by using just `TempoControl` and `PitchControl`. You'll understand soundbanks, programs, and other MIDI-related terminology and how to use them.

But first, you need to get a working understanding of MIDI.

Understanding MIDI

Even though you may not realize it, these days MIDI is all around you. Seen a movie at a cinema? The orchestra in the movie was most probably synthesized in MIDI using an electronic keyboard. Been to a concert or a nightclub? The themed lights are in all probability controlled using MIDI messages, synchronized with the music. Love a series on TV? The title music is done using a MIDI synthesizer. How about your cell phone? Your polyphonic ring tone is generated using MIDI!

With such widespread use, it's no wonder that there is a strong industry momentum behind this technology. An audio engineer named Dave Smith proposed the original MIDI standard, and the first specification was published in 1982. Although there have been several updates on this original specification, the current specification is still called MIDI 1.0 with a smaller version number of 96.1 Second Edition (released in November 2001).

Polyphonic ring tones that you have on your mobile phone are based on a variation of the original MIDI specification, called Scalable Polyphony MIDI (SP-MIDI). This specification allows a varying number of notes to define the same MIDI data and, therefore, caters to both high-end and low-end phones with varying polyphonic capabilities.

The official and definitive Web site for keeping up to date with the various facets of the MIDI specification is *http://www.midi.org*. Although it doesn't contain a free copy of the MIDI specification, it still contains a wealth of information. The MIDI specification is available for purchase as a book, although it's available on the Internet in snippets. You can also find useful MIDI-related information at *http://en.wikipedia.org/wiki/MIDI*.

Understanding the MIDI Specification

The MIDI specification has two parts. One deals with the physical hardware interface standard for transmitting MIDI; the other is a software protocol dealing with the communication, transmission, and format of MIDI messages. The physical specification is elaborate and specifies the serial transfer rate of messages (31.25 Kbaud), besides defining characteristics of ports and connector cables for MIDI IN, MIDI OUT, and MIDI THRU. The physical side of the MIDI specification doesn't help much with applying it to MMAPI, so it isn't covered further in this book.

The software specification specifies the MIDI message format, which is used for transmission of messages. Considering that the MIDI specification is a communication protocol, it helps to think of a transmitter and a receiver. A transmitter can be any instrument that is capable of producing synthesized music, such as a computer system or an electronic synthesizer. A receiver can also be another computer system and/or an electronic synthesizer, as long as it contains a MIDI IN port. A transmitter, as expected, should contain a MIDI OUT port. This simple configuration is depicted in Figure 7-1.

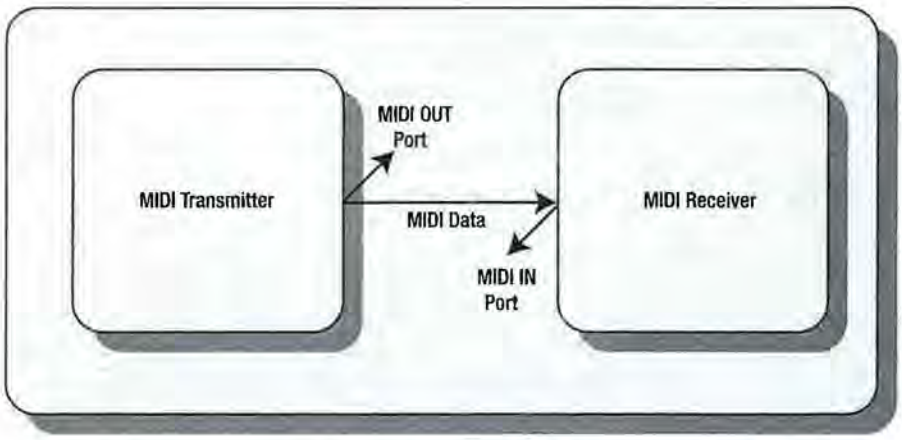

Figure 7-1. *MIDI communication*

As expected, a MIDI transmitter can act as a receiver and vice versa.

The MIDI data in Figure 7-1 is organized into messages. Each message can be thought of as a multi-byte packet that contains information about a particular channel. Think of a channel in MIDI as an exclusive transmission network for the transfer of note information for a particular musical instrument. Transmitters and receivers are primed to send and receive information about 16 possible channels. If any of the channel information is missing, for example, if there is no information about drums being played, then both parties ignore that channel.

The MIDI message format allows the depiction of all notes that can be played by a musical instrument. The MIDI specification assigns notes to particular messages, and any electronic instrument that follows this specification can interpret these messages.

MIDI Message Format

When a musician plays a note on, let's say, a musical keyboard, three events take place:

- Musician presses the key to play the note with a particular volume.
- Musician keeps pressing the key, increasing or decreasing the force with which the note is being played.
- Musician stops playing the note by taking his finger off the particular key.

All three events are transmitted via the MIDI OUT port serially, through a series of three messages, one for each event. Each of these messages is a MIDI message and consists of a multi-byte packet. The first byte in each message is a Status byte, and is followed by 0, 1, or 2 Data bytes. Status bytes have their most significant bit set to 1, and Data bytes have their most significant bit set to 0. This is the standard MIDI message format (see Figure 7-2).

Figure 7-2. *Standard MIDI message format*

These MIDI messages are then divided into two types, depending on whether they are carrying information for a particular channel or whether they are system-wide messages that are intended for all devices that may be interconnected in a MIDI network. These two types of messages are called Channel messages and System messages. These types are further subclassified, with the Channel messages divided into either the Voice or Mode Channel message type, and the System messages divided into Common, Real-Time, or Exclusive System message type. Figure 7-3 shows these classifications.

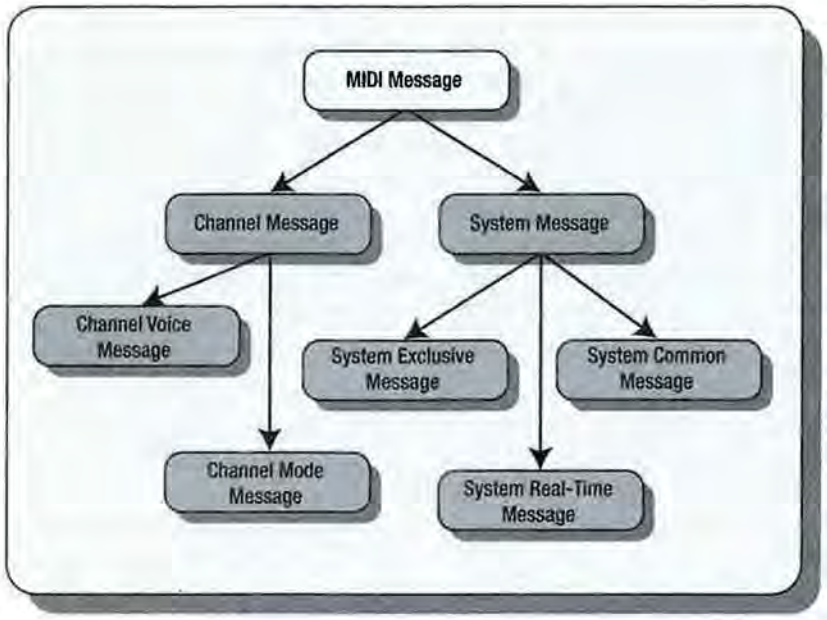

Figure 7-3. *MIDI message classifications*

System messages are differentiated from Channel messages by the presence of 1 in the first 4 bits of the Status byte. That is, if the Status byte is of the format 1111 XXXX, then the message is a System message; otherwise, it is a Channel message, in which case, the last 4 bits in the Status byte identify one of 16 channels that the message is intended for. For example, 1000 1111 as Status byte in a message indicates that it is intended for Channel 16, 1000 0000 indicates the message is for Channel 1, 1000 0001 is a message for Channel 2, and so on.

Further, a Channel message is classified as a Voice or a Mode Channel message by a specific set of bits in the first 4 bits of the Status byte. If the Status byte is of the format 1011 XXXX and has a special character in the Data byte that follows it, it is a Mode Channel message; otherwise, it is a Voice Channel message. A Voice Channel message controls a particular channel by starting or stopping the playing of a note, among other things. The Data bytes following this Status byte contain information about the note. The Mode Channel message is a response to the Voice Channel message.

Table 7-1 shows how to spot the different messages discussed so far.

Table 7-1. *Differentiating Between Different MIDI Messages*

First 4 Bits of Status Byte	Last 4 Bits of Status Byte	Message Type	Comment
1111	XXXX	System	
1011	XXXX	Mode Channel message	Only if the Data bytes following this Status byte contain a value between 121 and 127

First 4 Bits of Status Byte	Last 4 Bits of Status Byte	Message Type	Comment
1000			
1001			
1010			
1011			
1100			
1101			
1110	XXXX	Voice Channel message	Only if the Data bytes following this Status byte contain a value between 0 and 120

Continuing on to the three different System message types, their formats are shown in Table 7-2 along with a brief description.

Table 7-2. *The Three Different Types of System Messages in MIDI*

Message Type	Format	Comment
System Real Time	1111 1XXX	XXX is a value between 0 and 7 (000 = 0, 111 = 7). These messages are used to synchronize the whole MIDI system in real time and do not contain any Data bytes.
System Common	1111 0XXX	XXX is a value between 1 and 7. These messages may contain 0 to 2 Data bytes and are intended for an interconnected MIDI network.
System Exclusive	1111 0000	This tracing or debugging message may contain several Data bytes following it with system information.

More About the Voice Channel Messages

The majority of the messages in a MIDI transmission are the Voice Channel messages. These messages contain specific information about notes; how long to play them, what channel to play them on, whether to turn them on or off, how much key pressure is to be applied, and so on. As you have learned so far, these messages consist of a Status byte followed by one or two Data bytes. Let's examine the composition of these Data bytes now.

One of the primary functions of the Voice Channel message is to turn a particular note on or off on a specific channel. This message must also include information about the velocity (roughly equivalent to volume) at which the note was turned on or off. To turn a note on, the message is of the format 1001 XXXX 0YYY YYYY 0ZZZ ZZZZ. As you can see, the first byte is a Status byte followed by two Data bytes, which is indicated by the presence of 0 in the most significant bit. To turn the note off, the format is 1000 XXXX 0YYY YYYY 0ZZZ ZZZZ. The value of the note to turn on or off is indicated by the first Data byte (0YYY YYYY) and can be any value between 0 and 127. The velocity with which to turn the note on or off is indicated by the last Data byte (0ZZZ ZZZZ), and it can be a value between 0 and 127.

Note See the "Using MMAPI Formula to Calculate Note Values" section in Chapter 6 for an explanation of note values.

As an example, suppose you wanted to compose a MIDI message that would tell a MIDI receiver to turn on the note Middle C (equal to 60) on MIDI Channel 12 at a high velocity (remember velocity roughly means volume) of 100. Start with the Status byte:

```
1001 1011
```

The first 4 bits (from the left) are the Note ON command, and the last four bits represent Channel 12 (Channel 1 is 0000 *not* 0001). Next, write the first Data byte representing the note Middle C (equal to 60):

```
0011 1100
```

Finally, write the second Data byte, indicating the velocity as equal to 100:

```
0110 0100
```

Putting it all together,

```
1001 1011 0011 1100 0110 0100
```

will start playing the note Middle C at a velocity of 100 on the MIDI Channel indicated by the number 12. This will not stop playing until a corresponding Note OFF message is received:

```
1000 1011 0011 1100 0110 0100
```

Of course, the velocity with which to turn the note off could be made different than the original one in this Note OFF message, but in this example it has been left as is.

Turning notes on and off is not the only Voice Channel message, and Table 7-3 lists all the possibilities along with a brief description.

Table 7-3. *All Possible Voice Channel Messages*

Status Byte	First Data Byte	Second Data Byte	Message	Comment
1000 XXXX	0YYY YYYY	0ZZZ ZZZZ	Note OFF	Turn a note off on a channel with a given velocity.
1001 XXXX	0YYY YYYY	0ZZZ ZZZZ	Note ON	Turn a note on with a given velocity on a particular channel.
1010 XXXX	0YYY YYYY	0AAA AAAA	After-Touch	Key pressure for polyphony; second Data byte indicates the pressure value (0-127).
1011 XXXX	0BBB BBBB	0CCC CCCC	Control Change	First Data byte indicates which control to change (0-121); second Data byte indicates control value (0-127).

Status Byte	First Data Byte	Second Data Byte	Message	Comment
1100 XXXX	0DDD DDDD	No second Data byte	Program Change	Used to change the instrument of a channel to another instrument, so that more than 16 instruments can be used at one time.
1101 XXXX	0EEE EEEE	No second Data byte	Channel Pressure	Changes the pressure of a whole instrument, not just a single note (which is done with After-Touch).
1110 XXXX	0GGG GGGG	0FFF FFFF	Pitch Bend	A shift in a note's pitch in a very small increment or decrement.

The key Voice Channel messages are the first two for turning notes on or off on a channel, and you'll use these more often than the others. The fourth message (Control Change) is also used extensively to effect changes to various controls within the MIDI environment, including main volume (7), modulation wheel (1), and pan controller (10) controls, among others. Finally, you'll use the Program Change message to change instruments before sending the note to be played on a particular channel.

Storing and Distributing MIDI Messages

The format of MIDI messages presented in the previous section is true for live streaming of these messages, which essentially means that messages are played back as they are received in real time. However, MIDI messages can be stored in a file, and distributed for playback later as well. When these messages are stored in a file, they require timing information to be stored with them as well to allow for synchronization of these messages.

The most common format for storing these files is in Standard MIDI file (SMF) format, denoted by the extension `.smf`. These files are created (and read) using sequencer software on computers/electronic instruments and contain a sequence of tracks. Each track contains information about a particular channel and the note sequence to perform, including other meta-level information.

SMF files are generally distributed on the Internet with the extension of `.mid`. Most files with `.mid` (short for MIDI) extensions are compatible with `.smf` files, and you can interchange the use of these files. The distinction lies in the fact that `.mid` extension files correspond to a narrow interpretation of the MIDI file format specification, called the General MIDI specification.

General MIDI Specification

The General MIDI (GM) specification is a tighter, more focused interpretation of the overall MIDI specification that is intended for greater interoperability between MIDI devices. It specifies a general set of features that the GM devices must conform to. The core features of this specification are

- Support for polyphony (GM devices must allow playback of simultaneous, multiple notes on a single channel)
- Definite support for all 16 channels
- Defined and standard program numbers for various instruments

The standard program numbers for various instruments was one of the main driving forces for the adoption of the GM spec. These devices and their corresponding numbers are listed here: *http://en.wikipedia.org/wiki/General_MIDI*.

Note that only 128 instruments can be supported, as per this specification. To support more instruments, the concept of a *bank* was introduced. A soundbank, or bank, is a collection of the 128 instruments that are supported by a particular MIDI device. Soundbanks can be added or removed, and custom soundbanks can be created to support the existing ones in a device.

Using MIDI in MMAPI

Support for MIDI in MMAPI is provided in the form of the `MIDIControl` control and is aided by the use of `PitchControl` and `TempoControl` controls. However, note that `MIDIControl` is an optional control, and MMAPI implementations are not required to support it. Most instances, however, do support this popular control in one form or another. On one hand, at the minimum, if `MIDIControl` is implemented, you are guaranteed support for sending MIDI events to the control, thereby creating your own set of sequences and messages, as you learned in the previous section. If a full `MIDIControl` is implemented, you are allowed to query the installed soundbanks and manipulate them extensively. You'll learn shortly how to find out whether the MMAPI implementation that you are working on supports a minimum or full `MIDIControl` control.

The MMAPI specification states that for basic usage, you don't even need to access the `MIDIControl` control. This is true, as long as you have a basic MIDI file that you want to play as is, without any modifications. Let's try and play such a basic MIDI file.

Playing MIDI Without `MIDIControl`

Even though you may not directly need to access the `MIDIControl` control to play MIDI files, it doesn't mean that `MIDIControl` is not implemented. Behind the scenes, `MIDIControl` is used to access the synthesizer on the device that you are working on, but you won't need to use it directly. Instead, for simple changes, such as pitch and tempo, you can use the `PitchControl` and `TempoControl` controls. For volume changes, simply use the `VolumeControl` control.

Playing a MIDI File

As you may realize by now, playing, controlling, and using MIDI files is similar to playing other file types that you've learned about in previous chapters, thanks to a similar interface. Therefore, playing MIDI files should not require extra effort on your part. Listing 7-1 shows you a simple code listing that plays a local MIDI file.

Listing 7-1. *Playing a Local MIDI File*

```
package com.apress.chapter7;

import javax.microedition.midlet.*;
import javax.microedition.media.*;

public class PlayMIDIMIDlet extends MIDlet {
```

```
  Player midiPlayer = null;

  public PlayMIDIMIDlet() {
    try {
      midiPlayer = Manager.createPlayer(
        getClass().getResourceAsStream(
          "/media/midi/chapter7/cabeza.mid"), "audio/midi");
    } catch(Exception e) {
      System.err.println(e);
    }
  }

  public void startApp() {
    try {
      if(midiPlayer != null) {
        midiPlayer.start();
      }
    } catch(Exception e) {
      System.err.println(e);
    }
  }

  public void pauseApp() {
  }

  public void destroyApp(boolean unconditional) {
  }
}
```

To play the MIDI file, you just need to create a `Player` instance, passing the location of the file to the `Manager` class's `createPlayer()` method, as you learned to do before. The MIME type for the MIDI files is audio/midi or audio/x-midi, as the case may be. For network-based MIDI files, you can simply point to these files by using the `createPlayer(String locator)` method; the MIME type will be specified by the server that is retrieving the file. For example, if the same file was placed at

```
http://www.mmapibook.com/resources/media/midi/chapter7/cabeza.mid
```

you would use the `Manager.createPlayer("http://www.mmapibook.com/resources/media/midi/chapter7/cabeza.mid")` method to retrieve and play this MIDI file, taking care to make sure that the access is done in a separate thread, as you learned in Chapter 5.

Note The MIDI file (downloaded from the Internet) used here is `cabeza.mid`, which is a MIDI representation of the "Tango Por una cabeza" (the famous Tango, also used in the movie *True Lies*).

Controlling the Pitch, Tempo, and Volume of MIDI Files

Let's now add a few controls to control the pitch, tempo, and volume of a MIDI file. Figure 7-4 shows a MIDlet that allows you to do so (shown in Sun's DefaultColorPhone and Motorola C975 emulators, respectively).

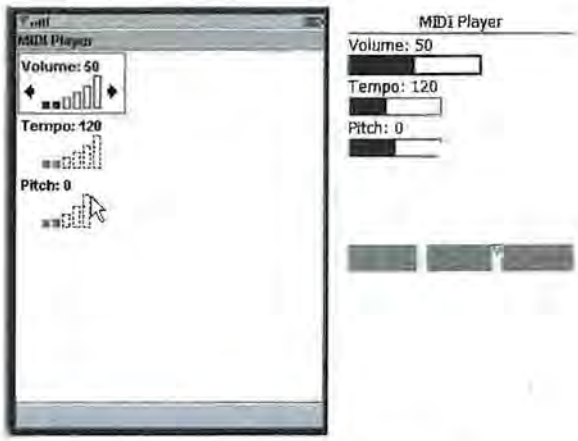

Figure 7-4. *Running* `ControllableMIDIMIDlet` *to control pitch, tempo, and volume in Sun's DefaultColorPhone and Motorola C975 emulators, respectively*

Listing 7-2 shows the code for this MIDlet. An explanation of the code follows this listing.

Listing 7-2. *Controlling MIDI with Pitch, Tempo, and Volume Controls*

```
package com.apress.chapter7;

import javax.microedition.lcdui.*;
import javax.microedition.midlet.*;
import javax.microedition.media.*;
import javax.microedition.media.control.*;

public class ControllableMIDIMIDlet extends MIDlet implements ItemStateListener {

  // the midi player
  Player midiPlayer = null;

  // the controls
  VolumeControl volControl = null;
  PitchControl pitchControl = null;
  TempoControl tempoControl = null;

  // the visual elements
  Form form = null;
```

```
Gauge volGauge = null;
Gauge pitchGauge = null;
Gauge tempoGauge = null;

public ControllableMIDIMIDlet() {
  try {

    // load the midi file
    midiPlayer = Manager.createPlayer(
      getClass().getResourceAsStream(
        "/media/midi/chapter7/cabeza.mid"), "audio/midi");

    // you must prefetch it to get the controls
    midiPlayer.prefetch();

    // extract the controls
    volControl = (VolumeControl) midiPlayer.getControl(
      "javax.microedition.media.control.VolumeControl");
    pitchControl = (PitchControl) midiPlayer.getControl(
      "javax.microedition.media.control.PitchControl");
    tempoControl = (TempoControl) midiPlayer.getControl(
      "javax.microedition.media.control.TempoControl");

    // create the visual elements
    form = new Form("MIDI Player", null);

    // volume is set at a max of 100 with initial value of 50
    volGauge = new Gauge("Volume: 50", true, 100, 50);

    // tempo is set at a max of 30 with 12 (default) as initial value
    tempoGauge = new Gauge("Tempo: 120", true, 30, 12);

    // pitch is set at a max of 5 with initial value of 0, and a min of -5
    // note that because pitch can be negative and positive, the starting value
    // is at 5 (which is pitch 0), with +5 being 10 and -5 being 0.
    pitchGauge = new Gauge("Pitch: 0", true, 10, 5);

    // add the gauges to the form
    form.append(volGauge);
    form.append(tempoGauge);
    form.append(pitchGauge);

    // add the listener to listen to gauge changes
    form.setItemStateListener(this);

    // and set this form as the current display
    Display.getDisplay(this).setCurrent(form);
```

```
    } catch(Exception e) {
      System.err.println(e);
    }
  }

  /**
   * Listens to changes in control gauges and applies them to actual controls
   */
  public void itemStateChanged(Item item) {

    // we are only interested in item state changes of gauges
    if(!(item instanceof Gauge)) return;

    // get the new value of this gauge
    Gauge gauge = (Gauge)item;
    int val = gauge.getValue();

    // and change the control and label accordingly

    // changing volume?
    if(item == volGauge) {
      volControl.setLevel(val);
      volGauge.setLabel("Volume: " + val);
    }

    // changing tempo? make sure that tempoControl is available
    if(item == tempoGauge && tempoControl != null) {
      tempoControl.setTempo((val) * 10 * 1000);
      tempoGauge.setLabel("Tempo: " + (val * 10));
    }

    // changing pitch? make sure that pitchControl is available
    // remember, actual pitch is (val - 5)
    if(item == pitchGauge && pitchControl != null) {
      pitchControl.setPitch((val - 5) * 12 * 1000);
      pitchGauge.setLabel("Pitch: " + (val - 5));
    }
  }

  public void startApp() {
    try {
      // start the MIDI player if it was created
      if(midiPlayer != null) {
        midiPlayer.start();
      }
    } catch(Exception e) {
      System.err.println(e);
    }
  }
```

```
  // standard pause and destroy methods
  public void pauseApp() {
    try {
      if(midiPlayer != null) {
        midiPlayer.stop();
      }
    } catch(Exception e) {
      System.err.println(e);
    }
  }

  public void destroyApp(boolean unconditional) {
    try {
      if(midiPlayer != null) {
        midiPlayer.close();
      }
    } catch(Exception e) {
      System.err.println(e);
    }
  }
}
```

After the Player instance is prefetched, TempoControl, PitchControl, and VolumeControl are extracted using the getControl() method, casting them appropriately. A form is created that contains three gauges, which allow you to control each of the controls individually. The default values of each gauge are set as well. For volume, the default is set at 50 with a maximum value of 100.

For tempo, the default is set at 12, with 30 as the maximum value. These values seem arbitrary, but they are used to show how the TempoControl control works.

How TempoControl Works

TempoControl allows you to vary the tempo of the MIDI file that you are working with. Tempo, which is measured in beats per minute (bpm), is a measure of how fast or slow a piece of music is being played. Using TempoControl, you can vary this speed of playback of a MIDI sequence by using the method setTempo(int milliTempo) and also retrieve the current speed of a sequence by using the getTempo() method. However, setting the tempo doesn't always mean that the desired value will be kept, because a MIDI sequence may contain its own information on the desired tempo. The tempo value in the sequence overrides any value for the tempo that you set using the setTempo() method, if such a value is found in a sequence.

The default tempo of any musical piece (not just MIDI) is usually 120 bpm. With any implementation of TempoControl, you are guaranteed to be able to set the tempo ranging between 10 bpm and 300 bpm. Actual implementations may support more values, specifically over the higher range, but no implementation will support 0 or negative values for the tempo. Instead, most revert to the lowest possible value for the tempo, which in most cases is 10 bpm, but could be as low as 1 bpm.

You can set the tempo using the `setTempo(int milliTempo)` method. Notice that it accepts the value in `milliTempo`. This means, to set the value at 200 bpm, you need to use the method `setTempo(200 * 1000)`. This method returns the actual tempo that was set, expressed as milli-beats per minute.

Returning to Listing 7-2, you can now see that the default value of `12` for the `TempoControl` gauge makes sense. The maximum value is set at `30`. When a change in value of this gauge is detected, the changed value is multiplied by 10 to get the effective value, and then by 1,000 to arrive at the final milli-beats per minute value. This is done in the `itemStateChanged(Item item)` method.

How `PitchControl` Works

As you learned in Chapter 6, pitch is the perception of the frequency of a musical note. The `PitchControl` control allows you to vary the pitch of not only a MIDI sequence, but a normal audio file as well.

Pitch changes are always relative to the original value and can never be set to an absolute value. The changes are specified in semitones; a semitone is one-twelfth of an octave (refer to Chapter 6). Thus, to raise the pitch of a sequence by an octave, you need to raise it by 12 semitones.

The `PitchControl`'s `setPitch(int milliSemitones)` method is used to set the actual value. As you can see, the value is set in milli-semitones. Thus, to raise the pitch by an octave, you need to use the method as `setPitch(12 * 1000)`. To *lower* the pitch by an octave, you use a negative value: `setPitch(-12 * 1000)`.

Of course, you don't have to raise or lower the pitch by an octave. You can change the pitch by any value, down to a single semitone. Just remember that the changes are relative to the original value. To raise by a single semitone, use `setPitch(1000)`; to lower it by a semitone, use `setPitch(-1000)`.

The current *raised* pitch value of a sequence can be queried by using the `getPitch()` method, which returns the value in milli-semitones.

Again, returning to code Listing 7-2, you can see now see why the maximum value of the `PitchControl` gauge is set at `10`, with a default (initial) value of `5`. Due to limitations in the `Gauge` item, negative values can't be set. Thus, the initial, default value of `5` represents `0`, whereas a value of `10` is 5 times the original value, and a value of `0` is –5 times. When you change the value from the default value `5` to, let's say `6`, the code in `itemStateChanged()` method interprets it as raising the pitch by a single octave. The corresponding code is shown here:

```
pitchControl.setPitch((val - 5) * 12 * 1000);
```

Raising the pitch any higher leads to higher octaves, whereas lowering the value below `5` means lowering the pitch by corresponding octaves, so the minimum pitch you can get is five times lower than the original one.

Lowering or raising the pitch up to five octave times the original one is only an arbitrary example that illustrates how to use this control. You can raise or lower the pitch to any values that you desire, which is only limited by the maximum or minimum values that are supported

by the particular Player instance. You can get these values by using the methods getMaxPitch() and getMinPitch() methods, respectively.

Differentiating Between TempoControl and RateControl

Figure 7-4 shows how Listing 7-2 plays out in two emulators: Sun's DefaultColorPhone and Motorola C975 emulator. Most MIDlets' working has been shown in a Motorola C975 device as well. However, because the TempoControl control doesn't work on the actual device, it isn't shown here. If you run this listing in an actual C975 device, you won't be able to control the tempo of the MIDI playback.

Tip You would think that the Motorola C975 emulator would exactly mimic the actual device, in terms of functionality and MIDlet support; however, in MIDlet development, what is promised is not always delivered. You should always confirm the working of your MIDlet on the actual device.

In the absence of TempoControl, to control the tempo on the actual device or on devices that don't support TempoControl, you use the superclass of TempoControl, called RateControl.

RateControl is analogous to the PitchControl control in terms of functionality. Like PitchControl, you can use the RateControl as *relative to original* change medium. Thus, RateControl changes the speed of playback relative to the original speed. Rates are specified in milli-percentages and can be negative as well, thereby allowing you to reduce the playback speed, compared to the original playback speed. This is something that you can't do with TempoControl (you can reduce the tempo from the default tempo, however).

It helps to think of TempoControl as a change medium for tempo, where you want an *absolute* value for the speed of playback of your musical piece. Think of RateControl as a *relative* change medium, where you change the speed of playback relative to the original value. Therefore, when using TempoControl, you use the setTempo() method where an absolute value of the desired tempo is required. When using RateControl, you can use the setRate() method where a relative value in percentages is specified.

Using the setTempo() method may not actually result in the desired tempo being set, as the musical sequence may override the tempo value. Using setRate() is guaranteed to succeed as the playback is relative to the original value, which is set against the Player instance's TimeBase and results in media time of the playback passing faster or slower than the original rate.

Besides the setRate() method, the RateControl control provides the getRate() method, which returns the current playback rate of a musical piece. You can also query for the minimum rate by using getMinRate(), and you can query for the maximum rate by using getMaxRate(). All these methods return the actual rate in milli-percentages.

Listing 7-3 (a modified version of Listing 7-2) uses RateControl instead of TempoControl, so that the new listing can be run on the Motorola C975 device, and you can modify the actual speed of playback. A quirk concerning the RateControl implementation in this device is described after the listing.

Listing 7-3. RateControllableMIDIMIDlet *Controls Playback Rate*

```
package com.apress.chapter7;

import javax.microedition.lcdui.*;
import javax.microedition.midlet.*;
import javax.microedition.media.*;
import javax.microedition.media.control.*;

public class RateControllableMIDIMIDlet extends MIDlet
  implements ItemStateListener {

  // the midi player
  Player midiPlayer = null;

  // the controls
  VolumeControl volControl = null;
  PitchControl pitchControl = null;
  RateControl rateControl = null;

  // the visual elements
  Form form = null;
  Gauge volGauge = null;
  Gauge pitchGauge = null;
  Gauge rateGauge = null;

  public RateControllableMIDIMIDlet() {
    try {

      // load the midi file
      midiPlayer = Manager.createPlayer(
        getClass().getResourceAsStream(
          "/media/midi/chapter7/cabeza.mid"), "audio/midi");

      // you must prefetch it to get the controls
      midiPlayer.prefetch();

      // extract the controls
      volControl = (VolumeControl) midiPlayer.getControl(
        "javax.microedition.media.control.VolumeControl");
      pitchControl = (PitchControl) midiPlayer.getControl(
        "javax.microedition.media.control.PitchControl");
      rateControl = (RateControl) midiPlayer.getControl(
        "javax.microedition.media.control.RateControl");

      // create the visual elements
      form = new Form("MIDI Player", null);
```

```
    // volume is set at a max of 100 with initial value of 50
    volGauge = new Gauge("Volume: 50", true, 100, 50);

    // rate is set at a max of 10 with 5 (default) as initial value
    rateGauge = new Gauge("Rate: 100%", true, 10, 5);

    // pitch is set at a max of 5 with initial value of 0, and a min of -5
    // note that because pitch can be negative and positive, the starting value
    // is at 5 (which is pitch 0), with +5 being 10 and -5 being 0.
    pitchGauge = new Gauge("Pitch: 0", true, 10, 5);

    // add the gauges to the form
    form.append(volGauge);
    form.append(rateGauge);
    form.append(pitchGauge);

    // add the listener to listen to gauge changes
    form.setItemStateListener(this);

    // and set this form as the current display
    Display.getDisplay(this).setCurrent(form);

  } catch(Exception e) {
    System.err.println(e);
  }
}

/**
 * Listens to changes in control gauges and applies them to actual controls
 */
public void itemStateChanged(Item item) {

  // we are only interested in item state changes of gauges
  if(!(item instanceof Gauge)) return;

  // get the new value of this gauge
  Gauge gauge = (Gauge)item;
  int val = gauge.getValue();

  // and change the control and label accordingly

  // changing volume?
  if(item == volGauge) {
    volControl.setLevel(val);
    volGauge.setLabel("Volume: " + val);
  }
```

```
    // changing rate? Is rateControl available?
    if(item == rateGauge && rateControl != null) {
      val = (val == 5 ? 6 : val);
      rateControl.setRate((val - 5) * 100 * 1000);
      rateGauge.setLabel("Rate: " + ((val - 5) * 100) + "%");
    }

    // changing pitch? make sure that pitchControl is available
    // remember, actual pitch is (val - 5)
    if(item == pitchGauge && pitchControl != null) {
      pitchControl.setPitch((val - 5) * 12 * 1000);
      pitchGauge.setLabel("Pitch: " + (val - 5));
    }
  }

  // the rest of the methods are unchanged from Listing 7-2 and are omitted from
  // the book version for brevity
}
```

The changes from Listing 7-2 are highlighted in bold. For `rateGauge` values 5 and 6, the rate is set at 100%; that is, the rate of playback is not changed. For values higher than that, the rate is increased; for values lower, the playback rate is decreased.

If you run this MIDlet on the actual device, you can increase the rate, but decreasing the rate even by a single value completely stops playing it. This is where the Motorola C975 emulator differs from the actual device. You can confirm this by using the method `getMinRate()`, which returns 100% on the actual device and 500% on the emulator (or negative 500%). A value of 100% on the actual device confirms that the minimum rate will not be lower than the original rate of play.

This quirkiness reemphasizes the need to test your MIDlets on actual devices before distributing them.

Figure 7-5 shows this MIDlet running on the device.

Figure 7-5. `RateControllableMIDIMIDlet` *running on a Motorola C975 device*

Tip `RateControl`, unlike `TempoControl`, can be used to control the rate of all media types, not just MIDI.

Playing MIDI with MIDIControl

MIDIControl allows advanced handling of a MIDI file. In fact, using MIDIControl doesn't even require a MIDI file, although you can use one if required. This control allows you to create your own sequences from scratch. However, doing so requires expert knowledge of the MIDI specification and knowing exactly what commands to call.

Creating a Standalone MIDI Player Instance

Recall from Chapter 6 that to play tones, the Manager class provides a constant that can be used for creating Player instances that fetch a ToneControl, without requiring an actual tone file. Similarly, the Manager class provides a MIDI locator constant that can be used to create a standalone MIDI Player instance, from which you can retrieve a MIDIControl and create your own sequences. This constant is called MIDI_DEVICE_LOCATOR and has a value of device://midi. Using it is pretty straightforward and an example is shown here:

```
Player p = Manager.createPlayer(Manager.MIDI_DEVICE_LOCATOR);
p.prefetch();
MIDIControl mControl =
  (MIDIControl)p.getControl("javax.microedition.media.control.MIDIControl");
```

Of course, because this Player instance doesn't correspond to an actual file, it doesn't have any associated data. If you call the method getDuration() on this instance, it will return a value of 0.

Caution You can also retrieve the MIDIControl with the getControl("MIDIControl"); method. However, this is not guaranteed to work on all implementations, even though the Javadoc for the getControl(String controlName) method seems to suggest otherwise.

Querying for MIDIControl Capabilities

The "Using MIDI in MMAPI" section earlier in this chapter stated that MMAPI implementations that provide support for MIDIControl may do so in a minimum or full form. At the minimum, if MIDIControl is provided, you are guaranteed support for sending MIDI events to the underlying device. On the other hand, if a full MIDIControl is implemented, you are allowed to query the installed soundbanks and manipulate them as well. Next you'll see how to query the installed MIDIControl for its capabilities.

Listing 7-4 shows a MIDlet that informs whether a full MIDIControl is installed.

Listing 7-4. MIDICapabilitiesMIDlet *Provides Information About* MIDIControl*'s Capability*

```
package com.apress.chapter7;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import javax.microedition.media.control.MIDIControl;
```

```
public class MIDICapabilitiesMIDlet extends MIDlet {

  public void startApp() {
    try {

      // create Player using MIDI Device locator
      Player p = Manager.createPlayer(Manager.MIDI_DEVICE_LOCATOR);

      // must prefetch before extracting controls
      p.prefetch();

      // get the MIDIControl
      MIDIControl mControl =
        (MIDIControl)p.getControl(
          "javax.microedition.media.control.MIDIControl");

      // create a message based on whether advanced capabilities are supported
      String msg =
        mControl.isBankQuerySupported() ?
          "MIDIControl is fully supported" : "Minimum MIDIControl is provided";

      // and display message as alert
      Display.getDisplay(this).setCurrent(
        new Alert("Message", msg, null, AlertType.INFO));

    } catch(Exception e) {
      System.err.println(e);
    }
  }

  public void pauseApp() {
  }

  public void destroyApp(boolean unconditional) {
  }
}
```

As you can see, querying for advanced capabilities of a `MIDIControl` boils down to using the method `isBankQuerySupported()`, which returns true if these advanced queries are indeed supported and false otherwise. If this method returns true, then you can do the following with your `MIDIControl`:

- Get a list of all the installed soundbanks on your device. This is done by using the method `getBankList(boolean custom)`, which returns an array of integers, where each `int` corresponds to an installed soundbank. If the `custom` parameter is true, only custom soundbanks that you may have installed are returned, otherwise all soundbanks, preinstalled or custom, are returned.

- Get a list of all instruments installed or associated with a given soundbank. Instruments on a soundbank are also called programs. Thus, you can get all the program numbers by using the method `getProgramList(int bank)`, and you can get the name of the instrument/program by using `getProgramName(int bank, int prog)`.
- Get the current instrument/program assigned to a given channel using the method `getProgram(int channel)`. This returns an integer array with two values in it; the first integer represents the soundbank and the second represents the program number on that soundbank.
- Get the name of a key, given the soundbank, program, and key identifications. Thus, using the method `getKeyName(int bank, int program, int key)`, you can get the device-assigned name of this key.

With all the methods, the valid value for the soundbank parameter is `0-16383`, and the value is `0-127` for the program and key parameters.

With the target devices/emulators that you have been using so far, the result of running the MIDlet in Listing 7-4 is shown here:

- *Sun's DefaultColorPhone emulator*: Minimum `MIDIControl` is provided.
- *Motorola C975 emulator*: `MIDIControl` is fully supported.
- *Motorola C975 device*: Minimum `MIDIControl` is provided.

As you can see, the functionality on the emulator differs from the actual device. You'll use the C975 emulator to perform some of the functions provided by a full `MIDIControl`.

All implemented `MIDIControl` controls, minimum or full, can do the functions described in the following sections.

Send a Short MIDI Event to the Device

This means that you can send any MIDI message (refer to Figure 7-3), except System Exclusive to the device, and the device will interpret and react to it accordingly. To send a short MIDI event message, use the method `shortMidiEvent(int type, int data1, int data2)` where the type of the message is specified using the first parameter and the actual data, if any, using the last two parameters.

Refer to Tables 7-1, 7-2, and 7-3 for a list of the possible messages and their formats.

Send a Long MIDI Event to the Device

You can do this to send System Exclusive messages to the device using the `longMidiEvent (byte[] data, int offset, int length)` method.

Change Program and Volume of a Channel

You can set the program/instrument to use on a particular channel and set the volume for the channel as well.

The first is accomplished by the method `setProgram(int channel, int bank, int program)` and the second by `setChannelVolume(int channel, int volume)`. You can do the same using the `shortMidiEvent()` method, as these are really high-level convenience methods that are translated internally to use it. For a minimum `MIDIControl`, the `setProgram()` method uses a value of `-1` for the soundbank, which translates to the default soundbank on the device.

Sending Simple MIDI Messages

By using the `shortMidiEvent()` method, and to a lesser degree, the `longMidiEvent()` method, you can send all types of messages (as described at the beginning of this chapter) to the MIDI player on your device. In effect, you can create sequences of MIDI or create your own user-editable MIDI player.

Single MIDI Message

Let's start with how to send a single MIDI message by expanding on the "More About the Voice Channel Messages" section, where you learned to describe a MIDI message and created the message to turn on the note Middle C on MIDI Channel 12 at the velocity of 100. This complete Note ON command is repeated here:

```
1001 1011 0011 1100 0110 0100
```

The first byte from the left is the Status byte with the first 4 bits representing the Note ON command and the last four bits representing Channel 12 (again, Channel 1 is `0000`, *not* `0001`). The next Data byte represents Middle C (equal to 60) and the last Data byte is the velocity, equal to 100.

The `shortMidiEvent()` method takes three parameters; first, an integer that is the type of the message, and the next two are any data bytes associated with it. The type of the message is essentially information about the status and the channel that it is intended for, both of which are shown with the first byte. Thus, for the given message, `1001 1011` equals 155, `0011 1100` equals 60, and `0110 0100` equals 100. These are the three parameter values, and `shortMidiEvent(155, 60, 100)` will send the Note ON command for the note Middle C on MIDI Channel 12 at a velocity of 100.

Of course, you don't need to calculate the binary values first to arrive back at the decimal values, but this process illustrates the concept. Also, because it's so frequently used, `MIDIControl` provides a constant for the Note ON command, which you can use to create your Status bytes. For example, if you know your channel, note value, and velocity, you can use the following to send the command:

```
shortMidiEvent(MIDIControl.NOTE_ON | channel, note, velocity);
```

For the current case, this equates to:

```
shortMidiEvent(MIDIControl.NOTE_ON | 11, 60, 100); // 11 means Channel 12 not 11
```

The constant `NOTE_ON` has a value of `144`, as you would expect for the binary upper nibble value of `1001`.

You can send other MIDI messages in a similar way. For example, to send a corresponding Note OFF command, you can either use the actual value of 128 OR'ed with the channel number or send a Note ON command with a velocity of 0. Both examples are shown here:

```
shortMidiEvent(128 | 11, 60, 100);
shortMidiEvent(MidiControl.NOTE_ON | 11, 60, 0);
```

Both examples are equivalent and will achieve the same result.

Note Using the `shortMidiEvent()` method means that you don't have to physically start the associated `Player` instance for the event to be played. Sending the event acts on the MIDI device and not on any associated MIDI files.

Control Change Messages

`MIDIControl` provides another constant, `CONTROL_CHANGE`, which can be used to send Control Change messages. From Table 7-3, Control Change messages are used to change a particular control on a particular channel. For example, volume is a control that can be set individually for each channel. The format of Control Change messages is

```
1011 XXXX 0BBB BBBB 0CCC CCCC
```

The Status byte combines a static value with the channel information, while the first Data byte indicates the control that needs to be changed. The last Data byte provides the new value for this control. Thus, to change the volume of Channel 12 to 50, you can use the following command:

```
shortMidiEvent(MIDIControl.CONTROL_CHANGE | 11, 7, 50);
```

The actual value for the control is taken from the table provided by the MIDI organization at *http://www.midi.org/about-midi/table3.shtml*. Table 7-4 shows some of the more useful control numbers taken from this online table. As you can see, the Channel Volume control is given a value of 7.

Table 7-4. *Control Change Messages and Their Values*

Control Function	Control Number
Bank Select	0
Modulation Wheel or Lever	1
Foot Controller	4
Channel Volume	7
Balance	8
Pan	10

Instead of using the `shortMidiEvent()` method to change the volume of a channel, you can use the convenience method `setChannelVolume(int channel, int volume)`, which does the same thing internally.

Program Change Message

If you want to change the current instrument/program that is assigned to a particular channel, you can send one of the Program Change messages. This requires knowledge of the program numbers that can be assigned to each channel, which you can look up at *http://en.wikipedia.org/wiki/General_MIDI*.

The format of the Program Change message as per Table 7-3 is

```
1100 XXXX 0DDD DDDD No second Data byte
```

The new program number is identified by the only Data byte, and the Status byte is a combination of a static upper nibble and the channel number. Thus, as an example, to change the program on Channel 12 to a Xylophone (value 14), you can use:

```
shortMidiEvent(192 | 11, 14, 0);
```

As a convenience, `MIDIControl` provides another method that does the same thing, `setProgram(int channel, int bank, int program)`.

Giving Events Time to Process

One practical issue with using the `shortMidiEvent()` method arises because the method returns almost immediately. Now, this would be okay if the `MIDIControl` implementation was to form a queue of all the event messages arising out of the use of this method. However, there are no guarantees of this occurring. This doesn't mean it won't happen, but you'll rarely find two implementations that work the same way and queue the messages, thus ensuring that a message is received and processed in the order it was sent.

To overcome this issue, you need to give the device's MIDI receiver time to process the event, before sending it another one. Hence, a simple `Thread.sleep(100)` after every event will ensure that the events are received in order and processed in order as well.

Listing 7-5 combines the information from the previous three sections (and this section as well) to create a MIDlet that first sends a Note ON event, followed by a Note OFF event. A Program Change message is then sent to change the program to Xylophone. Finally, a Control Change message to change the volume is followed by a Note ON (and OFF) Message to see the effect of the changes.

Listing 7-5. *The* `shortMidiEvent()` *Method in Action*

```
package com.apress.chapter7;

import javax.microedition.midlet.*;
import javax.microedition.media.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.control.MIDIControl;

public class MIDIEventsMIDlet extends MIDlet {

  Display display = null;
  Alert alert = null;

  public MIDIEventsMIDlet() {
    display = Display.getDisplay(this);
    alert = new Alert("Message");
    alert.setString("Working...");
    alert.setTimeout(Alert.FOREVER);
  }
```

```
public void startApp() {

  // show the alert at startup
  display.setCurrent(alert);

  try {

    // create a MIDI player
    Player p = Manager.createPlayer(Manager.MIDI_DEVICE_LOCATOR);

    // prefetch
    p.prefetch();

    // extract MIDI Control
    MIDIControl mControl =
      (MIDIControl)p.getControl(
        "javax.microedition.media.control.MIDIControl");

    if(mControl == null) throw new Exception("MIDIControl not available");

    // send Note ON for Channel 12 for note MIDDLE C at 100 velocity
    mControl.shortMidiEvent(MIDIControl.NOTE_ON | 11, 60, 100);

    Thread.sleep(100);

    // send Note OFF
    mControl.shortMidiEvent(MIDIControl.NOTE_ON | 11, 60, 0);

    Thread.sleep(100);

    // send program change to Xylophone (14)
    // alternatively, use setProgram(11, -1, 14);
    mControl.shortMidiEvent(192 | 11, 14, 0);
    // mControl.setProgram(11, -1, 14);

    Thread.sleep(100);

    // set volume change to 50
    // alternatively, use setChannelVolume(11, 50);
    mControl.shortMidiEvent(MIDIControl.CONTROL_CHANGE | 11, 7, 50);

    Thread.sleep(100);

    // send Note ON for Channel 12 for note MIDDLE C at 100 velocity
    mControl.shortMidiEvent(MIDIControl.NOTE_ON | 11, 60, 100);

    Thread.sleep(100);
```

```
      // send Note OFF
      mControl.shortMidiEvent(MIDIControl.NOTE_ON | 11, 60, 0);

      Thread.sleep(100);

    } catch(Exception e) {
      alert.setString(e.getMessage());
      System.err.println(e);
    }
  }

  public void pauseApp() {
  }

  public void destroyApp(boolean unconditional) {
  }
}
```

In this code, the main MIDlet thread sleeps for 100 milliseconds each time an event is sent, but you can use a lesser value (and send the events in a separate thread) for better performance and responsiveness. When you run this MIDlet, you will hear a single beep followed by a lesser audible beep made by the Xylophone.

Caution On the Motorola C975 device, the Program Change message using `shortMidiEvent(192 | 11, 14, 0);` doesn't work, so you'll have to use the alternate method `setProgram(11, -1, 14);`.

Working with Soundbanks

A soundbank, as you learned earlier, is a collection of 128 programs (or instruments) that are supported by a particular MIDI device, to overcome the limitation of only 128 programs. You also learned that not all MIDI devices support the concept of soundbanks, and the subsequent support for soundbank operations is limited, leading to either a full `MIDIControl` or minimum `MIDIControl` implementation.

The method `isBankQuerySupported()` is used to find out whether a full or minimum `MIDIControl` is available. Of the devices/emulators that you have used so far in this book, only the Motorola C975 emulator supports a full `MIDIControl`. Let's exercise this full `MIDIControl` to query the installed soundbank(s).

Figure 7-6 shows a MIDlet running on the C975 emulator, taking advantage of its support for a full `MIDIControl`. The MIDlet first queries the installed soundbanks and then lists the available programs, along with their names. When the user selects a program from the list, a note is played using that particular program.

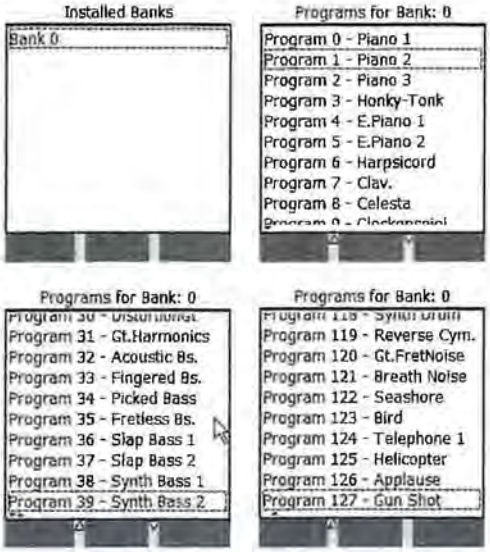

Figure 7-6. *Installed banks and programs on the C975 emulator*

As you can see, only one soundbank is installed, and it has 128 programs installed on it. This list of programs and their names mimics the one mentioned earlier, which is found at *http://en.wikipedia.org/wiki/General_MIDI*.

Note The fact that you can't query Sun's DefaultColorPhone emulator or the actual Motorola C975 device doesn't mean that no soundbank is installed. There is a default soundbank installed, but querying it is not permitted.

The full code for this MIDlet is shown in Listing 7-6. A brief explanation follows this listing, which should be read along with the comments in the code.

Listing 7-6. `ProgramNamesMIDlet` *Queries Installed Soundbanks/Programs and Plays Notes in Different Programs*

```
package com.apress.chapter7;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import javax.microedition.media.control.MIDIControl;

public class ProgramNamesMIDlet extends MIDlet implements CommandListener {
```

```
// MIDlet's display
private Display display = null;

// the bank and program lists
private List bankList = null;
private List programList = null;

// the actual banks and programs (instruments)
private int[] banks = null;
private int[] programs = null;

// the player and MIDIControl
private Player player = null;
private MIDIControl mControl = null;

public ProgramNamesMIDlet() {

  display = Display.getDisplay(this);

  try {
    // create a MIDI player
    player = Manager.createPlayer(Manager.MIDI_DEVICE_LOCATOR);

    // prefetch
    player.prefetch();

    // extract MIDI Control
    mControl = (MIDIControl)player.getControl(
      "javax.microedition.media.control.MIDIControl");

  } catch (Exception e) {
    error(e);
  }
}

public void startApp() {

  try {

    // check if we can query the banks
    if(mControl.isBankQuerySupported()) {

      // get the list of banks
      banks = mControl.getBankList(false);

      // create a list to display the banks
      bankList = new List("Installed Banks", Choice.IMPLICIT);
```

```
      // and populate the list
      for(int i = 0; i < banks.length; i++) {
        bankList.append("Bank " + banks[i], null);
      }

      // add this MIDlet as the CommandListener
      bankList.setCommandListener(this);

      // and show the list
      display.setCurrent(bankList);

    } else { // Bank Query not supported
      display.setCurrent(new Alert("Bank Query not supported"));
    }

  } catch(Exception e) {
    error(e);
  }
}

public void commandAction(Command cmd, Displayable disp) {

  // only bankList and programList commands are being listened for
  if(disp != bankList && disp != programList) return;

  try {

    // for bankList
    if(disp == bankList) {

      // the selected bank
      int selectedBank = banks[bankList.getSelectedIndex()];

      // get the programs for this selected bank
      programs = mControl.getProgramList(selectedBank);

      // and create a programList
      programList =
        new List("Programs for Bank: " + selectedBank, Choice.IMPLICIT);

      // populate this list
      for(int i = 0; i < programs.length; i++) {
        programList.append("Program " + programs[i] + " - " +
          mControl.getProgramName(selectedBank, programs[i]), null);
      }

      // add this MIDlet as the CommandListener
      programList.setCommandListener(this);
```

```
        // and show this list
        display.setCurrent(programList);

      } else { // can be programList only

        // send command to change program
        mControl.setProgram(
          11, // on channel 11
          banks[bankList.getSelectedIndex()], // the selected bank
          programs[programList.getSelectedIndex()]); // the selected program

        // sleep
        Thread.sleep(100);

        // send a Note ON command
        mControl.shortMidiEvent(MIDIControl.NOTE_ON | 11, 60, 100);

        // sleep
        Thread.sleep(100);

        // send a Note OFF command
        mControl.shortMidiEvent(MIDIControl.NOTE_ON | 11, 60, 0);

        // shorter sleep
        Thread.sleep(20);
      }

    } catch(Exception e) {
      error(e);
    }
  }

  // general purpose error method, displays on screen as well to output
  private void error(Exception e) {
    display.setCurrent(new Alert(e.getMessage()));
    e.printStackTrace();
  }

  public void pauseApp() {
  }

  public void destroyApp(boolean unconditional) {
  }
}
```

The MIDlet starts by finding out whether querying the soundbanks is permitted. If not, a brief message is displayed. Otherwise, the `getBankList(false)` method is used to get a list of all soundbanks. This list is then displayed, and the user can make a soundbank selection

(in the case of the C975 emulator, there is only one soundbank). The programs installed on this soundbank are then displayed, along with their names, using the methods `getProgramList(selectedBank)` and `getProgramName(selectedBank, programs[i]), null)`. Finally, when the user selects any program from the list, a Note ON command with Middle C note and velocity 100 is sent after changing the program by using the `setProgram(int channel, int bank, int program)` method.

Mapping key presses on a device to a program in a soundbank should now be fairly easy. This can be used to create a user-controlled MIDI player if you want to do so.

Summary

MIDI is an extensive and diverse communication protocol for transmission of audio messages. It is a widely used protocol for digital music, and MMAPI does well to support MIDI by providing `MIDIControl` as a separate control.

Of course, the exact level of support varies between MMAPI implementations, with the most basic support being the capability to play MIDI files. This chapter introduced you to the concepts of MIDI, including a guide on how MIDI works and an overview of its message structure.

MMAPI allows you to control MIDI files without actually needing to use a `MIDIControl` control, and this chapter showed you how, using `VolumeControl`, `PitchControl`, and `TempoControl` only.

Of course, greater control is provided by using `MIDIControl`, which was shown with the help of various examples, including working with soundbanks, program and control change messages, and the like.

The next chapter will show you how to work with audio and video in MMAPI, one of the most exciting parts of this specification.

CHAPTER 8

Working with Audio and Video

Being able to embed audio and video in your MIDlets provides the biggest advantage that MMAPI brings. The entertainment value provided by multimedia-based options like these is a sure way to get your MIDlets noticed. These MIDlets provide a richer user experience than those without any such visual stimuli.

By being an open-ended API, MMAPI provides a single, simple yet powerful medium to embed audio and video in your MIDlets. Device manufacturers decide which part of the API they want to and can support and consequently provide implementations that take full advantage of the device's features. For example, if the device contains a camera, the MMAPI implementation on it may provide means to capture snapshots or full videos. The point is that the device manufacture is in full control of the capabilities that it wants enabled and can do so with a single API interface.

Whether audio capture or live radio streaming, video capture to video playback, synchronized audio and video, or simple snapshots, MMAPI provides the means using your device. The trick is to find a device that supports all these options so you can create your magical MIDlet. This chapter shows you all the capabilities provided by the MMAPI to support these features.

Querying the Capabilities of Your Device

Before you decide to make an audio/video-enabled MIDlet, you should find out the capabilities of your target device(s). MMAPI provides a simple way of finding out these capabilities, by using the `System.getProperty(String key)` method, which, technically, is a CLDC method.

MMAPI defines several unique properties that you can query for using this method. Table 8-1 gives a list of these properties, along with what they indicate. Almost all these properties relate to the support of audio and video in a particular MMAPI implementation, which is why they are introduced in this later chapter.

Table 8-1. *MMAPI System Properties*

Property Key	Description
`microedition.media.version`	Returns the version of MMAPI that the implementation implements. Currently it returns either 1.1 or 1.0, depending on the implementation that you try it on.
`supports.recording`	Returns true or false, depending on whether either audio and/or video capture is supported by the implementation. Thus, if neither audio nor video can be captured, it returns false; otherwise, true is returned in all other cases.
`streamable.contents`	Returns a list of supported media types, only if the MMAPI implementation supports streaming of media data. In most cases, this returns null, meaning that streaming content is not supported.
`supports.mixing`	Returns true if audio media data can be "mixed" or returns false otherwise. If true, you can have more than one `Player` instance playing audio and/or tones at the same time.
`supports.audio.capture`	Returns true if audio can be captured; returns false otherwise. If true, the following property must not return a null or empty value.
`audio.encodings`	Returns the supported formats for recording audio; returns null if audio capture is not supported.
`supports.video.capture`	Similar to audio, returns true if video capture is supported; returns false otherwise. If true, the following property must not return a null or empty value.
`video.encodings`	Returns the supported formats for recording video content; returns null if video capture is not supported.
`video.snapshot.encodings`	Returns the list of supported formats for taking snapshots with the device camera; returns null if this is not supported.

Listing 8-1 shows a MIDlet that you can use to find out the value of these properties and hence the capabilities of your MMAPI implementation.

Listing 8-1. `CapabilitiesMIDlet` *Lists the Capabilities of a MMAPI Implementation*

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;

public class CapabilitiesMIDlet extends MIDlet {
```

```
  // all the possible capabilities
  private String[] capabilitiesIdx = {
    "microedition.media.version",
    "supports.mixing",
    "supports.audio.capture",
    "supports.video.capture",
    "supports.recording",
    "audio.encodings",
    "video.encodings",
    "video.snapshot.encodings",
    "streamable.contents"
  };

  public void startApp() {

    // create a list
    List list = new List("Audio/Video Capabilities", Choice.IMPLICIT);

    // and query the device for each of the properties
    for(int i = 0; i < capabilitiesIdx.length; ++i) {
      list.append(
        System.getProperty(capabilitiesIdx[i]) + " - " +
        capabilitiesIdx[i], null);
    }

    // show this list
    Display.getDisplay(this).setCurrent(list);
  }

  public void pauseApp() {
  }

  public void destroyApp(boolean unconditional) {
  }
}
```

Finally, Figure 8-1 gives you the result of running this MIDlet in the three development environments used so far in this book: Sun's DefaultColorPhone, Motorola C975 emulator, and Motorola C975 device.

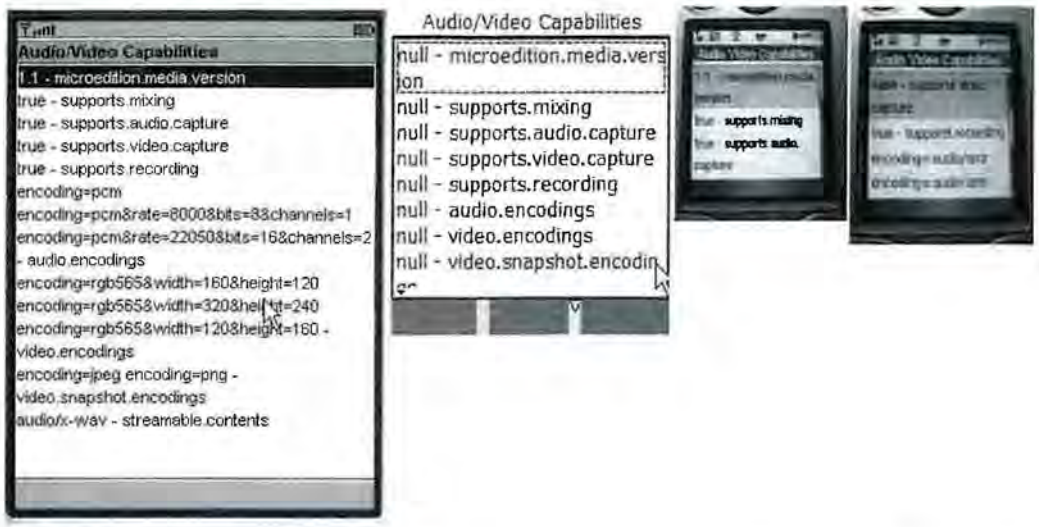

Figure 8-1. *MMAPI capabilities in Sun's DefaultColorPhone emulator, Motorola C975 emulator, and Motorola C975 device (last two figures)*

As you can see, the result of running this MIDlet in various environments is less than encouraging. The Motorola C975 emulator gives a twisted result, returning null for every property, whereas the actual device returns null for `supports.video.capture`, a disappointing result for the continued use of this device for testing in this chapter on audio/video.

Note A variance in the output between the Motorola C975 emulator and the actual device must come as no surprise at this stage. Emulator and actual device implementations vary considerably and no MIDlet should be released without testing on target devices.

You may also wonder why the actual device does not support capturing of video, especially if you glance at Table 2-3 from Chapter 2, which shows the result of running `getSupportedContentTypes("capture")`. This table suggests that the Motorola C975 device should support capture of audio, video, and camera (meaning snapshots), yet Figure 8-1 shows that `supports.video.capture` for the actual device is false.

This is the bane of Java ME development. It's one thing to worry about matching the behavior of devices to their emulators, but even devices themselves don't support the MMAPI implementation consistently. Worse, the implementations sometimes give contradictory results, as in this case, which can confuse the developer to no end. All device manufacturers are guilty of this lapse in consistency, lest you believe that it is a Motorola-specific problem.

One reason for this contradiction is that `System.getProperty(String key)` is a CLDC implementation method, whereas `getSupportedContentTypes(String protocol)` is a MMAPI implementation method. Each API may be implemented by different teams, which may result in the said inconsistency. A feeble excuse, but an excuse nonetheless.

Because the Motorola C975 device can't be used to develop video capture MIDlets, the BenQ (formerly Siemens) M75 (*http://www.benqmobile.com/cds/frontdoor/0,2241,hq_en_0_89745_rArNrNrNrN,00.html*) is used in this chapter. The emulator for this device can be downloaded from the BenQ developer site at *http://developer.benqmobile.com/*. This device and the associated emulator are used interchangeably between the Motorola C975 emulator and device for the rest of the MIDlets in this chapter and the next.

Running the MIDlet from Listing 8-1 again in this new emulator and actual device gives the results shown in Figure 8-2.

Figure 8-2. *BenQ M75 emulator and device MMAPI capabilities*

Because it may not be very easy to make out the properties completely in Figure 8-2, they are tabulated in Table 8-2. Thankfully, both the emulator and the device support the same set of properties.

Table 8-2. *MMAPI Capabilities on BenQ M75 Emulator and Device*

Property Name	Value
`microedition.media.version`	`1.1`
`supports.mixing`	`false`
`supports.audio.capture`	`true`
`supports.video.capture`	`true`
`supports.recording`	`true`
`audio.encodings`	`encoding=audio/AMR`
`video.encodings`	`encoding=video/3gpp`
`video.snapshot.encodings`	`encoding=jpeg encoding=image/jpeg`
`streamable.contents`	`null`

With the support for audio and video capture, the device/emulator must specify the supported format(s) of the captured media. This is done with the help of `audio.encodings`, `video.encodings`, and `video.snapshot.encodings` properties.

Understanding Media Encodings

Media encoding strings are used for specifying the format of media supported, or desired, for a particular operation. It is explained with the help of a string that has the supported or desired formats separated by a single space. The MMAPI specification states that there are four types of intermixable strings, but in reality, not all are supported, and almost certainly, intermixing of these strings is rare (but possible).

These four types of encoding strings are used to define the format of audio, video, intermixed, and custom media data. The general format for each type is

```
encoding=contentType&encodingParams
```

which resembles the HTTP URL query format. As you saw in Table 8-2 and Figures 8-1 and 8-2, the supported formats vary greatly with the specific device MMAPI implementation.

Audio encodings specify, or request, the correct audio formats. From Figure 8-1, you can see that the Sun's DefaultColorPhone emulator specifies the following encoding formats for the property `audio.encodings`:

```
encoding=pcm encoding=pcm&rate=8000&bits=8&channels=1
encoding=pcm&rate=22050&bits=16&channels=2
```

Using this format, the emulator is informing you that it supports three encoding formats for audio capture:

- PCM (Pulse Code Manipulation), which is a ubiquitous form of storing audio data
- PCM at a frequency rate of 8,000 and 8 bits per sample and a single channel (mono)
- PCM at a frequency rate of 22,050, 16 bits per sample, and dual channels (stereo)

All three formats are separated by a single space, and each starts with the text `encoding=`. This is followed by the content type of the encoding and then the parameters (if any) of the content type that qualifies it. Each parameter and its value are separated by the ampersand sign (&), which also separates the content type from its parameters.

The first encoding is assumed to be the default encoding. That is, as you'll see later, if you don't request a particular encoding, and there are multiple encodings that the device may support for a particular operation, the first returned encoding is the format of the resulting media.

Similarly, the video encodings specify the correct video formats, given by the `video.encodings` property. Again, taking the example from Figure 8-1, Sun's DefaultColorPhone emulator supports the following formats for video capture:

```
encoding=rgb565&width=160&height=120 encoding=rgb565&width=320&height=240
encoding=rgb565&width=120&height=160
```

The content type is the same for all the encodings, and the formats only differ in the size of the capture that is supported. This is only a theoretical possibility with this emulator, as it only simulates video capture and doesn't actually implement it.

Mixed encodings allow you to specify audio and video encodings together in one single string for operations that require specific encodings for mixed formats. Each encoding is separately specified, as if they were being specified for single encodings, and then combined using the ampersand (&) operator. The following is an example of mixed encoding, where the first part is the audio encoding, and the latter (in bold) part is the video encoding:

```
encoding=pcm&rate=8000&bits=8&channels=1&encoding=rgb565&width=320&height=240
```

Finally, custom encodings allow you to create your own encodings, albeit remaining true to the audio, video, and mixed encodings formats. An example is shown here:

```
encoding=custom&key=value
```

A Brief Overview of Sampled Audio

Digitally recorded audio data is often referred to as sampled audio. This section gives you a brief overview of the concepts behind sampled audio. You can skip this section if you have a fair understanding of this concept.

Sampled audio represents successive *samples* of audio data. Audio data, in physical terms, is represented as a signal (of a sound wave). By taking discrete samples of the amplitude of a sound wave and representing it using bits and bytes, digital audio data is generated. In a sense, sampled audio is only an approximation of the actual sound wave because you are taking samples of the original and not recreating the whole thing.

This implies that the quality of sampled audio depends on how many samples you take per second. This is true; however, the quality of the finished samples also depends on how you represent them digitally. The more bits used to represent each sample, the better it represents the original audio data accurately.

These two measurements are then a representation of sampled audio. The first, which is effectively a measurement of resolution in time, is called the *sampling rate*. The second, which is the resolution in amplitude, is called *quantization* (or just *resolution*). For example, the music on CDs has a sample rate of 44.1 Khz and a quantization of 16 bits per sample. So, sampled audio on a CD has been sampled 44,100 times per second, and each sample is represented using 16 bits. As a comparison, DVD is sampled at 48 Khz to 96 Khz, and professional recording equipment boasts of sample rates of 192 Khz.

This process of producing sampled audio from analog signals is called Pulse Code Manipulation (PCM). The format on its own is not very efficient, because it doesn't deal with redundancy of samples, thereby taking up a lot of space. By using compression algorithms such as MP3, a PCM-encoded sample can be reduced to contain the same amount of data in a smaller sample size. This has led to the tremendous popularity of using MP3, which produces CD-quality (and better) sound in smaller files. In purely technical terms, MP3 is a compression format of the PCM encoded signal and works by discarding samples not considered valuable for hearing.

Storing Sampled Audio

Although sampled audio is mostly encoded using PCM, it can be saved in a variety of formats for transmission, retrieval, and playback. You may be already familiar with the common storage formats, such as WAV, AU, MP3, AIFF, and so on. These file formats contain information about the sampled audio, but may also contain meta information about the file itself, including information about the size, the format, size of frames, and so on. Typically, this information is contained in the file header.

These files are differentiated by the compression offered in the stored data. As stated earlier, MP3 is an example of a compressed file, where the quality of the file is degraded to conserve space by getting rid of some samples. On the other hand, WAV, AIFF, and AU are uncompressed formats and contain the closest representation of the original sampled data; however, the file

size is an issue. There are other formats that guarantee not to lose any samples and yet compress the audio data, but these aren't very popular. For one thing, the compression is nowhere near that offered by MP3 compression. An example of such a format is True Audio (TTA).

Another popular format, especially as far as Java ME development is concerned, is the Adaptive Multi-Rate (AMR) format, which is a standard adapted by the 3rd Generation Participation Project (3GPP). This format is like MP3, in that it's a compression algorithm that loses quality of the original samples by dropping samples it considers unnecessary for transmission or playback. It specifies a varying number of bit rates, which is simply the number of bits of the sampled data that it can transmit per second. This format is extended to the AMR–Wide Band (WB), which offers a higher speech quality because of its support for a wider speech bandwidth than the AMR format. For this reason, the original AMR format is also referred to as AMR–Narrow Band (AMR-NB).

One final thing to note here is that the WAV file format cannot be used for streaming audio data, because the format requires the complete file data for calculating header information as opposed to the MP3 or AMR formats, which support streaming seamlessly.

Controlling Sampled Audio

Unlike video, sampled audio doesn't require anything extra, other than what you have already learned, to play it. In fact, the way that MMAPI is designed, tones and MIDI, along with sampled audio, can be played without distinguishing between them. If anything, they differ in the controls that are provided for controlling them. MIDI provides `MIDIControl`, and tones provide `ToneControl`, whereas sampled audio provides a variety of controls, most of which you have already come across in some form or another.

For example, `VolumeControl` was covered in Chapters 4 and 7, and the basics of using it with sampled audio remain the same. The same applies to `RateControl` and `PitchControl`, both of which were covered in Chapter 7. Therefore, this section covers the two controls that haven't been covered yet, `MetaDataControl` and `StopTimeControl`.

Note `MetaDataControl` and `StopTimeControl` are not exclusively for use with sampled audio, but like `VolumeControl`, their use applies to all media data that supports sampled audio.

Setting Preset Stop Times with `StopTimeControl`

Being able to set a preset stop time for media data may not sound very useful, but it can come in very handy when you want a precise action to happen at a particular instance. This is because when the `Player` instance stops at the preset time, the `STOPPED_AT_TIME` event is fired, which you can capture and act on.

Of course, not all media types, and for that matter, not all implementations, support `StopTimeControl`. This is to say that some MMAPI implementations may support this control, but only for certain media types. It's hard to judge which media types support this control, because unlike the `getSupportedContentTypes(String protocol)` and `getSupportedProtocols(String contentType)` methods, there is no corresponding `getSupportedControls(String contentType)` method. As you know, the `getControls()` and `getControl()` methods only work after a `Player` instance has been prefetched.

Listing 8-2 provides an example of using `StopTimeControl`. The code creates a `Player` instance that can be started with or without a `StopTimeControl` being used to preset a stop time. However, the `Player` instance remains the same, whether you are using a `StopTimeControl` or not, and you'll notice varying results due to this. An explanation follows the code listing, and Figure 8-3 shows the MIDlet in use in the Motorola C975 emulator.

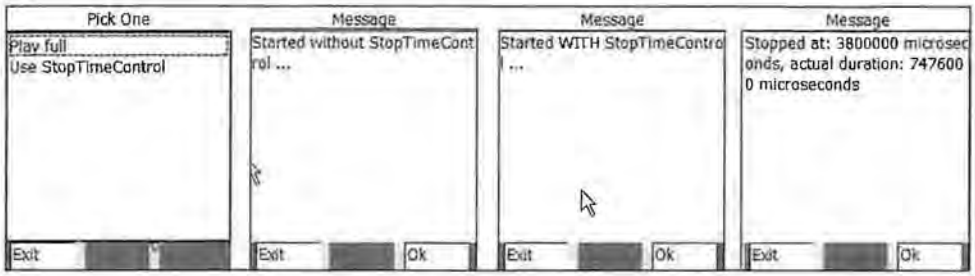

Figure 8-3. *Running* `StopTimeControlMIDlet` *in Motorola C975*

Figure 8-3 shows the `StopTimeControlMIDlet` in action, with the two different scenarios played out.

Listing 8-2. `StopTimeControlMIDlet` *Allows You to Play with the* `StopTimeControl`

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import javax.microedition.media.control.*;

public class StopTimeControlMIDlet extends MIDlet
  implements CommandListener, PlayerListener {

  // the display items
  private Display display = null;
  private Alert alert = null;
  private List list = null;

  // commands
  private Command exitCommand = null;
  private Command okCommand = null;

  // player and controls
  private Player player = null;
  private StopTimeControl stControl = null;

  public StopTimeControlMIDlet() {
```

```
    // create all the basic stuff
    display = Display.getDisplay(this);

    alert = new Alert("Message");

    exitCommand = new Command("Exit", Command.EXIT, 1);
    okCommand = new Command("Ok", Command.OK, 1);

    alert.addCommand(exitCommand);

    list = new List("Pick One", List.IMPLICIT);
    list.append("Play full", null);
    list.append("Use StopTimeControl", null);

    list.addCommand(exitCommand);
    alert.addCommand(okCommand);

    alert.setCommandListener(this);
    list.setCommandListener(this);

    // create the player and the stoptimecontrol
    try {
      player = Manager.createPlayer(
        getClass().getResourceAsStream(
        "/media/audio/chapter8/printer.wav"), "audio/x-wav");

      player.addPlayerListener(this);

      player.prefetch();

      stControl = (StopTimeControl)player.getControl(
        "javax.microedition.media.control.StopTimeControl");

      // no point continuing if stoptimecontrol is not supported
      if(stControl == null)
        throw new Exception("StopTimeControl is not supported");
    } catch(Exception e) {
      error(e);
    }
  }

  public void startApp() {
    // show the list of items
    display.setCurrent(list);
  }

  public void pauseApp() {
  }
```

```
public void destroyApp(boolean unconditional) {
}

public void commandAction(Command cmd, Displayable disp) {

  // if exiting
  if(cmd == exitCommand) {
    notifyDestroyed();
    return;
  }

  // if ok command
  if(cmd == okCommand) {
    try {
      // pause the player, so that it can be reused
      player.stop();

      // and redisplay the list
      display.setCurrent(list);
    } catch(Exception e) {
      error(e);
    }
  }

  // implicit list handling
  if(disp == list) {

    // the selected idx
    int selectedIdx = list.getSelectedIndex();

    // show the message
    display.setCurrent(alert);

    try {
      if(selectedIdx == 0) {
        // start player without stoptimecontrol
        if(player != null) player.start();
        alert.setString("Started without StopTimeControl ...");
      } else {

        // start with stoptimecontrol

        // set the stop time as half of the length
        stControl.setStopTime(player.getDuration()/2);

        // start the player
        if(player != null) player.start();
```

```
            alert.setString("Started WITH StopTimeControl ...");
          }
        } catch(Exception e) {
          error(e);
        }
      }
    }

    public void playerUpdate(Player player, String event, Object eventData) {

      // only interested in the STOPPED_AT_TIME event
      if(event == STOPPED_AT_TIME) {
        // give the message
        alert.setString("Stopped at: " + eventData + " microseconds" +
          ", actual duration: " + player.getDuration() + " microseconds");

        // and show the alert
        alert.setTimeout(Alert.FOREVER);
        display.setCurrent(alert);
      }
    }

    // general purpose error method, displays onscreen as well to output
    private void error(Exception e) {
      alert.setString(e.getMessage());
      alert.setTitle("Error");
      alert.setTimeout(Alert.FOREVER);
      display.setCurrent(alert);
      e.printStackTrace();
    }
  }
```

If you try this MIDlet in an emulator or a device and test it repeatedly, you'll notice some anomalous results. As per the code, when using the `StopTimeControl`, the `Player` instance is preset to stop playing when exactly half the duration has been reached. Figure 8-4 shows one such anomaly.

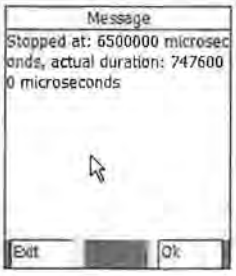

Figure 8-4. `StopTimeControl` *seems to stop after the preset time.*

Figure 8-4 seems to suggest that the Player instance was stopped after the preset time, which being half of the total duration, should be roughly 373,800 microseconds. This happened because in this particular case, the StopTimeControl's setStopTime(long stopTime) method was called *after* the media playback time of the Player instance had passed the preset time. In such cases, that is, when the current media time has already passed the preset time, the Player instance immediately stops at the current media time and generates a STOPPED_AT_TIME event.

You can remove a previously set preset time by using the constant RESET. Thus, setStopTime(StopTimeControl.RESET) will clear any preset times. Calling the getStopTime() method returns the preset time (remember, in microseconds, *not* milliseconds) and RESET if no preset time has been set.

Finally, if you call setStopTime() method on a *started* Player instance, which already has a preset time, an IllegalStateException is thrown. However, you can change the preset time on a stopped Player instance, as is done in Listing 8-2.

Gathering Information Using MetaDataControl

MetaDataControl provides a simple way for Player instances to expose the meta information about media data. This meta information can be exposed with a set of predefined keys, such as Author, Title, Date, and Copyright, or the media may contain its own proprietary keys (with associated values).

As with StopTimeControl, not all media exposes this control. WAV and MP3 in sampled audio and MPEG in video are the most likely candidates that will provide meta information such as this. This doesn't mean that other media doesn't contain this information, just that the MMAPI implementation may not provide the MetaDataControl control for it.

Listing 8-3 shows you an example of using this control, where the information contained in an MP3 is displayed on the screen.

Listing 8-3. *Using* MetaDataControl *to Display Meta Information*

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;

import javax.microedition.media.*;
import javax.microedition.media.control.MetaDataControl;

public class MetaDataControlMIDlet extends MIDlet implements CommandListener {

  // define the display items
  private Display display = null;
  private List list = null;
  private Command exitCommand = null;
  private Alert alert = null;

  // the player instance
  private Player player = null;
```

```
public MetaDataControlMIDlet() {

  // create the display items
  display = Display.getDisplay(this);
  alert = new Alert("Message");
  exitCommand = new Command("Exit", Command.EXIT, 1);
  alert.addCommand(exitCommand);
  alert.setCommandListener(this);

  list = new List("Message", List.IMPLICIT);
  list.addCommand(exitCommand);

  list.setCommandListener(this);

  // create and prefetch the player instance
  try {
    player = Manager.createPlayer(
      getClass().getResourceAsStream(
      "/media/audio/chapter8/frogs.mp3"), "audio/mp3");

    player.prefetch();
  } catch(Exception e) {
    error(e);
  }
}

public void startApp() {

  // if player was created, extract control
  if(player != null) {

    MetaDataControl mControl =
      (MetaDataControl)player.getControl(
        "javax.microedition.media.control.MetaDataControl");

    // if control is provided, show information onscreen
    if(mControl == null) {

      // no info
      alert.setString("No Meta Information");
      display.setCurrent(alert);
    } else {

      // get all the keys of this control
      String[] keys = mControl.getKeys();

      // and append the key and its value to the list
      for(int i = 0; i < keys.length; i++) {
```

```
        list.append(keys[i] + " -- " + mControl.getKeyValue(keys[i]), null);
      }

      // show the list
      display.setCurrent(list);
    }
  }
}

public void commandAction(Command cmd, Displayable disp) {
  if(cmd == exitCommand) {
    notifyDestroyed();
  }
}

public void pauseApp() {
}

public void destroyApp(boolean unconditional) {
}

// general purpose error method, displays onscreen as well to output
private void error(Exception e) {
  alert.setString(e.getMessage());
  alert.setTitle("Error");
  alert.setTimeout(Alert.FOREVER);
  display.setCurrent(alert);
  e.printStackTrace();
}
}
```

As you can see, to get a list of keys, you use the method `getKeys()`, which returns a `String` array. There are four predefined keys in the `MetaDataControl` class: `AUTHOR_KEY`, `TITLE_KEY`, `COPYRIGHT_KEY`, and `DATE_KEY`. After you have the keys, whether predefined or retrieved using the `getKeys()` method, you can use the `getKeyValue()` method to get the value assigned to each key.

Figure 8-5 shows this MIDlet running in the Motorola C975 device, with only the title key showing a value. The Motorola C975 emulator doesn't support the playback of MP3 audio.

Figure 8-5. *Using* `MetaDataControl` *to display meta information*

Mixing Sampled Audio, MIDI, and Tones

One of the properties listed in Table 8-1, `supports.mixing`, indicates whether a particular MMAPI implementation supports the concept of multiple `Player` instances for sampled audio and tones. If true, it indicates that mixing is supported; in short, you can have multiple `Player` instances for audio, MIDI, and tone playback, playing simultaneously. Multiple `Player` instances mostly equals to a maximum of two or three, although different implementations vary in their support of simultaneous instances. There is no sure way of knowing how many instances you can create for mixing, and the Java ME documentation for your device may give an answer. Of course, you have to be careful creating too many `Player` instances, as this will result in a memory hog, especially prefetched and/or realized instances.

The concept of an implementation supporting mixing is slightly more advanced than just being able to support multiple instances of `Player` objects in memory. When a `Player` instance, created to play back sampled audio, MIDI, or tone, is in the PREFETCHED state, it has acquired the resources required to immediately play back. This means that it has exclusive access to the device's resources, especially the audio output hardware. Thus, the MMAPI implementation that supports mixing must switch intelligently and efficiently between `Player` instances to manage the flow of media data without any errors, using either a software or hardware mixer. This is why most implementations eschew audio mixing, because it becomes too complicated to implement, or provide a simplified version that only caters for specific possibilities.

The Motorola C975 device only implements MIDI mixing (that is, two or more MIDI `Player` instances playing simultaneously) and doesn't support the mixing of either audio or tones, even though it returns a true value for the `supports.mixing` property. However, it does support the mixing of a MIDI file with a WAV file, as long as the MIDI file is started first *and* the WAV file is a PCM encoded, single channel (mono), 8,000 Khz, 8-bit file. Go figure! Siemens M75 doesn't support any mixing and indicates so with a value of false for the property.

Note This is another case of device manufacturers not sticking with the intent of the MMAPI specification and providing an arbitrary implementation. As per the specification, if `supports.mixing` returns true, the MMAPI implementation must be able to support the playback of two sampled audio `Player` instances simultaneously. For what it's worth, Motorola is not the only device manufacturer guilty of providing an arbitrary implementation.

One of the most common requirements of mixing sampled audio, MIDI, and/or tones is in Java ME games. Most games have a background score playing continuously, while short audio events will accompany some action on the screen. In these cases, you'll have one `Player` instance playing the background score in a loop and other prefetched instances that start playing a short sound such as firing, jumping, opening doors, and so on, depending on the user interaction with the action on the screen.

Listing 8-4 shows an example of mixing a MIDI file with a sampled audio WAV file (as per the Motorola C975 specification!) and another MIDI event. The MIDI event is a fire sound, implemented by issuing the program change (instrument change) of `"Gunshot"` (see Chapter 7, Figure 7-6). The main MIDI sound is a background score that plays continuously, and the audio WAV file is a short sound that mimics a character jumping onscreen. When the user presses the Jump! command, the corresponding `Player` instance is started to play the sound. When the user presses the Fire! command, a `shortMidiEvent()` command is issued. During all this, the background score continues to play.

Listing 8-4. *Mixing MIDI and Sampled Audio*

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import javax.microedition.media.control.MIDIControl;

public class MixingAudioMIDlet extends MIDlet implements CommandListener {

  // define Players and Controls
  private Player backgroundPlayer = null;
  private Player firePlayer = null;
  private Player jumpPlayer = null;
  private MIDIControl mControl = null;

  // define commands and display items
  private Display display = null;
  private Alert alert = null;
  private Command exitCommand = null;
  private Command fireCommand = null;
  private Command jumpCommand = null;

  public MixingAudioMIDlet() {

    // create the display items
    display = Display.getDisplay(this);

    // this is the alert that will be displayed
    alert = new Alert("Message");
    alert.setString("Playing background score. " +
      " Use menu to mix sampled audio and/or other midi");
    alert.setTimeout(Alert.FOREVER);

    // create the commands
    exitCommand = new Command("Exit", Command.EXIT, 1);
    fireCommand = new Command("Fire!", Command.SCREEN, 1);
    jumpCommand = new Command("Jump!", Command.SCREEN, 1);

    // attach the commands to the alerts
    alert.addCommand(exitCommand);
    alert.addCommand(fireCommand);
    alert.addCommand(jumpCommand);

    // and set the command listener
    alert.setCommandListener(this);
```

```
    // finally create the Player instances
    initPlayers();
  }

  private void initPlayers() {

    try {

      // the background player that will play a MIDI file throughout
      backgroundPlayer =
        Manager.createPlayer(getClass().getResourceAsStream(
            "/media/midi/chapter8/cabeza.mid"), "audio/midi");

      // prefetch it and make sure it repeats if it finishes
      backgroundPlayer.prefetch();
      backgroundPlayer.setLoopCount(-1);

      // create another MIDI Player for the firing sound
      firePlayer = Manager.createPlayer(Manager.MIDI_DEVICE_LOCATOR);
      firePlayer.prefetch();

      // extract its MIDIControl
      mControl = (MIDIControl)firePlayer.getControl(
        "javax.microedition.media.control.MIDIControl");

      // set program to the Gunshot sound (See Figure 7-6 in Chapter 7)
      mControl.setProgram(11, -1, 127);

      // create another sampled audio player for jump sound
      jumpPlayer = Manager.createPlayer(getClass().getResourceAsStream(
            "/media/audio/chapter8/jump.wav"), "audio/x-wav");

      // prefetch it as well
      jumpPlayer.prefetch();

    } catch (Exception e) {
      error(e);
    }
  }

  public void startApp() {

    // start background player
    try {
      if(backgroundPlayer != null) {
        backgroundPlayer.start();
      }
```

```
    } catch(Exception e) {
      error(e);
    }

    // and show message
    display.setCurrent(alert);
  }

  public void commandAction(Command cmd, Displayable disp) {

    // if closing
    if(cmd == exitCommand) {
      destroyApp(true);
      notifyDestroyed();
      return;
    }

    try {

      // if fire command is issued, send the NOTE_ON command
      if(cmd == fireCommand) {
        mControl.shortMidiEvent(MIDIControl.NOTE_ON | 11, 60, 100);
      }

      // if jump command is issued, start the jump player
      if(cmd == jumpCommand) {
        jumpPlayer.start();
      }
    } catch(Exception e) {
      error(e);
    }

  }

  public void pauseApp() {

    // pause any players if MIDlet is paused
    try {
      if(backgroundPlayer != null) backgroundPlayer.stop();
      if(firePlayer != null) firePlayer.stop();
      if(jumpPlayer != null) jumpPlayer.stop();
    } catch(Exception e) {
      error(e);
    }
  }

  public void destroyApp(boolean unconditional) {
```

```
    // close players once application is destroyed
    try {
      if(backgroundPlayer != null) {
        backgroundPlayer.close();
        backgroundPlayer = null;
      }
      if(firePlayer != null) { firePlayer.close(); firePlayer = null; }
      if(jumpPlayer != null) { jumpPlayer.close(); jumpPlayer = null; }
    } catch(Exception e) {
      error(e);
    }
  }

  // general purpose error method, displays onscreen as well to output
  private void error(Exception e) {
    alert.setString(e.getMessage());
    alert.setTitle("Error");
    display.setCurrent(alert);
    e.printStackTrace();
  }
}
```

Figure 8-6 shows this MIDlet playing in the C975 device. The Jump! command is accessed by pressing the Menu button.

Figure 8-6. *Mixing MIDI and audio in the Motorola C975 device*

Capturing Audio

An implementation supports capture of audio via a MIDlet if it returns true for the `supports.audio.capture` system property. If this property is true, then the `audio.encodings` system property must not return null, but must provide the formats in which audio can be recorded. The Motorola C975 device supports the audio/amr and audio/amr-wb (Wide band) formats.

To capture media, you use the `RecordControl` control, whether for audio or video. This control doesn't distinguish between the media types and is a simple mechanism to start, stop, and control the data recording. It provides several methods to achieve these tasks.

A `Player` instance to capture audio is created by passing the special locator `capture://audio` to the `Manager.createPlayer(String locator)` method, which will then, once realized,

give up a `RecordControl` object for you to use. While creating the locator, you can pass parameters to it, which qualifies the format of the recorded data, as you learned in the "Understanding Media Encodings" section. When no format is specified, the format (content-type) of the recorded data is the default (the first value returned by `audio.encodings`) format. Thus, for the C975 device, the default recording format for audio is audio/amr.

Of course, recorded data must be either stored somewhere or played back to the user (and then discarded). `RecordControl` provides two methods for setting the location of recorded data. The `setRecordStream(OutputStream stream)` directs data to an `OutputStream`, and `setRecordLocation(String locator)` directs it to the location in the form of locators used to create `Player` instances using the `Manager.createPlayer(String locator)` method. Of course, you should be able to store data at the particular location identified by the locator `String`.

Tip Recording formats impact the way the MMAPI implementation handles them internally. For formats that can't be streamed, such as WAV for sampled audio and Quicktime for video, the full media data is required before it can be written to any location. This is because some portions in the header of these files require the availability of the full data, and this header will be written to when the complete recorded data is available. When you are recording data like this, the implementation needs to provide an internal buffer that will hold this data till the recording is complete, calculate the missing header information, and then write it to your desired location, either a stream (`setRecordStream()`) or location (`setRecordLocation()`). With data that can be streamed, such as MP3 for audio and MPEG for video, this is not a problem, and the data can be written to your desired location at the same time that it's read. This is why you are not likely to find too many devices with MMAPI implementations that support recording in a nonstreamable format.

Recording data itself requires permission from the user. As you saw in Chapter 5, permissions can be requested for in a JAD file (and put in a trusted domain). To record any media (audio or video), the following permission must be available:

```
javax.microedition.media.control.RecordControl
```

Alternatively, the user will be queried to give the permission when the recording commences.

Let's start by creating a MIDlet that will play back whatever you say to it, instead of storing it somewhere.

Timed Capture and Playback

Simple capture and playback of audio can be accomplished easily by using the two streams, `ByteArrayOutputStream` and `ByteArrayInputStream`. Because data doesn't need to be stored anywhere, one `Player` instance can be used to record the raw audio data into the `ByteArrayOutputStream`'s byte array, and another instance created to retrieve data from this buffer using the `ByteArrayInputStream`. Of course, you can't expect the data to be recorded continuously. For this example, the timed limit is 10 seconds.

Listing 8-5 shows the code for this timed audio capture and playback MIDlet.

Listing 8-5. *Timed Capture and Playback of Audio*

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import java.io.ByteArrayOutputStream;
import java.io.ByteArrayInputStream;
import javax.microedition.media.control.RecordControl;

public class CapturePlaybackAudioMIDlet extends MIDlet
  implements CommandListener {

  // the display items
  private Display display = null;
  private Alert alert = null;
  private Command exitCommand = null;

  // players and controls
  private Player capturePlayer = null;
  private Player playbackPlayer = null;
  private RecordControl recordControl = null;

  // buffers
  private ByteArrayOutputStream bos = new ByteArrayOutputStream();
  private ByteArrayInputStream bis = null;

  public CapturePlaybackAudioMIDlet() {

    // create the display
    display = Display.getDisplay(this);
    alert = new Alert("Message");
    alert.setTimeout(Alert.FOREVER);
    alert.setString("Capturing for 10 seconds. Say something intelligent!");
    exitCommand = new Command("Exit", Command.EXIT, 1);
    alert.addCommand(exitCommand);
    alert.setCommandListener(this);

    try {
      // create the capture player
      capturePlayer = Manager.createPlayer("capture://audio");

      if (capturePlayer != null) {

        // if created, realize it
        capturePlayer.realize();
```

```
      // and grab the RecordControl
      recordControl = (RecordControl)capturePlayer.getControl(
        "javax.microedition.media.control.RecordControl");

      // set the alert as the current item
      display.setCurrent(alert);

      // if it is null throw exception
      if(recordControl == null)
        throw new Exception("No RecordControl available");

      // create the buffer in which recording will be done
      bos = new ByteArrayOutputStream(1024);

      // and set this buffer as the destination for recording
      recordControl.setRecordStream(bos);

    } else {
      throw new Exception("Capture Audio Player is not available");
    }

  } catch(Exception e) {
    error(e);
  }
}

public void startApp() {

  try {

    // first start the corresponding player
    capturePlayer.start();

    // and then start the RecordControl
    recordControl.startRecord();

    // now wait 10 seconds
    Thread.sleep(10000);

    // stop recording after time is up
    recordControl.stopRecord();

    // commit the recording
    recordControl.commit();

    // and close the Player instance
    capturePlayer.close();
```

```
        // finished, set the message
        alert.setString("Well done! Now Processing...");

        // flush the buffer
        bos.flush();

        // create an inputstream of this buffer
        bis = new ByteArrayInputStream(bos.toByteArray());

        // create the playback Player instance with this stream,
        // using the specified content type, as given by the RecordControl
        playbackPlayer =
          Manager.createPlayer(bis, recordControl.getContentType());

        // start the playback
        playbackPlayer.start();

        // and set the message
        alert.setString("Playing back ... ");

      } catch(Exception e) {
        error(e);
      } finally {
        try {
          if(bos != null) bos.close();
          if(bis != null) bis.close();
        } catch(Exception ex) {
          error(ex);
        }
      }

    }

    public void pauseApp() {
    }

    public void destroyApp(boolean unconditional) {
    }

    public void commandAction(Command cmd, Displayable disp) {
      if(cmd == exitCommand) {
        notifyDestroyed();
      }
    }

    // general purpose error method, displays onscreen as well to output
    private void error(Exception e) {
      alert.setString(e.getMessage());
```

```
    alert.setTitle("Error");
    display.setCurrent(alert);
    e.printStackTrace();
  }

}
```

After a Player instance is created and realized for capturing audio, the RecordControl control is extracted. The setRecordStream(OutputStream os) method is used to set a ByteArrayOutputStream with an initial buffer size of 1,024 bytes. When the MIDlet is started, recording is started by using the startRecord() method of RecordControl. You first have to start the underlying Player instance by using the start() method; otherwise, no recording will actually take place. This is because the Player instance is created on the audio microphone on the device, which then releases a RecordControl for you to use. If you call startRecord() first, then the RecordControl will be ready to record, but won't actually record anything till the corresponding Player instance is started. Thus, it's best to first start the Player instance, and then start the recording by calling the startRecord() method.

The recording is done for 10 seconds by making the main application thread sleep. After the 10 seconds are over, the recorded data is put into the ByteArrayInputStream after committing the recorded data by calling the commit() method and closing the Player instance. Note that calling stopRecord() is not necessary, as commit() calls it internally. When stopRecord() is called, the Player instance doesn't actually stop, but continues in the STARTED state until it is stopped or closed.

The data is now available in the ByteArrayInputStream and a new Player instance is created to use this as the InputStream for playback. The getContentType() method of RecordControl is used to specify the content type for this new instance. It's now a simple matter of calling the start() method on this instance to play back the captured audio data.

Controlled Capture and Playback

Although timed capture as seen in the previous section shows you the basics of capturing audio, it doesn't show you how to provide controls to better manage the recording time. In this section, you'll add some commands to a modified recording MIDlet created in the previous section, giving you these controls. Listing 8-6 shows the code for this MIDlet, with an explanation following the listing.

Listing 8-6. *Controlling Audio Capture*

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import java.io.ByteArrayOutputStream;
import java.io.ByteArrayInputStream;
import javax.microedition.media.control.RecordControl;

public class ControlledAudioCaptureMIDlet extends MIDlet
  implements CommandListener, PlayerListener {
```

```
// the display items
private Display display = null;
private Alert alert = null;
private Command exitCommand = null;
private Command startCommand = null;
private Command pauseCommand = null;
private Command doneCommand = null;
private Command playbackCommand = null;

// players and controls
private Player capturePlayer = null;
private Player playbackPlayer = null;
private RecordControl recordControl = null;

// buffers
private ByteArrayOutputStream bos = new ByteArrayOutputStream();
private ByteArrayInputStream bis = null;

// Boolean flag to indicate when recording is being done
private boolean recording = false;

public ControlledAudioCaptureMIDlet() {

  // create the display
  display = Display.getDisplay(this);
  alert = new Alert("Message");
  alert.setTimeout(Alert.FOREVER);
  alert.setString("Press Start Recording to capture audio");

  // create the various commands
  exitCommand = new Command("Exit", Command.EXIT, 1);
  startCommand = new Command("Start", Command.SCREEN, 1);
  pauseCommand = new Command("Pause", Command.SCREEN, 1);
  doneCommand = new Command("Done", Command.SCREEN, 1);
  playbackCommand =
    new Command("Playback", Command.SCREEN, 1);

  // and initialize the commands with the alert
  alert.addCommand(exitCommand);
  alert.addCommand(startCommand);

  // set this class as the PlayerListener for command actions
  alert.setCommandListener(this);

  // now set the alert as the current item
  display.setCurrent(alert);
```

```
  try {

    // create the capture player
    capturePlayer = Manager.createPlayer("capture://audio");

    if (capturePlayer != null) {

      // if created, realize it
      capturePlayer.realize();

      // and grab the RecordControl
      recordControl = (RecordControl)capturePlayer.getControl(
        "javax.microedition.media.control.RecordControl");

      // if RecordControl is null throw exception
      if(recordControl == null)
        throw new Exception("No RecordControl available");

      // create the buffer in which recording will be done
      bos = new ByteArrayOutputStream(1024);

    } else {
      throw new Exception("Capture Audio Player is not available");
    }
  } catch(Exception e) {
    error(e);
  }
}

public void startApp() {
  display.setCurrent(alert);
}

public void pauseApp() {
}

public void destroyApp(boolean unconditional) {

  // close any open player instances, underlying controls will be
  // closed by calling the close method
  if(capturePlayer != null)  {
    capturePlayer.close(); // releases the microphone
    capturePlayer = null;
  }
  if(playbackPlayer != null)  {
    playbackPlayer.close();
    playbackPlayer = null;
  }
}
```

```
public void commandAction(Command cmd, Displayable disp) {

  // if exit ..
  if(cmd == exitCommand) {
    destroyApp(true);
    notifyDestroyed();
  }

  // now based on what command is called, take the right action
  try {

    // if starting or restarting recording
    if(cmd == startCommand) {

      // remove other commands
      alert.removeCommand(startCommand);
      alert.removeCommand(playbackCommand);

      // add pause and done commands
      alert.addCommand(pauseCommand);
      alert.addCommand(doneCommand);

      // now, if a playback was being done, close it to preserve
      // system resources
      if(playbackPlayer != null) {
        playbackPlayer.close();
        playbackPlayer = null;
      }

      // are we restarting an existing recording or a new one?
      if(!recording) { // this means a new one

        // set the ByteArrayInputStream to null
        bis = null;

        // initialilze the ByteArrayOutputStream
        bos = new ByteArrayOutputStream(1024);

        // set the output of recording
        recordControl.setRecordStream(bos);

        // and start the underlying player
        capturePlayer.start();
      }

      // now start the recording
      recordControl.startRecord();
```

```
    // set the flag
    recording = true;

    // and show the message
    alert.setString("Recording now. Say something nice" +
      " and then press Pause or Done Recording");

  } else if(cmd == pauseCommand) {

    // pausing an existing recording

    // so remove the pause command and add the start (or restart command)
    alert.removeCommand(pauseCommand);
    alert.addCommand(startCommand);

    // stop the control, this only pauses the recording
    recordControl.stopRecord();

    // and show message
    alert.setString("Recording paused. " +
      " Press Start Recording to restart");

  } else if(cmd == doneCommand) {

    // done recording, so remove commands
    alert.removeCommand(doneCommand);
    alert.removeCommand(pauseCommand);

    // add command to play back or start a new recording
    alert.addCommand(startCommand);
    alert.addCommand(playbackCommand);

    // complete the recording
    completeRecording();

    // show message
    alert.setString("Press Start Recording to capture new audio or " +
      " Playback Recording to playback recorded audio");

  } else if(cmd == playbackCommand) {

    // remove the start recording command
    alert.removeCommand(startCommand);

    // start the playback
    playbackPlayer.start();
```

```
        // and set the message
        alert.setString("Playing back recorded audio");
      }
    } catch(Exception e) {
      error(e);
    }
  }

  private void completeRecording() throws Exception {

    // flush the output buffer
    bos.flush();

    // commit the recording
    recordControl.commit();

    // create the input buffer from the output buffer
    bis = new ByteArrayInputStream(bos.toByteArray());

    // create the playback player
    playbackPlayer =
      Manager.createPlayer(bis, recordControl.getContentType());

    // add a listener on it
    playbackPlayer.addPlayerListener(this);

    // and initialize the recording flag
    recording = false;

  }

  public void playerUpdate(Player player, String event, Object data) {

    // only listening on the playback player
    if(event.equals(PlayerListener.END_OF_MEDIA)) {

      // add the commands back
      alert.addCommand(startCommand);
      alert.addCommand(playbackCommand);
    }
  }

  // general purpose error method, displays onscreen as well to output
  private void error(Exception e) {
    alert.setString(e.getMessage());
    alert.setTitle("Error");
    display.setCurrent(alert);
```

```
    e.printStackTrace();
  }
}
```

Although the listing is long, it shows you how to control the recording using menu commands. Four commands are defined, `startCommand`, `pauseCommand`, `doneCommand`, and `playbackCommand`. The first three control the recording, and the last controls the playback of the recorded data. If you press the `pauseCommand`, it stops the recording for the moment, and when `startCommand` is pressed again, the recording starts from the point that you left off.

The main action takes place in the `commandAction()` method, where the four commands are handled. When the `startCommand` is handled, the recording is checked to see whether it's new or previously paused using the `recording` flag. For new recordings, new buffers are created, the location of the recording data is reinitialized, and the underlying recording `Player` instance is started. For previously paused recordings, all this is ignored, and only `startRecord()` method is called, which takes off from the previously paused recording location.

When the `pauseCommand` is called, the `stopRecord()` method of `RecordControl` is called, which, as you may realize now, only pauses the recording of the media data, while the underlying `Player` instance is still in the STARTED state.

The rest of the commands you should be familiar with, as they mimic the work you did in the previous section. The only other noteworthy code is in the `playerUpdate()` method, where a `Player` instance adds `startCommand` and `playbackCommand` back to the displayed alert, when the `END_OF_MEDIA` event is received.

Figure 8-7 shows the MIDlet in action on the Motorola C975 device.

Figure 8-7. *Controlled audio recording MIDlet in action on the Motorola C975*

As you can see, when you press Start, the user must give permission for the recording to be done. Make sure that you select the Yes, ask once option; otherwise, the MIDlet gives an exception if you do multiple recordings (if you select Yes, always ask). The permission is not requested when either the `capturePlayer` or `recordControl` instances are created or initialized, but it is requested when the output stream is set using the `setRecordStream()` method.

Note At this point, the Sun's emulator throws a deadlock issue. Because the `setRecordStream()` method may take a long time to return, it advises you to run this part of the code in a separate thread. This is only an issue on the Sun emulator, however, and most devices don't require separate threads. Creating new threads for simple tasks like this can be counterproductive on small memory footprint devices.

In the next section, you'll learn how to save the recorded data in a particular location, for playback at a later time, and not just in the present MIDlet session.

Saving Captured Audio

Captured audio can be saved to a couple of locations, depending upon the capabilities of your device. The easiest place to save the captured audio is the file system on the device itself, so that you can switch the device (or the MIDlet) off and still come back later and retrieve the recording from this persistent storage.

You can also save the data to another device (most likely a computer) using the serial port. This can be achieved by using the `CommConnection` interface defined in the `javax.microedition.io` package. This interface gives you an `OutputStream` (with the `openOutputStream()` method) to which you can direct the recorded data bytes using the `setRecordStream()` method. Of course, this means that on the other side, the receiving device must have a listener on this serial port that can receive these data bytes and store them for later use. The two devices must also be connected at all times via this port, for data to be stored and later retrieved as well. As you can see, saving this data to another device via the serial port throws several issues and is not the best option.

You can also store the data on the Internet using HTTP. Because the basics remain the same for storing audio, image, or video data, this type of storage is covered in the next chapter. This section shows you how to store the data on the device itself using the `FileConnection` API (JSR-75).

Note Strictly speaking, you don't need the `FileConnection` API for this to work, as you are not going to use any of the `FileConnection` API classes. However, depending on your implementation, you may or may not need to have this API in your `CLASSPATH` and available on your device. Further, access to the local file system requires permissions from the user that are similar to network access and audio/video/image capture, so you may end up requesting two sets of permissions when you run this MIDlet, one to access the file system, and one to capture audio.

Listing 8-7 shows how to store captured audio on the device's file system and how to retrieve it for playback. Although very similar to Listing 8-5, the difference is in the way the location of the final captured audio is specified.

Tip Listing 8-7 stores captured audio in the root folder of the device. The root folder can be found by using the `listRoots()` method of the class `FileSystemRegistry` from the `FileConnection` API. As stated before, however, you don't need this API in the `CLASSPATH` to access the file system for Listing 8-7, but you'll need it to find the root folder (unless you can get that information from the documentation for the device).

Listing 8-7. *Storing Captured Audio*

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import javax.microedition.media.control.RecordControl;

public class SaveCapturedAudioMIDlet extends MIDlet
  implements CommandListener {

  // the display items
  private Display display = null;
  private Alert alert = null;
  private Command exitCommand = null;

  // players and controls
  private Player capturePlayer = null;
  private Player playbackPlayer = null;
  private RecordControl rControl = null;

  private boolean error = false;

  public SaveCapturedAudioMIDlet() {

    // create the display
    display = Display.getDisplay(this);
    alert = new Alert("Message");
    alert.setTimeout(Alert.FOREVER);
    alert.setString("Capturing for 10 seconds. Say something intelligent!");
    exitCommand = new Command("Exit", Command.EXIT, 1);
    alert.addCommand(exitCommand);
    alert.setCommandListener(this);

    try {

      // create the capture player
      capturePlayer = Manager.createPlayer("capture://audio");

      if (capturePlayer != null) {

        // if created, realize it
        capturePlayer.realize();

        // and grab the RecordControl
        rControl = (RecordControl)capturePlayer.getControl(
          "javax.microedition.media.control.RecordControl");
```

```
        // set the alert as the current item
        display.setCurrent(alert);

        // if it is null throw exception
        if(rControl == null) throw new Exception("No RecordControl available");

        // and set the destination for this captured data
        // check your device documentation to find out the root.
        // The following will work on devices that have the root
        // specified as shown
        rControl.setRecordLocation("file:///test.wav");

      } else {
        throw new Exception("Capture Audio Player is not available");
      }

    } catch(Exception e) {
      error(e);
    }
  }

  public void startApp() {

    if(error) return;

    try {

      // first start the corresponding recording player
      capturePlayer.start();

      // and then start the RecordControl
      rControl.startRecord();

      // now record for 10 seconds
      Thread.sleep(10000);

      // stop recording after time is up
      rControl.stopRecord();

      // commit the recording
      rControl.commit();

      // stop the Player instance
      capturePlayer.stop();

      // and close it to release the microphone
      capturePlayer.close();
```

```
      // finally, create a Player instance to playback
      playbackPlayer = Manager.createPlayer("file:///test.wav");

      // and start it
      playbackPlayer.start();

    } catch(Exception e) {
      error(e);
    }
  }

  public void pauseApp() {
  }

  public void destroyApp(boolean unconditional) {
    if(capturePlayer != null) capturePlayer.close();
    if(playbackPlayer != null) playbackPlayer.close();
  }

  public void commandAction(Command cmd, Displayable disp) {
    if(cmd == exitCommand) {
      destroyApp(true);
      notifyDestroyed();
    }
  }

  // general purpose error method, displays onscreen as well to output
  private void error(Exception e) {
    alert.setString(e.getMessage());
    alert.setTitle("Error");
    display.setCurrent(alert);
    e.printStackTrace();
    error = true;
  }
}
```

The major changes are highlighted in bold. The code sets the location of the captured audio to a file called `test.wav` on the root folder of the underlying device file system. You'll get an error if this access is not supported. You'll also get an error if the file already exists, as you can see by running the listing twice (without changing the name of the file, see Figure 8-8). The new flag `error` doesn't run the `startApp()` method if there is a problem with either file system access or audio capture.

The location is set using the `setRecordLocation(String locator)` method. This listing runs perfectly on the BenQ M75 but fails on the Motorola C975 because it doesn't support file system access. However, note that the listing saves the file as a WAV file. If you refer to Table 8-2, you'll see that the only supported encoding for audio capture on the BenQ M75 is audio/amr. This seems like an anomaly, but is perfectly acceptable because the MMAPI specification allows implementations to change the format of recorded data. When you set the record location

with an extension of WAV, the format conversion is done by the implementation. You can save the data as `test.amr` as well (at least on the M75), without needing to do any format changes.

Figure 8-8 shows this MIDlet running on the M75.

Figure 8-8. *Storing captured audio on BenQ M75*

Capturing Audio from Existing Audio

Until now, you saw how audio is captured using the audio microphone on a device, by creating a `Player` instance using the special locator: `capture://audio`. This is fairly standard practice. The beauty of MMAPI is that you can use any `Player` instance to capture media data from, provided the instance gives you a `RecordControl` instance to work with. This is a great flexibility provided by MMAPI and allows you to, for example, create MIDlets that can read and record data from an existing format and convert to another. Another example may be for a MIDlet to capture media stored on the network and store it locally (with or without the change in formats).

Unfortunately, neither of the two actual devices supports provisioning `RecordControl` for existing audio data, and you'll have to use Sun's DefaultColorPhone emulator to test this in action. This is a simple matter of replacing

```
capturePlayer = Manager.createPlayer("capture://audio");
```

with

```
capturePlayer = Manager.createPlayer("http://www.somesite.com/media/file.amr");
```

or

```
capturePlayer = Manager.createPlayer("file:///root1/file.wav");
```

or

```
capturePlayer =
Manager.createPlayer(getClass().getResourceAsStream("/test.amr"),"audio/amr");
```

or something similar, in any of the listings so far, and you can test the capture of existing media.

Working with Video

A lot of the techniques discussed in the previous sections on audio apply to video as well because of the way the MMAPI is defined. The interfaces remain the same; what you do with the available data based on its type is the only thing that changes. For example, the methods and procedures defined in the previous sections on capturing audio data can be applied to video as well using the same `RecordControl` interface.

The major difference, of course, lies in the display of video. One special control, `VideoControl`, is used for this purpose, and it's augmented by the precise control provided by the `FramePositioningControl` control. `VideoControl` extends `GUIControl`, which is a generic control provided in case MMAPI implementations wanted to provide other methods of controlling and displaying GUI-based media data.

Displaying Video

`VideoControl`, which is the primary control for displaying video, is used to control how the video looks when displayed in a MIDlet, including its positioning and screen focus. As you might expect, the controls for playback, pause, rewind, and forward are provided by the underlying `Player` instance methods, and are therefore, generic.

The video formats you can display depend on your MMAPI implementation. Most implementations support MPEG-4, but an increasing number support 3GPP as well. Some may support proprietary formats. As you know, a full list of supported formats can be queried for by using the `getSupportedContentTypes(null)` method of the `Manager` class, which returns not only the supported formats for video, but the supported formats for all media types. With our target devices, the BenQ M75 supports only the 3GPP and MP4 video formats, whereas the Motorola C975 supports several formats, as you might recall from Chapter 2, Table 2-3, including 3GPP, MP4, and RealVideo.

Note MPEG-4 and MP4 mean the same thing. Similarly, video/mpeg4 and video/mp4 also define the same content type, however, different implementations may or may not accept one content type over another, so you have to test your videos to make sure the implementation accepts the content type. The same applies to video/3gpp and video/3gp content types.

`VideoControl` provides several methods to control the display of your video. Most of these methods provide control over the positioning of the video, but the main method that initializes the display is the one inherited from `GUIControl`. This method, `initDisplayMode(int mode, Object arg)`, provides the basis on which the video is displayed on the device screen. This method must be called only once for each video display (otherwise an `IllegalStateException` is thrown). Essentially, this method tells the implementation how you plan to display your video: as an embedded item in a `Form` or an independent display in a `Canvas`.

With MIDlet development, this is a powerful choice, and you are given the option to display your video in either a high-level, consistent environment (`Form`), or a low-level, precise display (`Canvas`). When added to a `Form`, the video is just another item in the display, whereas in a `Canvas`, you can work with the video and have more control over its positioning and display, including access to the `Graphics` object.

This choice is expressed using the mode argument. There are two valid constant values defined in the current specification for this argument: USE_GUI_PRIMITIVE and USE_DIRECT_VIDEO. The former is defined in the GUIControl interface, and you use this value when you want to embed your video in a Form. The latter is defined in the VideoControl interface, and you use it when you want to embed video in a Canvas. Because VideoControl extends GUIControl, it also gets to use the USE_GUI_PRIMITIVE mode. By defining USE_GUI_PRIMITIVE in the GUIControl interface, the option is left open for other GUI-based controls to use this mode.

The name USE_GUI_PRIMITIVE suggests that the video must be displayed on a primitive GUI. This is true, and the actual GUI component on which the video will be displayed is returned by the initDisplayMode() method. For Liquid Crystal Display User Interface (LCDUI), it returns an Item object, which can be attached to a Form instance using the append() method. For other environments (for example, CDC, which supports the Abstract Windows Toolkit), it returns a java.awt.Component object. When the mode is USE_DIRECT_VIDEO, the method returns null, because the object on which the video must be displayed is specified by the second parameter to the initDisplayMode() method, and it must be of the Canvas type (or a subclass). For USE_GUI_PRIMITIVE mode, this second parameter can either be null or the fully qualified class name of a GUI primitive (such as java.awt.component if available).

Listing 8-8 creates a MIDlet that allows you to display video on either a Canvas or a Form.

Listing 8-8. *Display Video in a Form or a Canvas*

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import javax.microedition.media.control.*;

public class DisplayVideoMIDlet extends MIDlet implements CommandListener {

  // the list to show the choice - form or canvas
  private List list = null;

  // the canvas to display the video on
  private Canvas canvas = null;

  // the form to add the video to
  private Form form = null;

  // a string item to add to form
  private StringItem descriptionItem = null;

  // the video player
  Player player = null;

  // commands
  private Command backCommand = null;
  private Command exitCommand = null;
```

```
// alert to show messages on
private Alert alert = null;

// and the display
private Display display = null;

// a flag to indicate error
private boolean error = false;

public DisplayVideoMIDlet() {

  // create the visual elements
  display = Display.getDisplay(this);
  exitCommand = new Command("Exit", Command.EXIT, 1);
  backCommand = new Command("Back", Command.ITEM, 1);

  // VideoCanvas is a non public class in this file
  canvas = new VideoCanvas();
  canvas.addCommand(exitCommand);
  canvas.addCommand(backCommand);
  canvas.setCommandListener(this);

  // create the form and add items and commands to it
  form = new Form("Video Form", null);
  descriptionItem = new StringItem("Desc: ", "Sydney Harbour - Bad audio");
  form.append(descriptionItem);
  form.addCommand(exitCommand);
  form.addCommand(backCommand);
  form.setCommandListener(this);

  // create the list
  list = new List("Pick One", List.IMPLICIT);
  list.append("Play Video on Form", null);
  list.append("Play Video on Canvas", null);
  list.addCommand(exitCommand);
  list.setCommandListener(this);

  // and an alert for errors
  alert = new Alert("Error");
}

public void startApp() {
  if(error) return;
  display.setCurrent(list); // show the list if no errors
}

public void pauseApp() {
}
```

```
public void destroyApp(boolean unconditional) {
  // close the player instance
  try {
    if(player != null) player.close();
  } catch(Exception e) {
    error(e);
  }
}

public void commandAction(Command cmd, Displayable disp) {

  // if exit
  if(cmd == exitCommand) {
    destroyApp(true);
    notifyDestroyed();
  } else if(cmd == backCommand) { // if the user clicks back

    // close the player instance
    try {
      if(player != null) player.close();
    } catch(Exception e) {
      error(e);
    }

    // display the list
    display.setCurrent(list);

    // and return
    return;
  }

  // implicit list handling
  try {

    // first load the Player instance
    loadPlayer();

    if(list.getSelectedIndex() == 0) { // form video

      // extract the GUIControl
      GUIControl guiControl = (GUIControl)player.getControl(
        "javax.microedition.media.control.GUIControl");

      // if not found, throw error
      if(guiControl == null) throw new Exception("No GUIControl!!");
```

```
        // add as a video item by initializing it to use GUI Primitive
        Item videoItem =
          (Item)guiControl.initDisplayMode(
            GUIControl.USE_GUI_PRIMITIVE, null);

        // insert at first place
        form.insert(0, videoItem);

        // show the form
        display.setCurrent(form);

        // finally start the player instance
        player.start();
      } else {  // canvas video

        // grab the videocontrol
        VideoControl videoControl = (VideoControl)player.getControl(
          "javax.microedition.media.control.VideoControl");

        // if not found throw error
        if(videoControl == null) throw new Exception("No VideoControl!!");

        // initialize to use direct video and show on canvas
        videoControl.initDisplayMode(VideoControl.USE_DIRECT_VIDEO, canvas);

        // make sure it is displayed full screen
        // not all devices support this, if your device is having trouble
        // showing the video, comment this line
        videoControl.setDisplayFullScreen(true);

        // must make the control visible
        videoControl.setVisible(true);

        // now show the canvas
        display.setCurrent(canvas);

        // and start the player
        player.start();
      }
    } catch(Exception e) {
      error(e);
    }
  }

  private void loadPlayer() throws Exception {
```

```
    // loads the Player on this MP4 file.
    // IMPORTANT: Change content type here for C975 to video/mp4
    // and M75 to video/mpeg4 or use Netbeans device fragmentation
    // feature
    player = Manager.createPlayer(
      getClass().getResourceAsStream(
        "/media/video/chapter8/sydharbour.mp4"), "video/mpeg4");

    player.realize();
  }

  // general purpose error method, displays onscreen as well to output
  private void error(Exception e) {
    alert.setString(e.getMessage());
    alert.setTimeout(Alert.FOREVER);
    display.setCurrent(alert);
    e.printStackTrace();
    error = true;
  }
}

// VideoCanvas that is the container for the video
class VideoCanvas extends Canvas {
  public void paint(Graphics g) {
    // does nothing..
  }
}
```

Tip If you have trouble running this video, comment out the line that sets the video to full screen mode. Many devices don't support full screen mode and throw a `MediaException`.

When the MIDlet is run, it gives you two choices: either run your video in a `Form` or run it in a `Canvas`. The user's choice is handled in the `commandAction()` method, which realizes a `Player` instance with the said video by calling the `loadVideo()` method. This is done each time the choice is made, because once initialized with the display mode, the same `Player` instance can't be reinitialized with the `initDisplayMode()` method. This is also the reason why each `Player` instance is closed when the user presses the Back button.

You'll notice that for the `Form` video, the control extracted from the `Player` instance is of the type `GUIControl`. Although correct, this is not necessary. Instead, you should extract `VideoControl` each time a video `Player` instance is created. Recall that `VideoControl` extends `GUIControl`, so if you wanted to add your video to a `Form` instance, you can still initialize it by using the `initDisplayMode()` method and passing it the inherited constant `USE_GUI_PRIMITIVE`. Further, by using `VideoControl`, you get access to the positioning methods of this control as well (although how useable they may be considering that the video is embedded in a `Form` object is another matter).

Finally, note that when displayed in a `Canvas`, the `setVisible(true)` method of the `VideoControl` must be called for the video to be displayed. By calling the same method with a value of false, you can make the video disappear.

Figure 8-9 shows this MIDlet running in the Motorola C975 device.

Figure 8-9. *Video playback on a canvas on the Motorola C975*

Positioning Video and Controlling Volume

When you're playing back video, you not only get access to the `VideoControl`, but because there is likely to be an audio component in the video as well, you also get access to all the controls that are accessible to sampled audio media data. Thus, you can easily set the volume or change the pitch of the accompanying audio, provided these controls are exposed.

Changing the volume or the pitch is one thing, and positioning the video is another. To position your video in a `Canvas`, you need to use the positioning methods provided by `VideoControl`. These methods, `setDisplayLocation(int x, int y)`, `setDisplaySize(int width, int height)`, and `setDisplayFullScreen(boolean fullScreenMode)`, are only applicable when using direct video on a `Canvas` (with the `USE_DIRECT_VIDEO` mode). On a `Form`, you are restricted by the amount of screen space that the underlying implementation allocates to `Form` items, and these methods usually return without doing anything.

You can query the size and position of your video by using the size and positioning methods, such as `getDisplayHeight()`, `getDisplayWidth()`, `getDisplayX()`, and `getDisplayY()`. If you change the position and size of your video to fit in any way on your canvas, you can use the `getSourceWidth()` and `getSourceHeight()` methods to find out the actual width and height of your video.

Note that all the size and positioning methods work relative to the component on which the video is displayed, such as a `Canvas`, and *not* relative to the device screen.

Listing 8-9 shows the code for a MIDlet that allows you to move your video in the vertical space after displaying it in the center of the display screen. It also allows you to mute the volume by using the exposed `VolumeControl`.

Listing 8-9. *Moving Video in Vertical Space and Muting Volume*

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import javax.microedition.lcdui.game.GameCanvas;
```

```
import javax.microedition.media.control.VideoControl;
import javax.microedition.media.control.VolumeControl;

public class MoveableVideoMIDlet extends MIDlet implements CommandListener {

  // all the controls and containers
  private Player player = null;
  private VideoControl videoControl = null;
  private VolumeControl volControl = null;

  private MovableVideoCanvas canvas = null;
  private Command exitCommand = null;
  private Command stopAudioCommand = null;

  private Display display = null;
  private Alert alert = null;

  private boolean error = false;

  public MoveableVideoMIDlet() {

    // create the alerts, canvas and displays
    display = Display.getDisplay(this);

    alert = new Alert("Error");
    exitCommand = new Command("Exit", Command.EXIT, 1);
    alert.addCommand(exitCommand);
    alert.setCommandListener(this);

    // load the Player and then the Volume and VideoControl
    try {

      // change content type for different devices, mp4 for C975, mpeg4 for M75
      player = Manager.createPlayer(getClass().getResourceAsStream(
        "/media/video/chapter8/sydharbour.mp4"), "video/mp4");
      player.realize();

      // realize the two controls
      videoControl = (VideoControl)player.getControl(
        "javax.microedition.media.control.VideoControl");
      volControl = (VolumeControl)player.getControl(
        "javax.microedition.media.control.VolumeControl");
    } catch (Exception e) {
      error(e);
    }

    if(!error) {
```

```
    // if no error, create the canvas and add commands to it
    canvas = new MovableVideoCanvas();
    canvas.setVideoControl(videoControl);
    stopAudioCommand = new Command("Stop Audio", Command.SCREEN, 1);

    canvas.addCommand(exitCommand);
    canvas.addCommand(stopAudioCommand);
    canvas.setCommandListener(this);

    // initialize the VideoControl display
    videoControl.initDisplayMode(VideoControl.USE_DIRECT_VIDEO, canvas);

    // and position it in the center of the canvas
    int halfCanvasWidth = canvas.getWidth()/2;
    int halfCanvasHeight = canvas.getHeight()/2;

    try {
      videoControl.setDisplayFullScreen(false);
      videoControl.setDisplaySize(halfCanvasWidth, halfCanvasHeight);
      videoControl.setDisplayLocation(halfCanvasWidth/2, halfCanvasHeight/2);
      videoControl.setVisible(true);
    } catch(Exception e) {
      error(e);
    }
  }
}

public void startApp() {

  if(error) return;

  try {
    player.start();
  } catch(Exception e) {
    error(e);
  }
  display.setCurrent(canvas);
}

public void pauseApp() {
}

public void destroyApp(boolean unconditional) {
  try {
    if(player != null) player.close();
  } catch(Exception e) { error(e); }
}
```

```
  public void commandAction(Command cmd, Displayable disp) {
    if(cmd == exitCommand) {
      destroyApp(true);
      notifyDestroyed();
    } else if(cmd == stopAudioCommand) { // if stop audio, mute VolumeControl
      if(volControl != null) volControl.setMute(true);
    }
  }

  // general purpose error method, displays onscreen as well to output
  private void error(Exception e) {
    alert.setString(e.getMessage());
    alert.setTitle("Error");
    display.setCurrent(alert);
    e.printStackTrace();
    error = true;
  }
}

// MovableVideoCanvas that is the container for the video
class MovableVideoCanvas extends GameCanvas {

  // VideoControl that will be managed
  private VideoControl videoControl = null;

  // distance to move
  private int dx, dy = 2;

  public MovableVideoCanvas() {
    super(false); // do not supress key events
  }

  void setVideoControl(VideoControl videoControl) {
    this.videoControl = videoControl;
  }

  public void paint(Graphics g) {
    // clear the screen first
    g.setColor(0xffffff);
    g.fillRect(0, 0, getWidth(), getHeight());

    // and flush off screen buffer to actual screen
    flushGraphics();
  }

  public void keyPressed(int keyCode) {
```

```
    // handles the user's interaction with the screen by capturing key press
    int gameAction = getGameAction(keyCode);
    int y = videoControl.getDisplayY();

    // only move in vertical direction
    if(gameAction == UP) {
      y -= dy;
    } else if(gameAction == DOWN) {
      y += dy;
    }

    // set the new location of the video
    videoControl.setDisplayLocation(videoControl.getDisplayX(), y);

    // and repaint
    repaint();
  }

}
```

This listing uses a `Canvas` class that is extended from `GameCanvas`. This class has an offscreen buffer that may help minimize flicker and is better for displaying video in a `Canvas` than the generic `Canvas` class, especially when you are going to move the video around as is the case here. When the user presses the Up or Down keys, the `VideoControl` is positioned and the screen cleared and repainted to display the video in the new up or down location.

The `stopAudioCommand` is handled by using the exposed `VolumeControl` and setting it to mute using the `setMute()` method of this control.

Figure 8-10 shows the resultant video in the Motorola C975 device.

Figure 8-10. *Moving video around and muting audio*

Capturing Video and Images

Capturing video is not terribly different from capturing audio, as you would expect, because both use the same `RecordControl` control to achieve the result. However, with video, you can also take a snapshot of a video. This is where capturing video differs from capturing audio: Taking a snapshot doesn't require a `RecordControl`, but is accomplished using a method in `VideoControl`.

The getSnapshot() method in VideoControl allows you to take a snapshot of the image that is playing on the device screen. Of course, because the getSnapshot() method is a method of the VideoControl class, you can take an image of any video that is playing on a device screen, not just captured video. The method returns the image data as a byte array, which you can then manipulate in any way you want using the LCDUI Image class.

In this section, you'll apply the methods learned in the previous sections, including capturing media data using RecordControl and displaying video using VideoControl. However, as opposed to capturing audio, capturing and displaying video must be done simultaneously so that the user can see what is actually being recorded.

So, can you just hook into the camera, without actually recording anything, to first show the user the view through the video? Of course!

Looking Through the Viewfinder

As you may expect by now, the locator to hook into a device camera takes the form of capture://video. This gives you a Player instance that returns video in the default format. The Motorola C975 doesn't support video capture, but the default (and the only) format supported by the BenQ M75 device is video/3gpp.

Note As you'll see shortly, even though the Motorola C975 device doesn't support video capture, it allows you to look through the viewfinder of the onboard camera (possibly because it supports camera snapshots).

After you have a Player instance hooked into a video camera, it's a simple matter of extracting a VideoControl from it to look through its viewfinder and display this video to the user. Note that to look through a viewfinder, you need to use a VideoControl and not a RecordControl, because you are not recording anything (yet).

As before, you can use a Canvas to display the video through the viewfinder to the user. Because you are not going to move the video around, you can either use a GameCanvas or a normal Canvas.

Listing 8-10 shows the code for plugging into the device's viewfinder and displaying it on a canvas. At this point, this is all the MIDlet does, but you'll extend it in the next sections to take a snapshot and capture video.

Listing 8-10. *Looking Through a Camera's Viewfinder and Displaying Onscreen*

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;
import javax.microedition.media.control.VideoControl;

public class CaptureVideoAndImageMIDlet extends MIDlet
  implements CommandListener {
```

```
// initialize the player and the canvas
private CaptureVideoCanvas canvas = null;
Player capturePlayer = null;

// and the other variables
private Alert alert = null;
private Command exitCommand = null;
Display display = null;
private boolean error = false;

public CaptureVideoAndImageMIDlet() {

  // create the display items
  alert = new Alert("Message");
  display = Display.getDisplay(this);
  exitCommand = new Command("Exit", Command.EXIT, 1);

  // create the video capture player
  try {
    capturePlayer = Manager.createPlayer("capture://video");
    capturePlayer.realize();

    // now create the canvas
    canvas = new CaptureVideoCanvas(this);
    canvas.addCommand(exitCommand);
    canvas.setCommandListener(this);
  } catch(Exception e) {
    error(e);
  }
}

public void startApp() {

  // if error, return
  if(error) return;

  // start the player
  try {
    capturePlayer.start();
  } catch(Exception e) { error(e); }

  // and set the canvas as the current item on display
  display.setCurrent(canvas);
}
```

```
  public void pauseApp() {
    try {
      if(capturePlayer != null) capturePlayer.stop();
    } catch(Exception e) {}
  }

  public void destroyApp(boolean unconditional) {
    if(capturePlayer != null) capturePlayer.close();
  }

  public void commandAction(Command cmd, Displayable disp) {
    if(cmd == exitCommand) {
      destroyApp(true);
      notifyDestroyed();
    }
  }

  // general purpose error method, displays onscreen as well to output
  void error(Exception e) {
    alert.setString(e.getMessage());
    alert.setTitle("Error");
    display.setCurrent(alert);
    e.printStackTrace();
    error = true;
  }
}

// the canvas that holds the video
class CaptureVideoCanvas extends Canvas {

  // the base midlet
  CaptureVideoAndImageMIDlet midlet = null;

  // the video control
  private VideoControl videoControl = null;

  public CaptureVideoCanvas(CaptureVideoAndImageMIDlet midlet)
    throws Exception {

    this.midlet = midlet;

    // initialize the video control
    videoControl =
      (VideoControl)midlet.capturePlayer.getControl(
        "javax.microedition.media.control.VideoControl");
```

```
    // if not present, throw error
    if(videoControl == null)
      throw new Exception("No Video Control for capturing!");

    // init display mode to use direct video and this canvas
    videoControl.initDisplayMode(VideoControl.USE_DIRECT_VIDEO, this);

    try { // try and set to full screen
      videoControl.setDisplayFullScreen(true);
    } catch(MediaException me) {
      // but some devices may not support full screen mode
      videoControl.setDisplayLocation(5, 5);
      try {
        videoControl.setDisplaySize(getWidth() - 10, getHeight() - 10);
      } catch(Exception e) {}
      repaint();
    }

    // and make the video control visible
    videoControl.setVisible(true);
  }

  public void paint(Graphics g) {

    // clear background
    g.setColor(0xffffff);
    g.fillRect(0, 0, getWidth(), getHeight());

    // and draw a rectangle with a different color
    g.setColor(0x44ff66);
    g.drawRect(2, 2,  getWidth() - 4, getHeight() - 4);
  }
}
```

When the CaptureVideoCanvas is created, it uses the MIDlet's capturePlayer to extract the VideoControl. CaptureVideoCanvas then initializes this control and tries to set the control to display full screen. If that fails, a display is created that is bounded by a rectangle through the paint() method. As you can see, the listing doesn't require RecordControl to plug in to the camera's viewfinder and just uses the VideoControl control exposed by the camera Player instance.

If you run this listing in the Sun's DefaultColorPhone emulator, you'll get a simulated video capture as can be seen in Figure 8-11.

Figure 8-11. *Simulated video capture on Sun's DefaultColorPhone emulator*

Of course, the actual devices don't give simulated but actual views, as can be seen in Figure 8-12. Also note the difference in Figures 8-11 and 8-12 with regard to the screen size. The emulator doesn't support full-screen display (through the `setDisplayFullScreen()` method) whereas the devices do.

Figure 8-12. *Looking through the viewfinder in BenQ M75 and Motorola C975 devices*

Taking Snapshots

Taking a snapshot is now easy, given that you only need to use the `getSnapshot(String imageFormat)` method of the `VideoControl` control. The format of the desired image can be specified using the encoding strings that your device supports, but if you just want the default format, then pass a `null` value. Both the Motorola C975 and BenQ M75 devices support jpeg (or image/jpeg), and this is the only option supplied.

Let's now modify Listing 8-10 and add code that will take a snapshot when the user presses the Action key (also called the Fire key). To accomplish this, the listing needs to add the `keyPressed(int keyCode)` method to the `CaptureVideoCanvas` class. This method is shown here:

```
public void keyPressed(int keyCode) {

  // see what game action key the user has pressed
  int key = getGameAction(keyCode);

  // if fire, take a snapshot
  if(key == FIRE) {
    try {
      // use the control to take the picture, using the default encoding
      byte[] imageArray = vControl.getSnapshot(null);

      // create an image using the LCDUI Image class
      Image image = Image.createImage(imageArray, 0, imageArray.length);

      // make this image a part of an Alert
      Alert imageAlert =
        new Alert("Snapshot", "", image, AlertType.INFO);

      // show this alert for 5 seconds
      imageAlert.setTimeout(5000);

      // and show this alert
      midlet.display.setCurrent(imageAlert);

    } catch(Exception e) {
      midlet.error(e);
    }
  }
}
```

After taking the byte array that the `getSnapshot()` method creates, this method creates an image using the `createImage()` method of the `Image` class (from LCDUI). After this, it really depends on what you want to do with this image. You can save it to a local file system as you saw in the saving audio section, send it to a remote server via HTTP, or as I've done here, simply attach it to an `Alert` object and show the user the captured image for five seconds.

Note that when the device executes the `getSnapshot()` method, it requires permission from the user for taking the image. This permission is `javax.microedition.media.control.VideoControl.getSnapshot` and can be requested in the MIDlet's JAD file, as you saw in Chapter 5.

Capturing Video Clips

Video clips are captured by acquiring a `RecordControl` on the camera `Player` instance, and then following the principles discussed in the "Capturing Audio" section. Of course, after the video is captured, you may need to display it to the user, which requires either a video `Canvas` or a `Form`, the same concepts discussed in displaying video. The following code snippet is added to Listing 8-10 and allows the user to start and stop recording clips by pressing the Up and Down keys on a device. Displaying the clip to the user is left as an exercise for you.

Note The listing adds some new variables that are not in the original listing. The source code contains the full code in the Downloads section of the Apress Web site at *http://www.apress.com*.

```
} else if(key == UP) {

  // start recording
  try {

    // grab a record control
    rControl = (RecordControl)midlet.capturePlayer.getControl(
        "javax.microedition.media.control.RecordControl");

    // if not found, throw exception
    if(rControl == null) throw new Exception("No RecordControl found!");

    // create a ByteArrayOutputStream to store this recorded data in
    bos = new ByteArrayOutputStream();

    // set up the stream
    rControl.setRecordStream(bos);

    // and start recording - no need to start the underlying player
    // as it is already started
    rControl.startRecord();

    // set flag
    recording = true;
  } catch(Exception e) {
    midlet.error(e);
  }
} else if(key == DOWN) {

  try {
    rControl.stopRecord();
    rControl.commit();

    // do what is required with the byte array now, save it, display to user
    // or discard

    // reset the recording flag
    recording = false;
  } catch(Exception e) {
    midlet.error(e);
  }
}
```

This code snippet is added to the keyPressed() method of the CaptureVideoCanvas, along with the FIRE key event discussed in the previous section, to capture snapshots.

Seeking Video Frames with FramePositioningControl

Recall from Chapter 3 that you can fast forward or rewind through a Player instance by using the setMediaTime() method. With video media data, there is another way to go forward or back and that is by using the FramePositioningControl control, which allows you to seek individual frames within this data. Both methods of seeking data inherently do the same thing, that is, move the media time.

The FramePositioningControl control provides a simple way to seek frames by using the method seek(int frameNumber). This method doesn't throw any exceptions, which may be surprising considering that you could pass it any arbitrary value. However, if you pass it a negative value, the video stops at the first frame (the 0th frame); if you give it a value larger than the number of frames in the video, it stops at the last frame. Of course, if the video stops playing because it has reached the last frame, the Player state transitions from STARTED to STOPPED, and the right event is broadcast to registered listeners.

When the frame seek operation is done, you can query the current media time of the video by using the getMediaTime() method of the Player instance, which is updated by the seek() method to reflect time at the new frame. You can skip frames using the skip(int framesToSkip) method, which works similar to the seek() method. The difference is that if skip() is called on a Player instance that is in the STARTED state, then the number of frames that will be skipped cannot be known to an exact degree because a STARTED Player instance is in the process of changing frames when the method is called.

This control also provides methods to convert media time to frame numbers and vice versa. This is useful when you don't actually want to transition to a new frame, but just want to calculate the media time between different frames. You can use the methods mapTimeToFrame (long mediaTime) and mapFrameToTime(int frameNumber) as required. Both these methods will return -1 if mapping is unsuccessful and use microseconds (not milliseconds) as the unit of time measurement.

Streaming Media

Most of you are familiar with streaming media over the Internet. When you play video or audio from a favorite multimedia site, you are streaming media, which in many cases is based on HTTP. Streaming media occurs when the media data isn't downloaded on the host computer, but only sections of it are, leading to on-demand and live broadcast. Streaming media via HTTP is inefficient and doesn't allow seeking operations because it's based on TCP. Most professional streaming media solutions rely on the Real Time Transport Protocol (RTSP), which is User Datagram Protocol (UDP) based. Many MMAPI implementations support RTSP for streaming data, so in this section, you'll learn how to use it.

Note that when you create a Player instance with an HTTP-based locator, depending on the media type, it may resort to streaming as well, instead of downloading the entire contents. HTTP-based streaming doesn't preclude the idea of actually streaming the contents, it's just that it is inefficient.

To plug into streaming data, you need to work with a streaming server. Specialized servers abound, including RealTime Server (*http://www.realnetworks.com*), Apple's Darwin streaming server (*http://developer.apple.com/darwin/projects/streaming/*), and Helix (*http://www.helixcommunity.org*). For the example in this section, the streaming service provided by the BBC's live radio broadcast (*http://www.bbc.co.uk/radio/*) is used.

A streaming media Player instance is created by using the special locator string: rtsp://<path-to-server>/<path-to-file-on-server>. Thus, RTSP is the protocol, but the rest of the locator string resembles HTTP for accessing files.

Sadly, not many devices support RTSP, including the Motorola C975 (even though it says it does) and BenQ M75. However, you can use Listing 8-11 to run in any device that does support it, and tune into the BBC service.

Listing 8-11. *Streaming Media over the Network*

```
package com.apress.chapter8;

import javax.microedition.midlet.*;
import javax.microedition.lcdui.*;
import javax.microedition.media.*;

public class StreamingMediaMIDlet extends MIDlet {

  private Player player = null;
  private Display display = null;
  private Alert alert = null;

  private boolean error = false;

  public StreamingMediaMIDlet() {

    display = Display.getDisplay(this);
    alert = new Alert("Message");

    // try and create a Player instance for RTSP
    try {

      player = Manager.createPlayer(
        "rtsp://rmv8.bbc.net.uk/radio1/lockup.ra");

      if(player == null)
        throw new Exception("Could not create player for streaming");

      player.realize();

    } catch(Exception e) {
      error(e);
    }
  }
```

```
  public void startApp() {
    if(error) return;

    try {
      player.start();
    } catch(Exception e) {
      error(e);
    }

    alert.setString("Playing streaming radio from BBC");
    display.setCurrent(alert);
  }

  public void pauseApp() {
  }

  public void destroyApp(boolean unconditional) {
    if(player != null) player.close();
  }

  // general purpose error method, displays onscreen as well to output
  private void error(Exception e) {
    alert.setString(e.getMessage());
    alert.setTitle("Error");
    display.setCurrent(alert);
    e.printStackTrace();
    error = true;
  }
}
```

As you can see, there is nothing of note in this code, and you have learned to create `Player` instances like this several times over. This is the beauty of the MMAPI implementation because it permits several protocols and formats to be played using similar coding techniques.

Finally, note that the radio streaming via the BBC service uses the Real Networks real audio file for streaming. This means that the device you run this MIDlet on must not only support RTSP, but be able to recognize and play the real audio content type as well. Of course, this media format doesn't have to be real audio, and can be any other audio or even video format. For video streaming data, you can easily create a `VideoControl` on the data and display it to the user, as you have learned to do in the "Working with Video" section of this chapter. You can even create a `RecordControl` on this data, and record it to the local file system, as discussed in the "Capturing Audio" and "Capturing Video and Images" sections. It just depends on what options are available to your device.

Summary

This chapter should have brought one point to the forefront about MMAPI: It truly is protocol and format agnostic. Different devices support different formats and protocols, but the basics of using these varied formats and protocols remain the same.

This chapter brought to a conclusion the discussion on the various media types that are supported by MMAPI by focusing on the two main types: audio and video. You learned to query, display, control, record, save, and stream these two types using a variety of examples. You also saw the frailty of the MMAPI implementations currently present in the development world. In fact, I had to change devices midstream because one of the chosen devices didn't do what it was supposed to do. This is an important lesson: Test all code in the chosen device!

The next and final chapter will show you a case study that covers some of the concepts discussed so far to create an audio, image, and video blogging MIDlet.

CHAPTER 9

Case Study: Device Blogging

If you haven't been bit by the blogging bug yet, then blogging from your mobile phone is sure to make you give this exciting technology a try. Blogging allows you to post your ideas, experiences, and thoughts in an online journal-like medium, allowing for instantaneous access to the entire world. Couple this with integrated multimedia blogs and, in the case of mobile blogging, anywhere, anytime access, and you provide a richer, more involved user experience.

This chapter is a case study that details how to bring together the knowledge that you have gained in the rest of the book, especially concerned with audio/video/image capture and playback using MMAPI, and put that knowledge to good use by building a mobile blogging MIDlet called Device Blog. Device Blog will allow you to blog text-, audio-, image-, and video-based blog entries directly from your mobile phone or device.

About the Companion Web Site

Creating a mobile blogging application without an actual live Web site against which you can practice is not much fun. The issues that arise in posting blog entries to the server may not impact much on your knowledge of MMAPI, but it's nonetheless instructive to test your ideas in a live environment. Therefore, the companion Device Blog site, which is a very simple blog entries display site, lists the entries posted to it in a sequential order, along with any multimedia components. You can test the Device Blog MIDlet that you will build in this chapter against this site at *http://www.mmapibook.com/deviceblog/index.jsp*.

Besides the index page, the Device Blog site also contains other Java Server Page (JSP) based files, which allow a user to register, log in, and post entries to it. These pages are meant to be accessed from a mobile device, but to keep things simple, no checks are done if requests are made from other direct sources as well.

The Finished MIDlet in Action

Before you learn to build the Device Blog MIDlet, take a look at the final views in some of the devices as shown in the upcoming figures. This storyboard of sorts will also serve as a Use Case for this MIDlet application.

MIDlet Startup

At startup, the MIDlet presents three choices to the user: Login, Register, and Create Blog Entry. This is shown in Figure 9-1 across the Motorola C975 device, the BenQ M75 device, and Sun's DefaultColorPhone emulator.

Figure 9-1. *Starting the Device Blog MIDlet*

Registering with the Device Blog Web Site

The user can choose to register with the Device Blog server by selecting the Register option. The link to register is supplied in the MIDlet's JAD file as a system property: *http://www.mmapibook.com/deviceblog/register.jsp*. When the user selects the Register option, the screen shown in Figure 9-2 appears.

Figure 9-2. *Registering with the Device Blog Web site*

The user enters the desired values, which are just the username and password (with a confirm password field as well), to keep things simple and interaction fast.

Of course, because the mobile device interacts with the server, access over the Internet is required and permission from the user is requested, as shown in Figure 9-3. This applies not just for registration, but for logging in and posting blog entries as well.

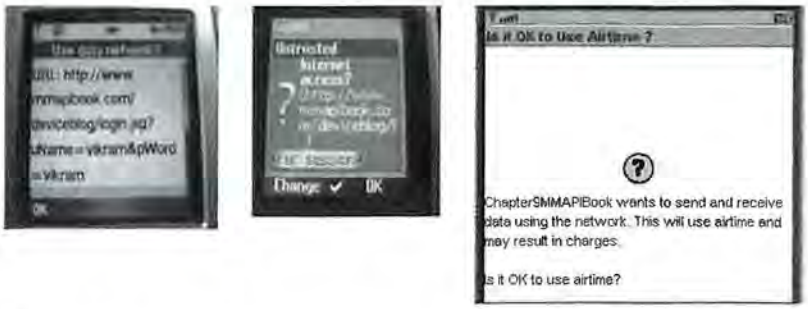

Figure 9-3. *Accessing the Internet requires user permission.*

The server sends back messages such as "Registered" for successful registration, "Username exists" for duplicate usernames, and any other error messages for protocol or network issues. Internet access is not attempted for nonmatching passwords and incomplete fields, which are handled at MIDlet level.

Logging in to Device Blog Web Site

After a successful registration, the user can log in. Note that the user cannot create a blog entry (the third option in Figure 9-1) until the user has registered and/or logged in first. The login screens are shown in Figure 9-4.

Figure 9-4. *Logging on to the Device Blog Web site*

As you may notice, the login and registration screens look remarkably similar; this common interface keeps things simple.

The login URL is *http://www.mmapibook.com/deviceblog/login.jsp* and is read from the MIDlet's JAD file.

The server's response will be either "Logged In", "Username not found. Please register", or "Invalid Password!", as the case may be. Figure 9-5 shows the screens for a successful login.

Figure 9-5. *Successful login to the Device Blog Web site*

Creating and Posting Blog Entries

By selecting the Create Blog Entry option, the user is presented with another screen where the choices allow the user to create one of four types of entries: Text Only, Audio, Image, and Video (see Figure 9-6).

Figure 9-6. *Selecting the entry type for posting to the Device Blog Web site*

Of course, not all phones support all the options, especially, video. The user is informed of this when selecting this option, as shown in Figure 9-7 on the Motorola C975 device, which as you may recall from Chapter 8, doesn't support video recording.

Figure 9-7. *Video recording is not supported on Motorola C975.*

As you may recall, the Sun DefaultColorPhone emulator doesn't support video recording either, and you'll get the same message in that if you select the video option.

Text Only

The text only option is the simplest and allows the user to write a title and an associated message as shown in Figure 9-8.

Figure 9-8. *Creating a text-only entry*

After the user selects the OK menu option, a preview of the entry appears as shown in Figure 9-9.

Figure 9-9. *Preview the text-only blog entry.*

At this point, the user can discard this entry, edit the text again, or post the entry to the server. These choices are the same throughout and apply to all types of blog entries. These choices are shown in Figure 9-10 in Sun's DefaultColorPhone emulator.

Figure 9-10. *User presented with blog entry choices*

Choosing Edit Text takes the user back to the screen shown earlier in Figure 9-8. Choosing Discard Entry takes the user to the startup screen. Finally, Post Entry makes the connection to the server and posts the entry.

The URL for posting entries is picked up from the JAD file: *http://www.mmapibook.com/deviceblog/postentry.jsp*. The resultant message is shown to the user on the screen; for a successful post, it reads "Posted". At this point, the startup screen is shown to the user.

As expected, these choices and actions remain the same for any type of blog entry.

Audio

Recording audio requires permission from the user; therefore, before the record audio screen is shown, the MIDlet shows the permissions screen (see Figure 9-11).

Figure 9-11. *Getting permission from the user for recording audio*

Of course, all three media types require the user to grant these permissions. The user has the choice of granting the permissions only once or for the session, in which case, he won't be prompted for them again.

After the permission is given, the recording canvas is shown, which automatically starts recording audio and doesn't finish until the user selects the Done menu item. These two stages are shown in Figure 9-12 on the Motorola C975 device.

Figure 9-12. *Recording and previewing audio on the Motorola C975 device*

As you can see, when the user presses the Done menu item, the device previews the recorded audio by playing it back. At this point, the user can discard the entry, add text to it by selecting edit text, or post it to the server; the same choices that were discussed in the last section.

Image

For image recording and previewing, first the user is shown the viewfinder of the onboard camera and then shown the associated snapshot that is taken when the user presses the Done menu item. This process is shown in Figure 9-13 on the Motorola C975 device and in Figure 9-14 on the BenQ M75 device.

Figure 9-13. *Capturing and previewing images on the Motorola C975 device*

Figure 9-14. *Capturing and previewing images on the BenQ M75 device*

The user choices at this point remain the same as described in the previous sections.

Video

Video capture via MMAPI is not supported on too many devices. Fortunately, the BenQ M75 does support it in a limited way. Figure 9-15 shows the video capture and preview process in this device.

Figure 9-15. *Capturing and previewing video on the BenQ M75 device*

As expected, the options at this point remain the same: Discard Entry, Edit Text, or Post Entry.

Creating the MIDlet Design

To create the finished MIDlet's client application using the storyboard ideas penned in the last section, I'm using the Model-View-Controller (MVC) pattern, popularized by the Struts Web framework. Generalizations and modifications to this pattern need to be made, however, to keep the realities of development on small devices in check.

The Model

Based on what you know so far, a fair crack at building the model for the Device Blog can be attempted. This model is shown in Figure 9-16 using Unified Modeling Language (UML).

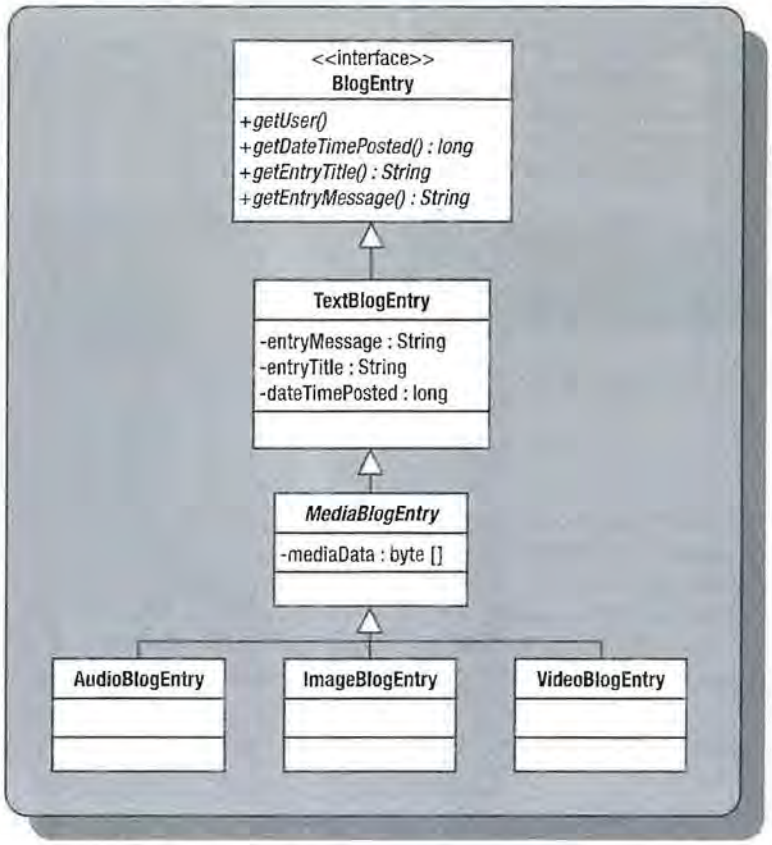

Figure 9-16. *Model for the Device Blog MIDlet application*

A `BlogEntry` interface sits at the top of this model and defines the characteristics of any entry created in this MIDlet. It mandates four self-explanatory methods that must be implemented by its implementations.

The `TextBlogEntry` class is the only implementation for this interface in this model and provides representation for blog entries that are only textual in nature, without any associated media parts. `MediaBlogEntry`, which extends the `TextBlogEntry` class, adds the media part, but is an abstract class. Concrete implementations include representation for each of the three different types of blog entries: `AudioBlogEntry`, `ImageBlogEntry`, and `VideoBlogEntry`. Each of the media blog entries gets a textual part and a media part.

These are not the only classes in the model. You need something to represent the user of the MIDlet and a class to model the server. These two classes are shown in Figure 9-17.

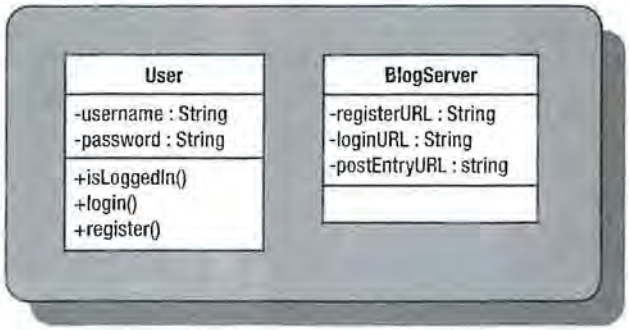

Figure 9-17. `User` *and* `BlogServer` *classes round up the Device Blog model.*

The View

The view of this MIDlet consists of the various `Form` and `Canvas` instances that interact with the user, along with a few `List` elements. These instances are generalized in this MIDlet to arrive at a common set of functionalities.

The `List` instances are easy to conceptualize. Only two areas require lists: at MIDlet startup (refer to Figure 9-1) and at the time of presenting the blog creation choice to the user (refer to Figure 9-6). These lists follow the same theme of presenting a list, using implicit list handling for commands, and providing a similar set of commands. Therefore, a `GenericList` is created, and the actual lists derive from this class. The UML diagram for these lists is shown in Figure 9-18.

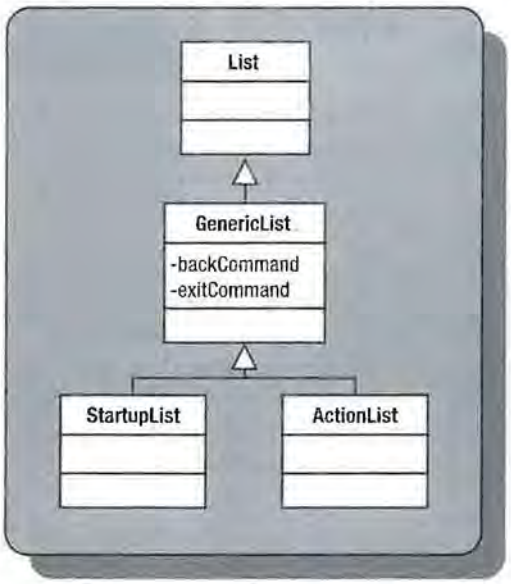

Figure 9-18. *Bundling together common functionalities of a* `List`

The same concept applies to the login and registration `Form` instances, common functionality of which can be put together in a `GenericForm` class. This class adds the commands OK, Exit, and Back, and classes that derive from this class can add their own `Form` items and behaviors. The UML for this structure is shown in Figure 9-19.

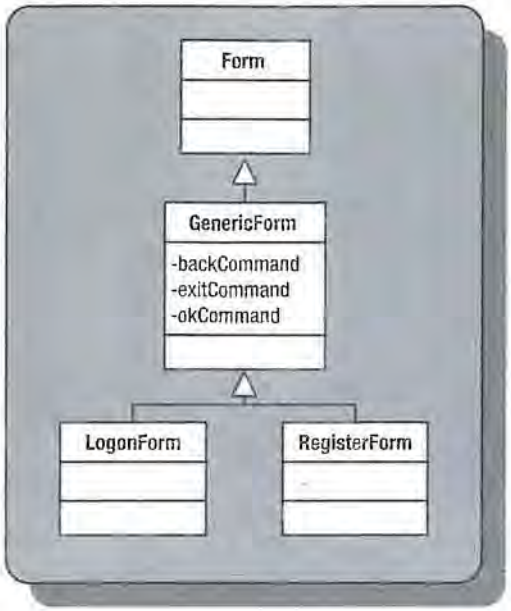

Figure 9-19. *Bundling together common functionalities of a* `Form`

Two sets of views remain to be created: one set for editing blog entries and one for previewing them. For editing (as with preview), it's useful to define a common set of functionalities and behaviors for the view that work similarly across all implementations. With this in mind, `EditableDisplay` is created as an interface that has only one method called `showDisplay()`. All implementations are then free to create their own way of handling the editable parts of the display by providing an implementation for the `showDisplay()` method. For textual entries, it's essential to provide a `Form`-based view, whereas others may provide `Canvas`-based views. The UML for the editing set of classes is shown in Figure 9-20.

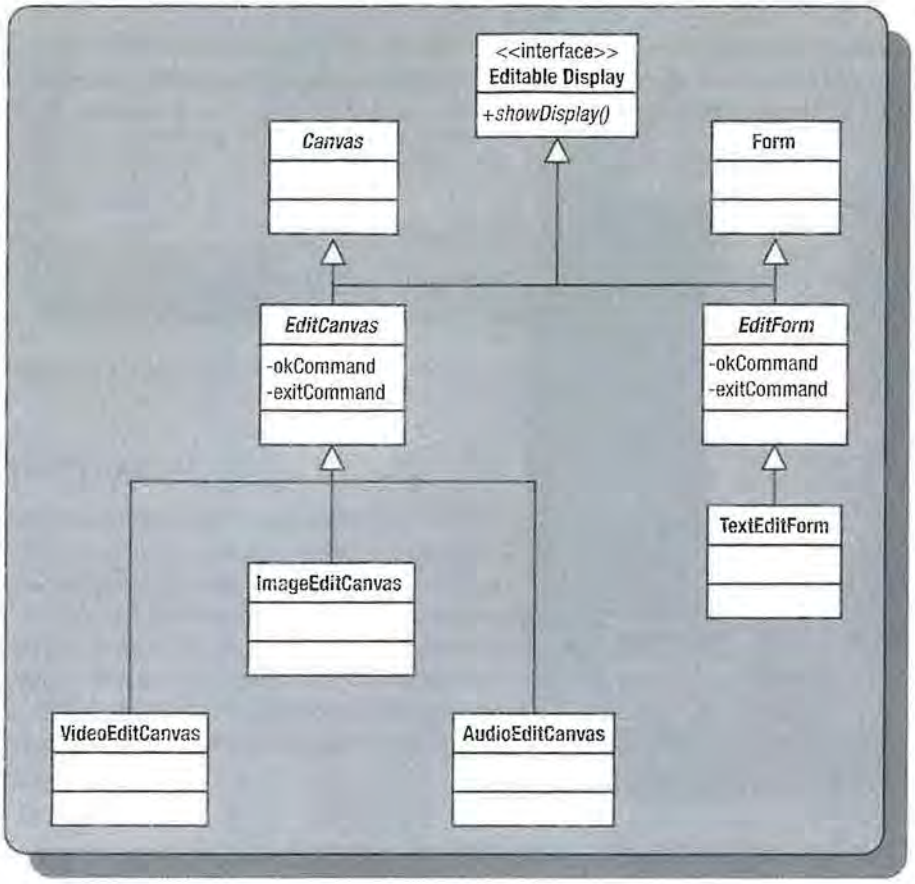

Figure 9-20. *Defining the blog editing set of classes in the Device Blog MIDlet*

As you can see, two abstract classes implement the `EditDisplay` interface. These classes are `EditForm`, which extends the `Form` class and provides the base class for editing textual blog entries, and `EditCanvas`, which extends the `Canvas` class and provides the base class for editing media blog entries.

Similarly, the set of view classes for previewing blog entries can be created. However, no separate distinction needs to be made between text- and media-based entries because everything is to be displayed on a `Canvas`. These set of classes are shown in Figure 9-21.

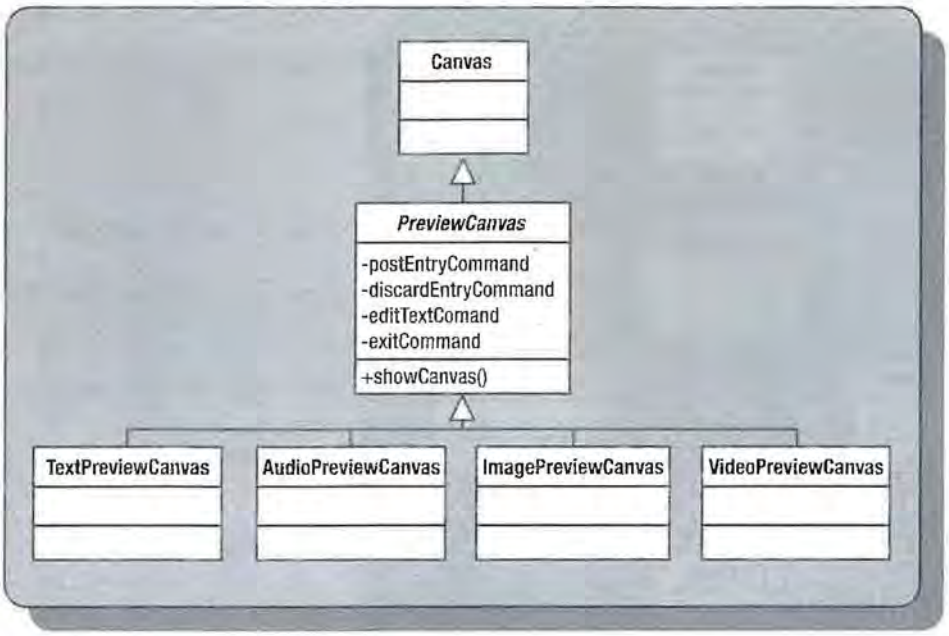

Figure 9-21. *Defining the blog preview set of classes*

As you can see, the `PreviewCanvas` abstract class encapsulates the behavior by providing the commands that are required at this stage of the view in this MIDlet. What remains is for the subclasses to provide an implementation of the `showCanvas()` method to display to the user a preview of the blog entry as the subclasses deem fit.

The Control

The control in this MVC pattern is made up of two classes: the `BootstrapMIDlet` and a specialized class called the `Controller`. The `Controller` class handles the interactions between the view and the model and generally keeps things moving by providing resources, action and error screens, and so on. The `BootstrapMIDlet`, as denoted by the name, is the class that starts this MIDlet application initially. Figure 9-22 shows these two classes.

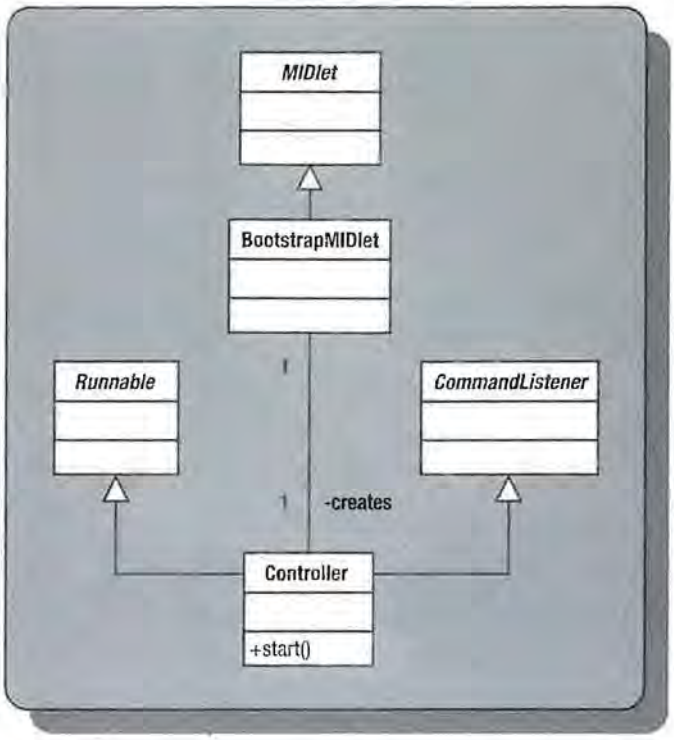

Figure 9-22. *The control classes of the Device Blog MIDlet*

Two other utility classes, `NetworkRunner` and `URLEncoder`, do not fit in any of the classifications so far. `NetworkRunner` provides network connections that are run via a single thread, whereas `URLEncoder` is used to encode the URL query strings.

Creating the MIDlet Code

The previous section provided an idea of what classes are required to create the Device Blog MIDlet application. Let's start by creating the classes of the model, which should be fairly easy because they are essentially Plain Old Java Objects (POJOs).

Creating the Model Classes

The model classes include the `BlogEntry` interface and its sole implementation, `TextBlogEntry`, which is then extended by the abstract class `MediaBlogEntry`. The `AudioBlogEntry`, `ImageBlogEntry`, and `VideoBlogEntry` then provide implementations for this class to represent audio, image, and video blog entries, respectively.

Listing 9-1 shows the code for the `BlogEntry` interface.

Listing 9-1. BlogEntry *Interface for All Types of Blog Entries*

```
package com.apress.chapter9.model;



/**
 * BlogEntry is the interface that represents the blog entries as a model
 */
public interface BlogEntry {

  /**
   * The user who is posting this entry
   */
  public User getUser();

  /**
   * The DateTime when the entry was posted
   */
  public long getDateTimePosted();

  /**
   * The title of this entry, if any
   */
  public String getEntryTitle();

  /**
   * The message of this entry, if any
   */
  public String getEntryMessage();

}
```

Listing 9-2 shows the code for TextBlogEntry.

Listing 9-2. TextBlogEntry *Represents All Entries That Have a Textual Component*

```
package com.apress.chapter9.model;

/**
 * TextBlogEntry implements BlogEntry and represents a TextEntry for the Blog.
 * It also acts as a base class for other media type entries.
 */
public class TextBlogEntry implements BlogEntry {

  // the title of this entry, if any
  private String entryTitle = null;
```

```
  // the message of this entry, if any
  private String entryMessage = null;

  // the time this entry was posted
  private long dateTimePosted = 0;

  // the user who is making this entry
  private User user = null;

  public TextBlogEntry(User user) {
    this.user = user;
  }

  // getter and setters for entry title and message
  public String getEntryTitle() { return this.entryTitle; }
  public void setEntryTitle(String entryTitle) {
    this.entryTitle = entryTitle;
  }

  public String getEntryMessage() { return this.entryMessage; }
  public void setEntryMessage(String entryMessage) {
    this.entryMessage = entryMessage;
  }

  // time posted is immutable
  public long getDateTimePosted() {
    return this.dateTimePosted;
  }

  // the user who is posting this entry
  public User getUser() {
    return this.user;
  }
}
```

Notice that the `getDateTimePosted()` method has only a getter method and is therefore immutable. This makes sense, because once posted, you wouldn't want to change this value. Also note that this value is stored as a `long` type.

Listing 9-3 shows the code for the `MediaBlogEntry` abstract class.

Listing 9-3. `MediaBlogEntry` *Represents Blog Entries That Have a Media Component*

```
package com.apress.chapter9.model;

/**
 * This abstract class encapsulates all the blog entries that have a media
 * component along with any text component. This is why it extends the
 * TextBlogEntry class
 */
public abstract class MediaBlogEntry extends TextBlogEntry {
```

```
  // the mediaData
  protected byte[] mediaData = null;

  // the contentType of the media
  protected String contentType = null;

  protected MediaBlogEntry(User user) {
    super(user);
  }

  public byte[] getMediaData() { return this.mediaData; }
  public void setMediaData(byte[] mediaData) { this.mediaData = mediaData; }

  public String getContentType() { return this.contentType; }
  public void setContentType(String contentType) {
    this.contentType = contentType;
  }

  /**
   * This method tries to guess the extension of the likely media data
   * file that will be gauged from the content type of this data
   */
  public String guessFileExtension() {

    if(contentType == null || contentType.length() == 0) return "";

    contentType = contentType.toLowerCase();

    if(contentType.equals("audio/x-wav")) return "wav";
    if(contentType.equals("audio/amr") ||
       contentType.equals("audio/amr-nb") ||
       contentType.equals("audio/amr-wb")) return "amr";

    if(contentType.equals("jpeg") ||
       contentType.equals("jpg") ||
       contentType.equals("image/jpeg") ||
       contentType.equals("image/jpg")) return "jpg";
    if(contentType.equals("gif") ||
       contentType.equals("image/gif")) return "gif";

    if(contentType.equals("video/mpeg")) return "mpg";
    if(contentType.equals("video/3gpp") ||
       contentType.equals("video/3gp")) return "3gp";

    return "unknown";
  }
}
```

This class contains an interesting method, guessFileExtension(). This method analyzes the content type of the media data and returns an appropriate file extension, which is useful when this data is being posted to the server to help the server make an educated guess about the media type. Of course, this extension is guessed based on the content type of the media, which has its own getter and setter methods. The guessFileExtension() method may need to be changed to cater for different media types that may be available on your mobile device.

The class also contains getter and setter methods for the media data, which is stored in this class in a byte array.

The concrete implementations of MediaBlogEntry, VideoBlogEntry, AudioBlogEntry, and ImageBlogEntry are now easy to write and only contain a single constructor. Listing 9-4 shows the code for the VideoBlogEntry class. The other implementations are similar and are provided in the source code in the Downloads section of the Apress Web site at *http://www.apress.com* (as is the rest of the code).

Listing 9-4. VideoBlogEntry *Extends* MediaBlogEntry *and Represents Video Blog Entries*

```
package com.apress.chapter9.model;

/**
 * The VideoBlogEntry extends MediaBlogEntry and represents an entry that
 * has a video component in addition to a text component
 */
public class VideoBlogEntry extends MediaBlogEntry {

  public VideoBlogEntry(User user) {
    super(user);
  }
}
```

The only thing of note here is that while creating an entry, the user who is creating the entry must be provided. A user for this system is created using the User class shown in Listing 9-5 and forms part of the model.

Listing 9-5. *User Class Represents the User of the Device Blog MIDlet*

```
package com.apress.chapter9.model;

import com.apress.chapter9.control.Controller;

/**
 * A simple user class to represent a user of this MIDlet. Contains only
 * userName and password. Once created, these values cannot be
 * changed
 **/
public class User {

  // parameters that define this user
  private String userName = null;
  private String password = null;
```

```
// flag to indicate if the user has been successfully logged in
private boolean loggedIn = false;

// the controller
private Controller controller = null;

public User(String userName, String password, Controller controller) {

  // check for invalid values
  if(userName == null || userName.length() == 0 ||
     password == null || password.length() == 0)
    throw new IllegalArgumentException("One of the arguments is invalid");

  this.userName = userName;
  this.password = password;

  this.controller = controller;
}

// getters for the parameters
public String getUserName() { return this.userName; }
public String getPassword() { return this.password; }

/**
 * Tries to log the user into the blog server.
 */
public void login(String loginURL) {

  // use the Network Runner to make the connection
  controller.getNetworkRunner().makeConnection(
    loginURL + "?uName=" + getUserName() + "&pWord=" + getPassword());
}

/**
 * @return true if the user is logged in, false otherwise
 */
public boolean isLoggedIn() {

  if(controller.getNetworkRunner().isLoggedIn()) {
    this.loggedIn = true;
  }

  return this.loggedIn;
}

/**
 * Registers this user with the blog server.
 * Successful registration doesn't log the user in, and login must be
```

```
   * done separately.
   */
  public void register(String registerURL) {

    // use the Network runner to make the connection
    controller.getNetworkRunner().makeConnection(
      registerURL + "?uName=" + getUserName() + "&pWord=" + getPassword());
  }
}
```

The class provides getter and setter methods for the username and password properties and also methods that log on and register the user. The class uses the `NetworkRunner` class to make the connections; this class will be introduced in the next section.

Finally, the model also contains the `BlogServer` class, which acts as a container for the server on which blogging will be done. This class is shown in Listing 9-6.

Listing 9-6. `BlogServer` *Class Acts As a Container for the Blog Server*

```
package com.apress.chapter9.model;

/**
 * BlogServer represents the server on which the blog is hosted, and includes
 * URLs for various actions, such as registration, logging in, and posting entries
 */
public class BlogServer {

  // the URL for registration
  private String registerURL = null;

  // the URL for logging in
  private String loginURL = null;

  // the URL for posting a blog entry
  private String postEntryURL = null;

  public BlogServer(String registerURL, String loginURL, String postEntryURL) {
    this.registerURL = registerURL;
    this.loginURL = loginURL;
    this.postEntryURL = postEntryURL;
  }

  public String getRegisterURL() { return this.registerURL; }
  public String getLoginURL() { return this.loginURL; }
  public String getPostEntryURL() { return this.postEntryURL; }

}
```

The BootstrapMIDlet or the Controller class are responsible for creating the BlogServer class and provide values for the actual URLs. These are listed in the JAD file so that any change in their value doesn't require the MIDlet application to be recompiled.

Creating the Utility Classes

Before moving on to either the view or the control, let's create the utility classes because they are important for testing the MIDlet. Two utility classes are required: NetworkRunner and URLEncoder.

NetworkRunner is required because it acts as a central class for making all connections to the blog server. However, instead of creating a separate thread each time a network connection is required; this class keeps a single thread running. Creating multiple threads is an issue on mobile devices because of small memory footprints, especially in a situation where several connections may be required. Listing 9-7 shows this class.

Listing 9-7. NetworkRunner *Is a Single-Threaded* HTTPConnection *Class*

```
package com.apress.chapter9.utils;

import java.io.IOException;
import java.io.InputStream;
import java.io.OutputStream;
import javax.microedition.io.Connector;
import javax.microedition.io.HttpConnection;

import com.apress.chapter9.model.BlogEntry;
import com.apress.chapter9.control.Controller;
import com.apress.chapter9.model.MediaBlogEntry;
import com.apress.chapter9.control.BootstrapMIDlet;

public class NetworkRunner extends Thread {

  // the calling MIDlet
  private BootstrapMIDlet midlet = null;

  // the controller
  private Controller controller = null;

  // the reusable connection
  private HttpConnection connection = null;

  // flags
  private boolean cancel = false;
  private boolean running = false;

  // the URL to connect to, this will change
  private String url = null;
```

```
// the BlogEntry that may be sent
private BlogEntry entry = null;

// flags that indicate the success or failure of logging in,
// registration and posting
private boolean logInSuccess = false;
private boolean registerSuccess = false;
private boolean postSuccess = false;

public NetworkRunner(BootstrapMIDlet midlet, Controller controller) {
  this.midlet = midlet;
  this.controller = controller;
  running = true;
}

/**
 * Waits till a request is made for making a connection
 */
public synchronized void run() {
  while(running) {
    try {
      wait();
    } catch(InterruptedException ie) {}

    if(running) connect();
  }
}

/**
 * Calling threads must use this method to make a connection
 * providing the URL to connect to
 */
public synchronized void makeConnection(String url) {
  makeConnection(url, null);
}

public synchronized void makeConnection(String url, BlogEntry entry) {
  this.url = url;
  this.entry = entry;
  notify();
}

/**
 * Tries to make a connection with the network server, using the
 * URL that is provided to the makeConnection method
 */
private void connect() {
```

```
InputStream in = null;
OutputStream out = null;

 try {

   // first encode the URL String
   controller.activityMessage("Encoding URL ...");
   String encodedURL = URLEncoder.encodeURL(this.url);

   // next get an HttpConnection on this URL
   controller.activityMessage("Opening connection ...");
   connection =
     (HttpConnection)Connector.open(encodedURL);

   // now check if this connection contains a media object by way
   // of an Entry object
   // if yes, then make this connection via HTTP POST
   if(this.entry != null) {

     // get the media data from this entry
     byte[] mediaData = ((MediaBlogEntry)entry).getMediaData();

     // set connection type and content length
     connection.setRequestMethod(HttpConnection.POST);
     connection.setRequestProperty(
       "Content-Length", (mediaData.length) + "");

     // open the OutputStream over which the media data will be sent
     out = connection.openOutputStream();

     // write the media data over this stream
     controller.activityMessage("Sending media data ...");
     out.write(mediaData);

     // to actually flush the stream check the response code
     int responseCode = connection.getResponseCode();

     if(responseCode != HttpConnection.HTTP_OK)
       throw new IOException("Transmission failed as server " +
         "responded with response code: " + responseCode);
   }

   // now irrespective of whether it was a POST or GET,
   // simply display to the user the response from the server

   // grab the input stream
   controller.activityMessage("Reading response ...");
   in = connection.openInputStream();
```

```
      // this can take a long time.. so check if the user has cancelled
      // before this
      if(cancel) return;

      // see the response and make sure it is not more than
      // 255 characters long
      int contentLength = (int)connection.getLength();
      if (contentLength == -1) contentLength = 255;
      byte[] data = new byte[contentLength];
      int length = in.read(data);

      // create a response message
      String message = new String(data, 0, length);
      midlet.message(message, 3000);

      // and process the type of the message
      processMessage(message);
    }
    catch (IOException ioe) {
      midlet.error(ioe); // show error
    } finally {

      // close connections
      if (!cancel) {
        try {
          if (in != null) in.close();
          if (out != null) out.close();
          if (connection != null) connection.close();
        }
        catch (IOException ie) {}
      }

      this.cancel = false;

    }
  }

  /**
   * This method is a way for the NetworkRunner to inform the rest of the
   * classes about the state of logging, registering and posting
   */
  private void processMessage(String message) {
    if(message == null) return;

    message = message.trim();

    if(message.equals("Logged In!")) { logInSuccess = true; }
    else if(message.equals("Registered")) registerSuccess = true;
```

```
    else if(message.equals("Posted")) postSuccess = true;
  }

  public boolean isLoggedIn() { return this.logInSuccess; }
  public boolean isRegistered() { return this.registerSuccess; }
  public boolean isPosted() { return this.postSuccess; }

  /**
   * Cancel the network attempt
   */
  public void cancel() {
    try {
      cancel = true;
      if (connection != null) connection.close();
    } catch (IOException io) {} // ignore
  }

}
```

This listing is complete code and makes use of the `Controller`, `BootstrapMIDlet`, and the `URLEncoder` classes, which you'll encounter soon.

When this class is created in a thread and started, the `run()` method kicks into an infinite loop. However, this method lies in wait until `notify()` is called from the `makeConnection()` method. Classes that need to make a connection call this method, providing the URL to connect to. In case the connection needs to be done to post a `BlogEntry` to the server, an instance of that object is provided as well.

The `connect()` method makes the actual connection. All URLs are invoked using the HTTP `GET` method, except when an entry is being posted, in which case, the `POST` method is used. Actual media data is posted by opening an `OutputStream` and sending data across to it (the corresponding server process must accept the opening of such a connection).

The server sends simple strings back, which, in case of successful completion, will be one of three values: "Logged In!", "Registered", or "Posted". In this sense, this class is tied in with the Device Blog MIDlet application. You can remove these values and simply return the message returned by the server to make this class generic and useful in other applications.

In case of error, the `BootstrapMIDlet` is used to convey an error message, whereas the `Controller` class is used to display messages representing system activity that may take a while and that the user could possibly cancel. You'll see these methods shortly.

Before making a connection, the `connect()` method encodes the URL using the `URLEncoder` class. This is important to do because the user may type messages that contain characters that are invalid for use over HTTP. Listing 9-8 shows this class, which contains a single method `encodeURL()`.

Listing 9-8. `URLEncoder` *Class Contains a Single Method to Encode URLs*

```
package com.apress.chapter9.utils;

public class URLEncoder {
```

```
  private static char getHex(int val) {
    if (val < 10) return (char)('0' + val);
    else return (char)('A' + (val - 10));
}

  public static String encodeURL(String url) {

    // the return encoded URL
    StringBuffer returnURL = new StringBuffer();

    // the length
    int size = url.length();

    for(int i = 0; i < size; i++) {

      // iterate over each character
      char ch = url.charAt(i);

      // if alphnumeric, it remains as such
      if ((ch >= '0' && ch <= '9') ||
          (ch >= 'a' && ch <= 'z') ||
          (ch >= 'A' && ch <= 'Z'))
            returnURL.append(ch);
      else {

        // non alphanumeric

        // see first if this is one of the special characters.
        int spec = special.indexOf(ch);

        if (spec >= 0) {

          // this character is not in the special chars
          // String defined later
          returnURL.append(ch);

        } else {

          // use the hex converter for the rest of the characters

          // first add the % character
          returnURL.append('%');

          // next convert the high bits
          returnURL.append(getHex((ch & 0xF0) >> 4));

          // and finally the low bits
          returnURL.append(getHex(ch & 0x0F));
```

```
        }
      }
    }

    // the final encoded url
    return returnURL.toString();
  }

  private static String special = "=&:/?\".-!~*_'()";
}
```

Creating the View

The view contains several classes, some of which are mundane, such as `GenericList` and `GenericForm`, which serve no purpose by being listed here. (You can see these classes in the Downloads section on the Apress Web site.) Instead, Listing 9-9 shows the code for the `EditableDisplay` interface, which acts as the base from which all editable screens will be created.

Listing 9-9. `EditableDisplay` *Is the Base Interface for All Editable Objects*

```
package com.apress.chapter9.view;

/**
 * An EditableDisplay interface specifies custom objects that can be shown on
 * a screen
 */
public interface EditableDisplay {

  /**
   * The method that all these objects must implement
   */
  public void showDisplay();

}
```

The first class created from this interface is the `EditForm` abstract class. This class is shown in Listing 9-10.

Listing 9-10. `EditForm` *Class Implements* `EditableDisplay`

```
package com.apress.chapter9.view;

import javax.microedition.lcdui.Form;
import javax.microedition.lcdui.Command;
import javax.microedition.lcdui.CommandListener;
```

```
import com.apress.chapter9.model.BlogEntry;
import com.apress.chapter9.control.Controller;

/**
 * The EditForm is the super class for editing form based blog entries.
 * Subclasses have the task of displaying the contents to the user
 */
public abstract class EditForm extends Form
  implements EditableDisplay, CommandListener {

  // the controller object
  protected Controller controller = null;

  // the commands
  protected Command okCommand = null;
  protected Command exitCommand = null;

  // and the blog entry object
  protected BlogEntry entry = null;

  protected EditForm(Controller controller, BlogEntry entry) {
    super("Edit Form");

    // controller and entry are essential, and must not be null
    if(controller == null || entry == null)
      throw new IllegalArgumentException("Controller or entry cannot be null");

    this.controller = controller;
    this.entry = entry;

    // create commands
    okCommand = new Command("Ok", Command.OK, 1);
    exitCommand = new Command("Exit", Command.EXIT, 1);

    // add them to the Form
    addCommand(okCommand);
    addCommand(exitCommand);

    // and set the controller as the listener for commamnds
    setCommandListener(this);
  }

  /**
   * Returns the associated blog entry
   */
```

```
  public BlogEntry getBlogEntry() {
    return this.entry;
  }


}
```

The EditForm class is abstract but provides a concrete protected constructor, which creates items common to all subclasses. This class can now be used as a template for creating editable forms that will have an OK and an EXIT command attached to them. Note that each form will have a corresponding BlogEntry object attached with it, because a form must contain an entry that is being edited. Each form will also have a corresponding handle to the controller object. Listing 9-11 shows the code for the TextEditForm class that extends the EditForm class and will be used to create the screen shown in Figure 9-8.

Listing 9-11. TextEditForm *Used to Create Editable Form Screens for Text Blog Entries*

```
package com.apress.chapter9.view.impl;

import javax.microedition.lcdui.Command;
import javax.microedition.lcdui.TextField;
import javax.microedition.lcdui.Displayable;

import com.apress.chapter9.view.EditForm;
import com.apress.chapter9.model.BlogEntry;
import com.apress.chapter9.control.Controller;
import com.apress.chapter9.view.PreviewCanvas;
import com.apress.chapter9.model.TextBlogEntry;

/**
 * TextEditForm extends EditForm and is used for standalone text entries and
 * for editing text of media-based entries
 */
public class TextEditForm extends EditForm {

  // the title of this blog entry
  private TextField title = null;

  // the message of this blog entry
  private TextField message = null;

  public TextEditForm(Controller controller, BlogEntry entry) {

    super(controller, entry);

    // cast the entry to the right type
    TextBlogEntry textEntry = (TextBlogEntry)entry;
```

```
    // create the TextFields
    title =
      new TextField("Title", textEntry.getEntryTitle(), 255, TextField.ANY);
    message = new TextField(
      "Message", textEntry.getEntryMessage(), 255, TextField.ANY);

    // and append them to this Form
    append(title);
    append(message);
  }

  /**
   * The showDisplay() method displays the text entry fields to the user
   */
  public void showDisplay() {
    controller.getDisplay().setCurrent(this);
  }

  public void commandAction(Command cmd, Displayable disp) {

    int commandType = cmd.getCommandType();

    if(commandType == Command.EXIT) {
      controller.processExit();
      return;
    } else if(commandType == Command.OK) {
      // to be added
    }
  }
}
```

The subclasses of the `EditForm` class are responsible for handling the commands, OK and EXIT. In Listing 9-11, the EXIT command is handled by invoking a method in the controller object. You'll add code for the OK command later.

The constructor for `TextEditForm` creates two text fields and attaches them to the `Form` using the `append()` method. The `showDisplay()` method, inherited from `EditableDisplay`, then simply shows this form on the screen. As expected, the constructor also receives a `BlogEntry` object, which can be cast to an appropriate `TextBlogEntry`. Notice that this class is in the `com.apress.chapter9.view.impl` package, instead of the `com.apress.chapter9.view` package.

It shouldn't be hard to see how to create the `EditCanvas` class, which will be used to create editable canvas subclasses for image, audio, and video as shown earlier in Figure 9-20. Listing 9-12 shows the code for the `EditCanvas` class, which also implements the `EditableDisplay` interface from Listing 9-9.

Listing 9-12. EditCanvas *Class Used As the Base Class to Create Editable Canvases*

```
package com.apress.chapter9.view;

import javax.microedition.lcdui.Canvas;
import javax.microedition.lcdui.Command;
import javax.microedition.lcdui.Graphics;
import javax.microedition.lcdui.CommandListener;

import com.apress.chapter9.model.BlogEntry;
import com.apress.chapter9.control.Controller;

/**
 * The EditCanvas is the super class for editing blog entries. Subclasses
 * have the task of displaying the contents to the user
 */
public abstract class EditCanvas extends Canvas
  implements EditableDisplay, CommandListener {

  // the controller object
  protected Controller controller = null;

  // the commands
  protected Command doneCommand = null;
  protected Command exitCommand = null;

  // the blog entry
  protected BlogEntry entry = null;

  protected EditCanvas(Controller controller, BlogEntry entry) {

    super();

    // controller and entry are essential, and must not be null
    if(controller == null || entry == null)
      throw new IllegalArgumentException("Controller or entry cannot be null");

    this.controller = controller;
    this.entry = entry;

    // create commands
    doneCommand = new Command("Done", Command.OK, 1);
    exitCommand = new Command("Exit", Command.EXIT, 1);
```

```
    // add them to the Canvas
    addCommand(doneCommand);
    addCommand(exitCommand);

    // and set the controller as the listener for commands
    setCommandListener(this);
  }

  public void paint(Graphics g) {

    // first clear the screen
    g.setColor(0xFF8040);
    g.fillRect(0, 0, getWidth(), getHeight());

    // and then make a canvas with a border
    g.setColor(0x808040);
    g.fillRect(5, 5, getWidth() - 10, getHeight() - 10);

    // the rest of the work is left to subclasses

  }


}
```

Of course, EditCanvas must override the paint() method inherited from the Canvas class. However, it only clears the background, and subclasses are left to do the rest of the work. The protected constructor does tasks similar to the EditForm class and provides the basic infrastructure for subclasses, which must also provide implementation for the showDisplay() method. Listing 9-13 shows the code for the AudioEditCanvas, and the rest of the implementations are in code in the Downloads sections of the Apress Web site.

Listing 9-13. AudioEditCanvas *Used As the Editable Canvas for Audio Recordings*

```
package com.apress.chapter9.view.impl;

import java.io.IOException;
import java.io.ByteArrayInputStream;
import java.io.ByteArrayOutputStream;

import javax.microedition.lcdui.Image;
import javax.microedition.lcdui.Command;
import javax.microedition.lcdui.Graphics;
import javax.microedition.lcdui.Displayable;

import javax.microedition.media.Player;
import javax.microedition.media.Manager;
import javax.microedition.media.control.RecordControl;
```

```
import com.apress.chapter9.BlogException;

import com.apress.chapter9.model.BlogEntry;
import com.apress.chapter9.model.AudioBlogEntry;

import com.apress.chapter9.view.EditCanvas;
import com.apress.chapter9.view.PreviewCanvas;

import com.apress.chapter9.control.Controller;

/**
 * AudioEditCanvas is used to edit/record audio blog entry
 */
public class AudioEditCanvas extends EditCanvas implements Runnable {

  private Player capturePlayer = null;
  private RecordControl recordControl = null;
  private ByteArrayOutputStream bos = null;

  public AudioEditCanvas(Controller controller, BlogEntry entry) {
    super(controller, entry);
  }

  public void showDisplay() {

    // make this canvas the current display item
    controller.getDisplay().setCurrent(this);

    // repaint
    repaint();

    // and start the audio recording process
    new Thread(this).start();
  }

  public void run() {
    startAudioRecording();
  }

  public void paint(Graphics g) {

    // first call the superclass method
    super.paint(g);

    // now draw the mic image in the foreground
    try {
      g.drawImage(Image.createImage(
        getClass().getResourceAsStream("/media/images/chapter9/mic.gif")),
```

```
        getWidth()/2, getHeight()/2, Graphics.VCENTER | Graphics.HCENTER);
    } catch(IOException ioex) {} // ignore exception

    // also draw a message in white
    g.setColor(0x000000);

    g.drawString("Recording .... ",
      (getWidth()/2), (getHeight()/2) + 30, Graphics.TOP | Graphics.HCENTER);

  }

  private void startAudioRecording() {

    try {

      // create the capture player
      capturePlayer = Manager.createPlayer("capture://audio");

      if (capturePlayer != null) {

        // if created, realize it
        capturePlayer.realize();

        // and grab the RecordControl
        recordControl = (RecordControl)capturePlayer.getControl(
          "javax.microedition.media.control.RecordControl");

        // if RecordControl is null throw exception
        if(recordControl == null)
          throw new BlogException("RecordControl not available for audio");

        // create the buffer in which recording will be done
        bos = new ByteArrayOutputStream();

        // set the output of recording
        recordControl.setRecordStream(bos);

        // start the underlying player
        capturePlayer.start();

        // and the actual recorder
        recordControl.startRecord();

      } else {
        throw new Exception("Capture Audio Player is not available");
      }
```

```
  } catch(Exception e) {
    cleanUp(e);
  }

}

public void commandAction(Command cmd, Displayable disp) {

  int commandType = cmd.getCommandType();

  if(commandType == Command.EXIT) {
    controller.processExit();
    return;
  } else if(commandType == Command.OK) {

    // complete the recording

    try {
      // flush the output buffer
      bos.flush();

      // commit the recording
      recordControl.commit();

      // close the player
      capturePlayer.close();

      capturePlayer = null;

    } catch(Exception ex) {
      cleanUp(ex);
      return;
    }

    // set the media data on this entry
    ((AudioBlogEntry)entry).setMediaData(bos.toByteArray());

    // set the media content type
    ((AudioBlogEntry)entry).setContentType(recordControl.getContentType());

    // release the resources
    bos = null;
    recordControl = null;

    // create a preview canvas and set this entry for it
    AudioPreviewCanvas pCanvas = new AudioPreviewCanvas(controller, entry);
```

```
      // and show it
      pCanvas.showCanvas();
    }
  }

  /**
   * This method is used to clean up and release resources on error
   */
  private void cleanUp(Exception e) {

    // release resources on error
    if(recordControl != null) { recordControl = null; }
    if(capturePlayer != null) {
      capturePlayer.close();
      capturePlayer = null;
    }

    // and show the user the message
    controller.message(e.getMessage());
  }
}
```

AudioEditCanvas does a lot of work because it handles the recording of audio as a blog entry. When its showDisplay() method is called, it repaints the screen with a simple image and a message and then starts a thread that actually tries to capture audio via the startRecording() method. When the user is done recording, the OK command handler wraps up the data in the associated AudioBlogEntry using the setMediaData(byte[] data) method. After this is done, it tries to clean up resources such as the RecordControl and the associated Player instances by closing them and then setting them to null, so that the Garbage Collector can reclaim them and free up resources.

After the recording is created successfully, the user should be able to hear it and preview it by creating the AudioPreviewCanvas with the controller and the AudioBlogEntry.

Listing 9-9 didn't have any code for the OK command handler, so Listing 9-13 needs to set the title and message on the associated TextBlogEntry and display the TextPreviewCanvas. This is similar to what you've done with the OK command handler for the AudioEditCanvas. This is shown here:

```
// get the values from the form, and set them in the entry
((TextBlogEntry)entry).setEntryTitle(title.getString());
((TextBlogEntry)entry).setEntryMessage(message.getString());

// create a preview canvas and set the entry for it
TextPreviewCanvas pCanvas = new TextPreviewCanvas(controller, entry);

// and show it
pCanvas.showCanvas();
```

Of course, you haven't created any preview canvases yet. Let's take a look at Listing 9-14, which shows the abstract class, PreviewCanvas.

Listing 9-14. PreviewCanvas *Is the Base Abstract Class for All Preview Canvases*

```
package com.apress.chapter9.view;

import javax.microedition.lcdui.Canvas;
import javax.microedition.lcdui.Command;
import javax.microedition.lcdui.Graphics;
import javax.microedition.lcdui.Displayable;
import javax.microedition.lcdui.CommandListener;

import com.apress.chapter9.model.BlogEntry;
import com.apress.chapter9.control.Controller;
import com.apress.chapter9.view.impl.TextEditForm;

/**
 * The PreviewCanvas is the superclass for previewing blog entries to the
 * user. Subclasses have the task of displaying the contents to the user
 */
public abstract class PreviewCanvas extends Canvas
  implements CommandListener {

  // the controller object
  protected Controller controller = null;

  // the BlogEntry
  protected BlogEntry entry = null;

  // the commands
  protected Command postEntryCommand = null;
  protected Command discardEntryCommand = null;
  protected Command editTextCommand = null;
  protected Command exitCommand = null;

  protected PreviewCanvas(Controller controller, BlogEntry entry) {
    super();

    // controller and entry are essential and must not be null
    if(controller == null || entry == null)
      throw new IllegalArgumentException("Controller or entry cannot be null");

    this.controller = controller;
    this.entry = entry;

    // create commands
    postEntryCommand = new Command("Post Entry", Command.OK, 2);
    discardEntryCommand = new Command("Discard Entry", Command.CANCEL, 2);
    editTextCommand = new Command("Edit Text", Command.SCREEN, 2);
    exitCommand = new Command("Exit", Command.EXIT, 1);
```

```
    // add them to the Canvas
    addCommand(postEntryCommand);
    addCommand(discardEntryCommand);
    addCommand(editTextCommand);
    addCommand(exitCommand);

    // and set the controller as the listener for commamnds
    setCommandListener(this);
  }

  /**
   * Partially done paint method, which only paints the background
   */
  public void paint(Graphics g) {

    // first clear the screen
    g.setColor(0xFF8040);
    g.fillRect(0, 0, getWidth(), getHeight());

    // and then make a canvas with a border
    g.setColor(0x808040);
    g.fillRect(5, 5, getWidth() - 10, getHeight() - 10);

    // the rest of the work is left to subclasses

  }

  public void commandAction(Command cmd, Displayable disp) {

    // first grab the type of the command
    int commandType = cmd.getCommandType();

    if(commandType == Command.EXIT) {

      // let the controller process the exit
      controller.processExit();

    } else if(commandType == Command.SCREEN) { // means editing text

      // create a new text edit form with the BlogEntry
      TextEditForm form = new TextEditForm(controller, entry);

      // and show it
      form.showDisplay();

    } else if(commandType == Command.CANCEL) { // means discard entry
```

```
      // simply show the startup list
      controller.getDisplay().setCurrent(controller.getStartUpList());

    } else if(commandType == Command.OK) { // means post entry to server

      controller.postEntry(entry);
    }
  }

  /**
   * Subclasses must implement this method as they see fit to show the contents
   * of this canvas
   */
  public abstract void showCanvas();
}
```

This class is very similar to the EditCanvas, in that it creates a background but leaves the full painting to subclasses. However, this class does offer implementations for handling the various commands that are associated with it. These commands are Exit, Edit Text, Discard Entry, and Post Entry commands, as shown earlier in Figure 9-10. Thus, subclasses only need to worry about painting the partially done canvas as they see fit, leaving command handling to this class.

Listing 9-15 shows the code for the ImagePreviewCanvas. With most of the work handled by the superclass, this class only needs to work on its paint() method to display the image in the associated ImageBlogEntry object.

Listing 9-15. ImagePreviewCanvas *Shows the Associated Image to the User As a Preview*

```
package com.apress.chapter9.view.impl;

import java.io.IOException;
import java.io.ByteArrayInputStream;
import javax.microedition.lcdui.Image;
import javax.microedition.lcdui.Graphics;

import javax.microedition.media.Player;
import javax.microedition.media.Manager;

import com.apress.chapter9.control.Controller;

import com.apress.chapter9.view.PreviewCanvas;

import com.apress.chapter9.model.BlogEntry;
import com.apress.chapter9.model.ImageBlogEntry;

public class ImagePreviewCanvas extends PreviewCanvas {
```

```
  public ImagePreviewCanvas(Controller controller, BlogEntry entry) {
    super(controller, entry);
    setTitle("Image Entry Preview");
  }

  public void showCanvas() {

    // make this canvas as the current display item
    controller.getDisplay().setCurrent(this);

    // and then repaint it
    repaint();
  }

  public void paint(Graphics g) {

    // get the superclass to clear background and repaint it first
    super.paint(g);

    // now simply create an Image from the byte array, and show it on
    // the canvas
    Image snapshot = null;

    try {

      ImageBlogEntry imgEntry = ((ImageBlogEntry)entry);
      byte[] imgData = imgEntry.getMediaData();
      snapshot = Image.createImage(imgData, 0, imgData.length);

    } catch(Exception e) {

      // show the error message to the user
      controller.message(e.getMessage());

      // and return
      return;
    }

    // now draw the image on this canvas
    g.drawImage(snapshot, getWidth()/2, getHeight()/2,
      Graphics.HCENTER | Graphics.VCENTER);
  }

}
```

The showDisplay() method makes this canvas as the current display object and then calls repaint(), where the image data contained in the associated ImageBlogEntry is displayed on the screen using the Graphics object. Similarly, Listing 9-16 contains the code for the

VideoPreviewCanvas, which uses a video Player instance to preview the video to the user by using roughly the same principles.

Listing 9-16. VideoPreviewCanvas *Previews the Video to the User*

```
package com.apress.chapter9.view.impl;

import java.io.IOException;
import java.io.ByteArrayInputStream;
import javax.microedition.lcdui.Image;
import javax.microedition.lcdui.Graphics;

import javax.microedition.media.Player;
import javax.microedition.media.Manager;
import javax.microedition.media.MediaException;
import javax.microedition.media.control.VideoControl;

import com.apress.chapter9.control.Controller;

import com.apress.chapter9.view.PreviewCanvas;

import com.apress.chapter9.model.BlogEntry;
import com.apress.chapter9.model.VideoBlogEntry;

public class VideoPreviewCanvas extends PreviewCanvas  {

  public VideoPreviewCanvas(Controller controller, BlogEntry entry) {
    super(controller, entry);
    setTitle("Video Entry Preview");
  }

  public void showCanvas() {

    // make this canvas as the current display item
    controller.getDisplay().setCurrent(this);

    // and then repaint it
    repaint();

    // finally play back the recording
    playbackVideoRecording();

  }

  public void paint(Graphics g) {
```

```
    // get the superclass to clear the background and repaint it first
    super.paint(g);
  }

  private void playbackVideoRecording() {

    VideoBlogEntry vEntry = (VideoBlogEntry)entry;

    ByteArrayInputStream bis =
      new ByteArrayInputStream(vEntry.getMediaData());

    Player player = null;
    VideoControl vControl = null;

    try {

      // create the Playback player
      player = Manager.createPlayer(bis, vEntry.getContentType());

      // realize it
      player.realize();

      // create the playback video control
      vControl = (VideoControl)player.getControl(
        "javax.microedition.media.control.VideoControl");

      // initialize it
      vControl.initDisplayMode(VideoControl.USE_DIRECT_VIDEO, this);

      vControl.setDisplayLocation(5, 5);

      try {
        vControl.setDisplaySize(getWidth() - 10, getHeight() - 10);
      } catch (MediaException me) {} // ignore

      vControl.setVisible(true);

      // start it
      player.start();

    } catch(Exception e) {

      // release this player instance
      if(player != null) { player.close(); player = null; }

      // show the error message to the user
      controller.message(e.getMessage());
```

```
        // and return
        return;
      }
    }
}
```

The AudioPreviewCanvas is similar and is provided in the Downloads section of the Apress Web site.

This finishes the code listings for the view part. The only classes left are those of the control part, which hold the model and the view together.

Creating the Control Classes

As you may recall, the control classes are the BootstrapMIDlet class, which starts the Device Blog MIDlet, and the Controller class, which is the glue that holds this MIDlet together. The BootstrapMIDlet is shown in Listing 9-17.

Listing 9-17. BootstrapMIDlet *Is the Entry Point for the Device Blog MIDlet Application*

```
package com.apress.chapter9.control;

import javax.microedition.lcdui.Alert;
import javax.microedition.lcdui.Display;
import javax.microedition.lcdui.Command;
import javax.microedition.midlet.MIDlet;

import com.apress.chapter9.BlogException;
import com.apress.chapter9.model.BlogServer;
import com.apress.chapter9.utils.NetworkRunner;

/**
 * BootstrapMIDlet is the startup MIDlet that loads the initial data and
 * starts the service. If any initial parameters are missing, it will abort.
 * It requires the URLs for posting, logging, and registering defined in the
 * MIDlet JAD and manifest file.
 */
public class BootstrapMIDlet extends MIDlet {

  // the display
  private Display display = null;

  // the controller that will drive this MIDlet
  private Controller controller = null;

  // the thread in which this MIDlet will be run
  private Thread runner = null;

  // the thread used for creating network connections
  private NetworkRunner networkThread = null;
```

```
// the BlogServer contains the URL information
private BlogServer blogServer = null;

// flag to indicate if any error occurs
private boolean error = false;

public void startApp() {

  if(display == null) {
    // get the display
    display = Display.getDisplay(this);

    // load the initial URL parameters
    try {
      loadParameters();
    } catch(BlogException be) {
      error(be);
    }

    // create the new Controller passing this MIDlet as the reference
    controller = new Controller(this);

    // create the runner thread
    runner = new Thread(controller);

    // create the Network Runner thread
    networkThread = new NetworkRunner(this, controller);

    runner.start();
    networkThread.start();
  }
}

/**
 * loads the URL parameters from the Manifest
 */
private void loadParameters() throws BlogException {

  // the registration URL
  String registerURL = getAppProperty("Blog-registerURL");

  // the login URL
  String loginURL = getAppProperty("Blog-loginURL");

  // the URL for posting entries
  String postEntryURL = getAppProperty("Blog-postURL");
```

```
  // if any of them is null or not defined, throw Exception
  if(registerURL == null || registerURL.length() == 0 ||
     loginURL == null || loginURL.length() == 0 ||
     postEntryURL == null || postEntryURL.length() == 0)
    throw new BlogException("One of the Blog server URL's is not defined.");

  // otherwise create the BlogServer information object
  blogServer = new BlogServer(registerURL, loginURL, postEntryURL);
}

// getter for BlogServer
public BlogServer getBlogServer() { return this.blogServer; }

// getter for Display
public Display getDisplay() { return this.display; }

// getter for NetworkThread
public NetworkRunner getNetworkRunner() { return this.networkThread; }

public void pauseApp() {
}

public void destroyApp(boolean unconditional) {
}

/**
 * General purpose nonerror message display method
 */
public void message(String msg, int time) {
  Alert alert = new Alert("Message");
  alert.setString(msg);
  alert.setTimeout(time);

  display.setCurrent(alert, controller.getStartUpList());
}

/**
 * General purpose error message display method
 */
public void error(Exception e) {
  Alert alert = new Alert("Error");
  alert.setString(e.getMessage());
  alert.setTimeout(Alert.FOREVER);

  display.setCurrent(alert, controller.getStartUpList());
```

```
    error = true;
  }
}
```

The BootstrapMIDlet class loads the parameters for the blog server from the JAD file, initializes the Controller class and the NetworkRunner class, starts these threads (all in the startApp() method), and provides utility methods for showing error and normal message to the user.

The Controller actively controls the flow of the MIDlet application. It creates the GenericForm and GenericList classes and handles the commands associated with them. It leaves most of the command handling of the Preview and Edit canvases to these canvases themselves, but it keeps the task of posting entries to the server to itself. In the interest of conserving space, the complete code for this class is not listed here, but only a few code snippets. First, Listing 9-18 shows the code for the postEntry(BlogEntry entry) method.

Listing 9-18. postEntry(BlogEntry entry) *Method of the* Controller *Class*

```
/**
 * Has the responsibility of posting an entry to the server
 */
public void postEntry(BlogEntry entry) {

  // first show the message to the user
  activityMessage("Connecting to server ... ");

  // now get the post entry url
  String postURL = midlet.getBlogServer().getPostEntryURL();

  // construct the parameters in the URL
  postURL += "?title=" + entry.getEntryTitle() +
             "&message=" + entry.getEntryMessage() +
             "&dateposted=" + System.currentTimeMillis() +
             "&uName=" + entry.getUser().getUserName();

  // and use the network runner to post the URL based on the
  // type of the entry
  if(entry instanceof MediaBlogEntry) {

    MediaBlogEntry mediaEntry = ((MediaBlogEntry)entry);

    String type =
      ((mediaEntry instanceof AudioBlogEntry) ? "audio" :
      ((mediaEntry instanceof ImageBlogEntry) ? "image" : "video"));

    getNetworkRunner().makeConnection(
      postURL +
      "&media=" + mediaEntry.guessFileExtension() +
      "&type=" + type +
      "&mediasize=" + mediaEntry.getMediaData().length, entry);
```

```
  } else {
    getNetworkRunner().makeConnection(postURL);
  }
}
```

This method makes a distinction between posting text entries and media entries. If a media entry is being posted, it puts extra information about the entry, including the type of media, the size of the media, and expected file extension in the URL, as a query string. If a text-based entry is being sent, only the normal parameters, such as title, message, date posted, and username, are provided.

Listing 9-19 provides the code snippet of the `Controller` class handling the user selection for the type of blog entry to create, as shown earlier in Figure 9-6.

Listing 9-19. *Handling User Selection of Type of* `BlogEntry`

```
// if the user wants to create an entry
int selectedIdx = actionList.getSelectedIndex();

// initialize the display
EditableDisplay editDisplay = null;

// and the associated entry
BlogEntry blogEntry = null;

// now based on what type of entry it is, create the right
// editable display and entry
switch(selectedIdx) {
  case 0: // text only
  {
    blogEntry = new TextBlogEntry(user);
    editDisplay = new TextEditForm(this, blogEntry);
    break;
  }
  case 1: // audio
  {
    blogEntry = new AudioBlogEntry(user);
    editDisplay = new AudioEditCanvas(this, blogEntry);
    break;
  }
  case 2: // image
  {
    blogEntry = new ImageBlogEntry(user);
    editDisplay = new ImageEditCanvas(this, blogEntry);
    break;
  }
  case 3: // only case left, video
  {
    blogEntry = new VideoBlogEntry(user);
    editDisplay = new VideoEditCanvas(this, blogEntry);
```

```
    break;
  }
}

editDisplay.showDisplay();
```

Based on the user selection, the code creates the appropriate type of BlogEntry and editing form. In the end, the code invokes the showDisplay() method of EditableDisplay interface to display the right editing canvas/form created with the right BlogEntry type.

On the Server Side

The code for the server side contains four very simple JSP-based pages. To keep things simple, this example is using a file-based blogging system instead of blogging entries to a database. The postentry.jsp file receives the entries from the user and files them into user-based directories. This file is shown in Listing 9-20.

Listing 9-20. postentry.jsp *Accepts Blog Entries from the Device Blog and Files Them in the File System*

```
<%@ page contentType="text/plain;charset=UTF-8" language="java"
  import="java.io.File, java.io.*" %>

<%--
  Simple postentry.jsp tries to post an entry to the server
--%>

<%

  String title = (String)request.getParameter("title");
  String message = (String)request.getParameter("message");
  String datePosted = (String)request.getParameter("dateposted");
  String username = (String)request.getParameter("uName");
  String media = (String)request.getParameter("media");
  String type = (String)request.getParameter("type");
  String mediaSize = (String)request.getParameter("mediasize");

  // only username is a required value
  if(username == null || username.length() == 0) {

    out.println("Required parameter username is missing");
    return;
  }

  // now find out the working dir
  String workingDir = System.getProperty("user.dir");
```

```
// try to get to the user directory with the given username
// this assumes a specific working directory, change if you put files in
// different places
File userDir = new File(
  workingDir + "/webapps/MMAPI/deviceblog/users/" + username);

if(!userDir.exists()) {

  out.println("Internal error: no user directory");
  return;

}

// set the title if it is missing
if(title == null || title.equals("null") || title.length() == 0) {
  title = "Untitled " + (type == null ? "Text" : type) + " entry";
}

// try and figure out the date posted value
long datePostedLong = 0L;

if(datePosted == null) datePostedLong = System.currentTimeMillis();
else {
  try {
    datePostedLong = Long.parseLong(datePosted, 10);
  } catch (Exception e) {
    datePostedLong = System.currentTimeMillis();
  }
}

// now the file name for this entry will be based on the datePosted value
// but first create, if it doesn't exist, the entries directory for this user
// and also the media directories

File entriesDir = new File(userDir, "entries");

if(!entriesDir.exists()) {
  if(!entriesDir.mkdir()) {

    out.println("Internal error: could not create entries directory");
    return;

  } else {

    // entries directory created, now create the individual media directories
```

```
      new File(entriesDir, "audio").mkdir();
      new File(entriesDir, "video").mkdir();
      new File(entriesDir, "image").mkdir();

    }
  }

  // now see if this is a media entry, before saving the actual text entry
  if(media != null) {

    // this is a media entry

    InputStream in = null;
    FileOutputStream fos = null;

    try {

      // open up an input stream for media data
      in = request.getInputStream();

      // create a byte array to receive this data in
      byte[] rcdData = new byte[new Integer(mediaSize).intValue()];

      // read from the input stream in this byte array
      in.read(rcdData);

      fos = new FileOutputStream(
        new File(entriesDir, type + "/" + datePostedLong + "." + media));

      fos.write(rcdData, 0, rcdData.length);
      fos.flush();

    } catch(IOException ioex) {

      out.println("Internal error: " + ioex.getMessage());
      return;
    } finally {

      try {
        if(fos != null) fos.close();
        if(in != null)  in.close();
      } catch(IOException ix) { return; }

    }

  }
```

```
  // now save this entry
  File entryFile = new File(entriesDir, datePostedLong + ".txt");

  if(!entryFile.createNewFile()) {

    out.println("Internal error: could not create the entry file");
  }

  // now open this file, and write the title and message to it
  FileWriter fw = null;
  try {
    fw = new FileWriter(entryFile);

    // first the title
    fw.write(title, 0, title.length());
    fw.write("\r\n");

    // now the media file location, if any, if there is no media file,
    // still write an empty line
    if(media == null) fw.write("\r\n");
    else {
      fw.write(type + "/" + datePostedLong + "." + media);
      fw.write("\r\n");
    }

    // see if there is a message, if yes, write it
    if(message != null && !message.equals("null"))
      fw.write(message, 0, message.length());

    // flush the buffer
    fw.flush();

  } catch(IOException ioex) {

    out.println("Internal error: " + ioex.getMessage());
    return;

  } finally {

    if(fw != null) {
      try {
        fw.close();
      } catch(IOException io) { return; }
    }

  }

  out.println("Posted");
%>
```

The listing starts with identifying all the parameters in the request and throwing an error that says the required username is not found. It then proceeds to identify the users directory and create any missing ones. Finally, it checks to determine whether the request contains any media data and, if so, saves this in a specific media folder. The actual entry is saved in a date posted file that is also the name for the media file, if any.

The Web site for the blog lists the entries in the order that they are received, and this is done in the `index.jsp` file. This file, along with the `login.jsp` and `register.jsp` files, is in the source code available in the Downloads section of the Apress Web site.

Figure 9-23 shows the Device Blog server (*http://www.mmapibook.com/deviceblog/index.jsp*) as it looks at the moment!

Figure 9-23. *The Device Blog in action!*

Summary

MMAPI is a terrific tool for building purposeful and multimedia-enabled rich applications. However, to make full use of MMAPI, you must know how it works and how it relates to the rest of the APIs in the MIDlet world.

This chapter has culminated the knowledge path that you started in Chapter 1. The Device Blog MIDlet application is a useable and functional application that showcases a thorough use of MMAPI. Device Blog shows that you can successfully integrate MMAPI with the rest of the Java ME API and build business and entertainment applications.

The Device Blog MIDlet application is not complete, however. It can be extended to include MIDI and Tone Blog entries, and the server side can be made more robust and scalable. However, that was not the aim of this case study. It has shown you the way, and you are invited to experiment with it. I look forward to your entries on the Device Blog server!

APPENDIX A

Mobile Media API (MMAPI) Reference

This appendix is a reference to the MMAPI. All classes, interfaces, and exceptions are listed here so that you can find them in one easy-to-use place. The Javadocs, however, remain the best place for getting detailed explanation about each method and class and is used in this appendix to take the one-line explanation of each class, interface, and exception.

This API is listed alphabetically, grouped by package.

Package `javax.microedition.media`

Interface `Control`

A `Control` object is used to control some media processing functions.

```
public interface Control {
  // no methods
}
```

Interface `Controllable`

`Controllable` provides an interface for obtaining the controls from an object such as a `Player`.

```
public interface Controllable {
  // methods
  public Control getControl(java.lang.String controlType);
  public Control[] getControls();
}
```

Class Manager

Manager is the access point for obtaining system-dependent resources such as Player instances for multimedia processing.

```
public final class Manager {
  // Constructors
  public static final java.lang.String MIDI_DEVICE_LOCATOR;
  public static final java.lang.String TONE_DEVICE_LOCATOR;

  // Methods
  public static Player createPlayer(java.lang.String locator)
    throws java.io.IOException, MediaException;
  public static Player createPlayer(
      java.io.InputStream stream, java.lang.String type)
        throws java.io.IOException, MediaException;
  public static Player createPlayer(DataSource source)
    throws java.io.IOException, MediaException;
  public static java.lang.String[] getSupportedContentTypes(
    java.lang.String protocol);
  public static java.lang.String[] getSupportedProtocols(
    java.lang.String content_type);
  public static TimeBase getSystemTimeBase();
  public static void playTone(int note, int duration, int volume)
    throws MediaException;
}
```

Class MediaException

A MediaException indicates an unexpected error condition in a method.

```
public class MediaException extends java.lang.Exception {
  // Constructors
  public MediaException();
  public MediaException(java.lang.String reason);
}
```

Interface Player

Player controls the rendering of time-based media data.

```
public interface Player extends Controllable {
  // Constants
  public static final int CLOSED;
  public static final int PREFETCHED;
  public static final int REALIZED;
  public static final int STARTED;
  public static final long TIME_UNKNOWN;
  public static final int UNREALIZED;
```

```
  // Methods
  public void addPlayerListener(PlayerListener playerListener);
  public void close();
  public void deallocate();
  public java.lang.String getContentType();
  public long getDuration();
  public long getMediaTime();
  public int getState();
  public TimeBase getTimeBase();
  public void prefetch() throws MediaException;
  public void realize() throws MediaException;
  public void removePlayerListener(PlayerListener playerListener);
  public void setLoopCount(int count);
  public long setMediaTime(long now) throws MediaException;
  public void setTimeBase(TimeBase master) throws MediaException;
  public void start() throws MediaException;
  public void stop() throws MediaException;
}
```

Interface PlayerListener

PlayerListener is the interface for receiving asynchronous events generated by Player instances.

```
public interface PlayerListener {
  // Constants
  public static final java.lang.String BUFFERING_STARTED;
  public static final java.lang.String BUFFERING_STOPPED;
  public static final java.lang.String CLOSED;
  public static final java.lang.String DEVICE_AVAILABLE;
  public static final java.lang.String DEVICE_UNAVAILABLE;
  public static final java.lang.String DURATION_UPDATED;
  public static final java.lang.String END_OF_MEDIA;
  public static final java.lang.String ERROR;
  public static final java.lang.String RECORD_ERROR;
  public static final java.lang.String RECORD_STARTED;
  public static final java.lang.String RECORD_STOPPED;
  public static final java.lang.String SIZE_CHANGED;
  public static final java.lang.String STARTED;
  public static final java.lang.String STOPPED;
  public static final java.lang.String STOPPED_AT_TIME;
  public static final java.lang.String VOLUME_CHANGED;

  // Methods
  public void playerUpdate(Player player, java.lang.String event,
                                          java.lang.Object eventData);
}
```

Interface TimeBase

A TimeBase is a constantly ticking source of time.

```
public interface TimeBase {
  // Methods
  public long getTime();
}
```

Package javax.microedition.media.control

Interface FramePositioningControl

The FramePositioningControl is the interface to control precise positioning of a video frame for Player instances.

```
public interface FramePositioningControl extends Control {
  // Methods
  public long mapFrameToTime(int frameNumber);
  public int mapTimeToFrame(long mediaTime);
  public int seek(int frameNumber);
  public int skip(int framesToSkip);
}
```

Interface GUIControl

GUIControl extends Control and is defined for controls that provide GUI functionalities.

```
public interface GUIControl extends Control {
  // Constants
  public static final int USE_GUI_PRIMITIVE;

  // Methods
  public java.lang.Object initDisplayMode(int mode, java.lang.Object arg);
}
```

Interface MetaDataControl

MetaDataControl is used to retrieve metadata information included within the media streams.

```
public interface MetaDataControl extends Control {
  // Constants
  public static final java.lang.String AUTHOR_KEY;
  public static final java.lang.String COPYRIGHT_KEY;
  public static final java.lang.String DATE_KEY;
  public static final java.lang.String TITLE_KEY;
```

```
  // Methods
  public java.lang.String[] getKeys();
  public java.lang.String getKeyValue(java.lang.String key);
}
```

Interface MIDIControl

MIDIControl provides access to MIDI rendering and transmitting devices.

```
public interface MIDIControl extends Control {
  // Constants
  public static final int CONTROL_CHANGE;
  public static final int NOTE_ON;

  // Methods
  public int[] getBankList(boolean custom) throws MediaException;
  public int getChannelVolume(int channel);
  public java.lang.String getKeyName(int bank, int prog, int key)
    throws MediaException;
  public int[] getProgram(int channel) throws MediaException;
  public int[] getProgramList(int bank) throws MediaException;
  public java.lang.String getProgramName(int bank, int prog) throws MediaException;
  public boolean isBankQuerySupported();
  public int longMidiEvent(byte[] data, int offset, int length);
  public void setChannelVolume(int channel, int volume);
  public void setProgram(int channel, int bank, int program);
  public void shortMidiEvent(int type, int data1, int data2);
}
```

Interface PitchControl

PitchControl raises or lowers the playback pitch of audio without changing the playback speed.

```
public interface PitchControl extends Control {
  // Methods
  public int getMaxPitch();
  public int getMinPitch();
  public int getPitch();
  public int setPitch(int millisemitones);
}
```

Interface RateControl

RateControl controls the playback rate of a Player instance.

```
public interface RateControl extends Control {
  // Methods
  public int getMaxRate();
  public int getMinRate();
```

```
  public int getRate();
  public int setRate(int millirate);
}
```

Interface RecordControl

RecordControl controls the recording of media from a Player instance.

```
public interface RecordControl extends Control {
  // Methods
  public void commit() throws java.io.IOException;
  public java.lang.String getContentType();
  public void reset() throws java.io.IOException;
  public void setRecordLocation(java.lang.String locator)
    throws java.io.IOException, MediaException;
  public int setRecordSizeLimit(int size) throws MediaException;
  public void setRecordStream(java.io.OutputStream stream);
  public void startRecord();
  public void stopRecord();
}
```

Interface StopTimeControl

StopTimeControl allows one to specify a preset stop time for a Player instance.

```
public interface StopTimeControl extends Control {
  // Constants
  public static final long RESET;

  // Methods
  public long getStopTime();
  public void setStopTime(long stopTime);
}
```

Interface TempoControl

TempoControl controls the tempo, in musical terms, of a song.

```
public interface TempoControl extends RateControl {
  // Methods
  public int getTempo();
  public int setTempo(int millitempo);
}
```

Interface ToneControl

ToneControl is the interface to enable playback of a user-defined monotonic tone sequence.

```
public interface ToneControl extends Control {
  // Constants
  public static final byte BLOCK_END;
  public static final byte BLOCK_START;
  public static final byte C4;
  public static final byte PLAY_BLOCK;
  public static final byte REPEAT;
  public static final byte RESOLUTION;
  public static final byte SET_VOLUME;
  public static final byte SILENCE;
  public static final byte TEMPO;
  public static final byte VERSION;

  // Methods
  public void setSequence(byte[] sequence);
}
```

Interface VideoControl

VideoControl controls the display of video.

```
public interface VideoControl extends GUIControl {
  // Constants
  public static final int USE_DIRECT_VIDEO;

  // Methods
  public int getDisplayHeight();
  public int getDisplayWidth();
  public int getDisplayX();
  public int getDisplayY();
  public byte[] getSnapshot(java.lang.String imageType) throws MediaException;
  public int getSourceHeight();
  public int getSourceWidth();
  public java.lang.Object initDisplayMode(int mode, java.lang.Object arg);
  public void setDisplayFullScreen(boolean fullScreenMode) throws MediaException;
  public void setDisplayLocation(int x, int y);
  public void setDisplaySize(int width, int height) throws MediaException;
  public void setVisible(boolean visible);
}
```

Interface VolumeControl

VolumeControl is an interface for manipulating the audio volume of a Player instance.

```
public interface VolumeControl extends Control {
  // Methods
  public int getLevel();
  public boolean isMuted();
  public int setLevel(int level);
  public void setMute(boolean mute);
}
```

Package javax.microedition.media.protocol

Class ContentDescriptor

A ContentDescriptor identifies media data containers.

```
public class ContentDescriptor {
  // Constructors
  public ContentDescriptor(java.lang.String contentType);

  // Methods
  public java.lang.String getContentType();
}
```

Class DataSource

A DataSource is an abstraction for media protocol handlers.

```
public abstract class DataSource implements Controllable {
  // Constructors
  public DataSource(java.lang.String locator);

  // Methods
  public abstract void connect() throws java.io.IOException;
  public abstract void disconnect();
  public abstract java.lang.String getContentType();
  public java.lang.String getLocator();
  public abstract SourceStream[] getStreams();
  public abstract void start() throws java.io.IOException;
  public abstract void stop() throws java.io.IOException;
}
```

Interface SourceStream

Abstracts a single stream of media data.

```
public interface SourceStream extends Controllable {
  // Constants
  public static final int NOT_SEEKABLE;
  public static final int RANDOM_ACCESSIBLE;
  public static final int SEEKABLE_TO_START;

  // Methods
  public ContentDescriptor getContentDescriptor();
  public long getContentLength();
  public int getSeekType();
  public int getTransferSize();
  public int read(byte[] b, int off, int len) throws java.io.IOException;
  public long seek(long where) throws java.io.IOException;
  public long tell();
}
```

APPENDIX B

URI Syntax for Media Locators

The Uniform Resource Identifier (URI) syntax is described using a Request For Comment (RFC) paper as a universal means of describing the location of different types and kinds of resources. The RFC in question is 2396 and its full text can be accessed at *http://www.ietf.org/rfc/rfc2396.txt*.

Essentially, this RFC defines a way for providing a uniform and consistent way of describing the location of different types of resources, wherever they may be located. This is important to us in MMAPI, because MMAPI, being protocol and format agnostic, requires consistent means to access resources.

URI defines two parts to each identifier string: the scheme part and the scheme specific part separated by a ':' as shown here:

```
<scheme>:<scheme-specific-part>
```

As it applies to MMAPI, the scheme part is the protocol over which the resource is being referenced, whereas the scheme-specific part is a hierarchical, location-specific string, which tells the system the exact physical location of the resource.

Not surprisingly, the most common example of this is when resources are accessed over the Internet using HTTP. As an example, *http://www.ietf.org/rfc/rfc2396.txt* consists of the scheme "http" and the scheme-specific part of "//www.ietf.org/rfc/rfc2396.txt". The hierarchies in the scheme-specific parts are separated by the "/" character. Thus, `rfc2396.txt` is a physical document located in the `rfc` folder on the `www.ietf.org` server.

Of course, with MMAPI, the scheme part can be an entire range of options. As you have seen in this book, the scheme part can be any one of `capture`, `rtp`, `file`, `resource`, and, of course, `http` strings.

With each scheme part, different options for the scheme-specific part can be set. For capture scheme, you have used the `audio` and `video` scheme-specific parts. These can be further qualified to specify attributes, for example: `capture://audio?encoding=pcm` would give you a specific URI for capturing WAV audio files.

APPENDIX C

Advanced Multimedia Supplements—JSR 234

The Java Community Process (JCP) at *http://www.jcp.org* defines new technology for the Java technology using a community process, whereby new specifications are released for public overview and debated on. Once approved, the specs are introduced in the Java language. One of the most prolific areas of technology development is Java ME, and new APIs are being constantly created and released to target this area of Java development.

Specifications are released with a Java Specification Request (JSR) number. MMAPI was released as JSR 135 (*http://www.jcp.org/en/jsr/detail?id=135*). However, this specification is now more than two years old, and newer advances in technology have necessitated an update. JSR 234 (*http://www.jcp.org/en/jsr/detail?id=234*), titled Advanced Multimedia Supplements, is a step in updating the MMAPI for new technology devices. The final release of this specification was in June 2005.

However, note that JSR 234 is a supplement to JSR 135. Thus, it doesn't replace MMAPI nor is it used on its own, but provides supplementary implementations for newer technology devices. This appendix gives you an overview of the new JSR.

Introduction to JSR 234

JSR 234 was initiated by a Nokia request to create an API that could provide richer experiences to users of mobile devices. Mobile devices are increasing in their processing power capacity, so this enables sophisticated media processing functionalities available to MIDlet developers and distributors. Specifically, better controls for camera, radio and audio, and sophisticated MIDlets created based on them is the target aim of this specification.

The specification creates a new package, `javax.microedition.amms`, where `amms` stands for Advanced Multimedia supplements. The specification mostly defines new controls that are derived from the `javax.microedition.media.control.Control` interface, thus making these controls compatible with MMAPI (as you would expect, as JSR 234 is a supplement to JSR 135). It also defines four new concepts in the main `javax.microedition.amms` package, `GlobalManager`, `Spectator`, `Module`, and `MediaProcessor`.

GlobalManager

GlobalManager is like a Manager class for JSR 234. It provides methods to retrieve the specialized objects present in this specification. However, it doesn't replace or extend the Manager class, and you still use the Manager class for creating and managing Player instances.

Spectator

The Spectator class represents a virtual listener. It provides acoustic controls that can help create MIDlet applications that mimic sound coming from different locations and areas. You can create a Spectator class by using the getSpectator() static method in the GlobalManager class. This class implements the Controllable interface, which allows it to provide implementation of the getControl() and the getControls() methods.

Module

The Module interface is a logical grouping of multiple Player instances and/or MIDI channels. This functionality was missing from MMAPI, where you can treat a group of such instances as one entity. This interface is extended by two subinterfaces, EffectsModule and SoundsSource3D, which represent different types of groupings. EffectsModule represents Player instances and/or MIDI channels, to which a common effect can be applied, whereas SoundsSource3D represents this group in a virtual acoustical space.

Modules can be fetched from the GlobalManager class using the createEffectModule() or the createSoundSource3D() methods. Note that the Module interface also implements the Controllable interface.

MediaProcessor

MediaProcessor is an interface for postprocessing of media data. A MediaProcessor works very much like a Player interface and defines various states that mimic it as well. A MediaProcessor instance can be in one of UNREALIZED, REALIZED, STARTED, or STOPPED states.

You can retrieve an instance of MediaProcessor by using the GlobalManager class's static method createMediaProcessor(String type), passing to it the MIME type of target processor.

This interface also extends the Controllable interface.

Controls

The rest of the interfaces in this API are various controls and are divided in various packages depending on the type of functionality that they provide.

Package javax.microedition.amms.control

There are two main control interfaces in this package that impact the rest of the packages as well.

FormatControl is used for specifying the format of the various media types. This interface is implemented by four different types of media formats using their own interfaces: AudioFormatControl, ContainerFormatControl, ImageFormatControl, and VideoFormatControl.

`EffectControl` is used to preset a filter on some media data to provide different types of effects. This interface provides a method, `setEnabled(boolean enable)`, to turn the effects on or off. This interface is supported with the `EffectOrderControl` interface, which controls the order in which multiple effects are applied.

Finally, this package contains the interface `PanControl`, which controls the panning of audio and video media data, and `PriorityControl`, which allows the manipulation of the priority given to various `Player` instances in a group situation.

Packages `javax.microedition.amms.control.imageeffect` and `javax.microedition.amms.control.audioeffect`

All of the interfaces in these two packages extend the `EffectControl` interface and provide various effects that can be applied to audio and image media data.

Package `javax.microedition.amms.control.audio3d`

All of the interfaces in this package provide controls for manipulation of audio in a 3D environment. The controls are retrieved from either the `SoundSource3D` or `Spectator` class, as the case may be.

Package `javax.microedition.amms.control.camera`

The controls in this package are retrieved from a `Player` instance that is created by using the `Manager.createPlayer("capture://camera")` method. These controls provide control over the exposure, the flash, focus, zoom, and burst shooting of snapshots (as opposed to single snapshots using the `getSnapshot()` method of the `VideoControl` interface provided in MMAPI). A `CameraControl` control provides further control over the camera by providing methods for shutter control, camera rotation, and so on.

Package `javax.microedition.amms.control.tuner`

This package contains two control interfaces for radio tuning. `RDSControl` is used for Radio Data System (RDS) tuning and provides methods to manage that. `TunerControl` isn't specifically targeted for radio tuning, but it can be used to tune into any `Player` instance that supports tuning, however unlikely.

JSR 234 Implementations

At this point, being a relatively new API, there are no known implementations on any devices, and neither is there any known emulator support. However, Nokia provides a reference implementation with some examples, which can be downloaded at *http://forum.nokia.com/java/jsr234*.

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Beginning JSP 2 From Novice to Professional (Apress)

Pro Java ME MMAPI: Mobile Media API for Java Micro Edition

Dear Reader,

The Mobile Media API (MMAPI) is a protocol- and format-agnostic optional API for the Java ME platform (formerly J2ME). With mobile devices becoming multimedia powerhouses, this API is all you need to fully use these multimedia capabilities. This book shows you how to use these device multimedia capabilities with a variety of options, including tones, MIDI, audio, and video.

Although the final version of MMAPI (1.1) was released in 2002, only now are we seeing devices that support this API in full. Nearly every mobile device released today supports the API in some form. The main advantage of the API being protocol and format agnostic is that it gives device manufacturers a lot of flexibility in its implementation; at the same time, however, this also makes it a little difficult for application developers to keep up with the plethora of options. Without a structured understanding of this API, it can be difficult to create applications that work seamlessly on multiple devices and retain support for a minimum set of protocols and formats.

With this in mind, this book addresses the structure of this API in detail. Chapters 1 through 5 focus on the architecture of this API from the ground up, including explanations of threading, networking, and event management. Chapter 6 covers creating and managing tones, Chapter 7 focuses on MIDI, and Chapter 8 explains how to capture audio and video as well as streaming media over a server, among other things. Chapter 9 is a case study that uses the book's companion site at http://www.mmapibook.com to develop a device blogging application that allows you to blog using audio, video, images, and simple text.

I hope that you find this book useful in creating multimedia-rich applications for your devices using Java ME. I look forward to your comments and feedback. You can contact me directly at vikram@mmapibook.com.

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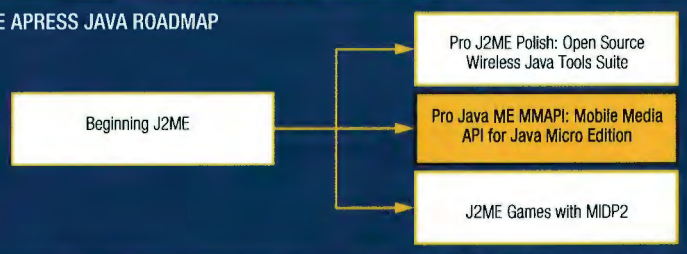

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