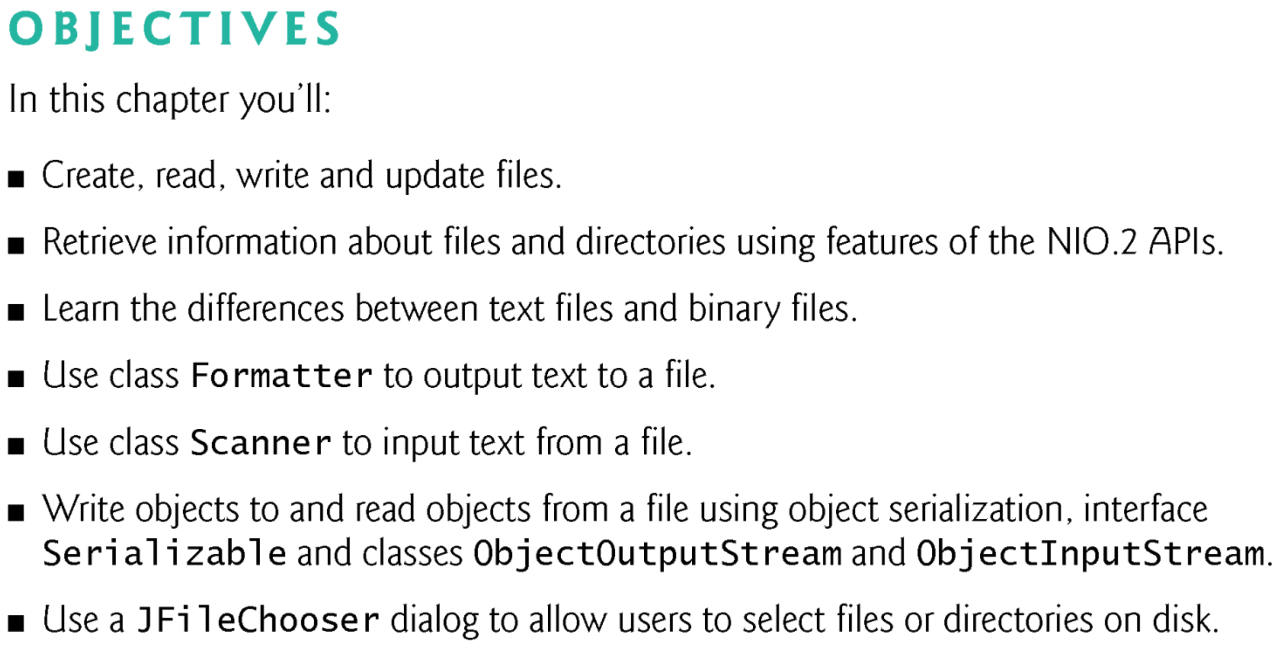
Chapter 15
Files, Streams and Object Serialization

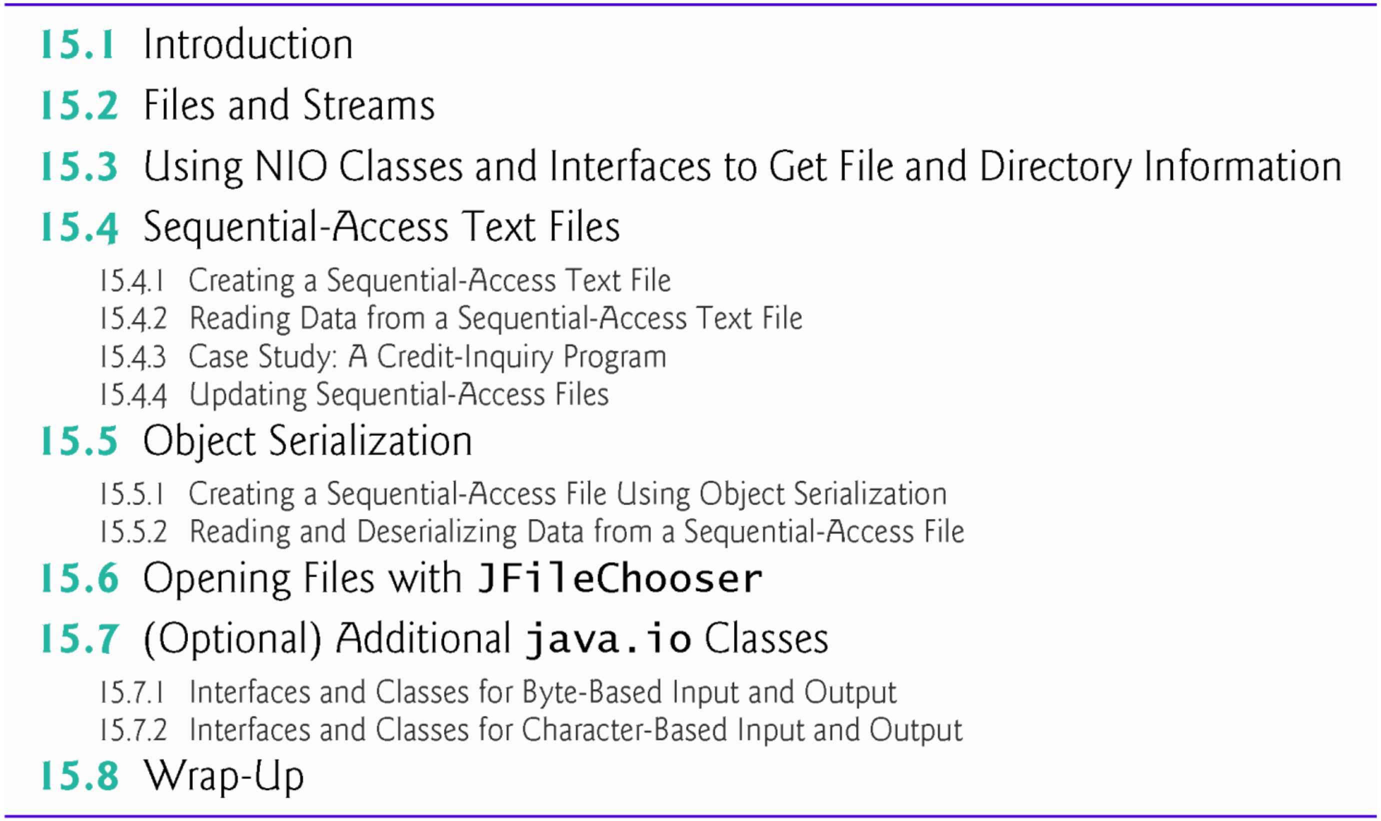
Java How to Program, 10/e



OBJECTIVES

In this chapter you'll:

- Create, read, write and update files.
- Retrieve information about files and directories using features of the NIO.2 APIs.
- Learn the differences between text files and binary files.
- Use class **`Formatter`** to output text to a file.
- Use class **`Scanner`** to input text from a file.
- Write objects to and read objects from a file using object serialization, interface **`Serializable`** and classes **`ObjectOutputStream`** and **`ObjectInputStream`**.
- Use a **`JFileChooser`** dialog to allow users to select files or directories on disk.



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- 15.7.1 Interfaces and Classes for Byte-Based Input and Output
- 15.7.2 Interfaces and Classes for Character-Based Input and Output

15.8 Wrap-Up

15.1 Introduction

- Data stored in variables and arrays is temporary
  - It’s lost when a local variable goes out of scope or when the program terminates
- For long-term retention of data, computers use **files**.
- Computers store files on **secondary storage devices**
  - hard disks, flash drives, DVDs and more.
- Data maintained in files is **persistent data** because it exists beyond the duration of program execution.

15.2 Files and Streams

- Java views each file as a sequential **stream of bytes** (Fig. 15.1).
- Every operating system provides a mechanism to determine the end of a file, such as an **end-of-file marker** or a count of the total bytes in the file that is recorded in a system-maintained administrative data structure.
- A Java program simply receives an indication from the operating system when it reaches the end of the stream

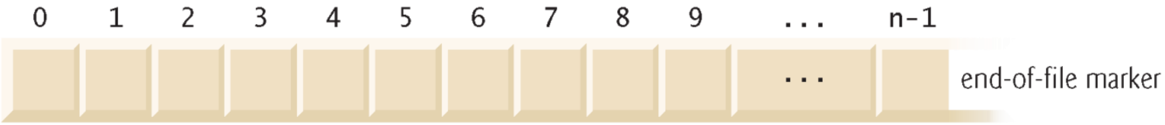


Fig. 15.1 | Java's view of a file of *n* bytes.

15.2 Files and Streams (cont.)

- File streams can be used to input and output data as bytes or characters.
  - **Byte-based streams** output and input data in its *binary* format—a `char` is two bytes, an `int` is four bytes, a `double` is eight bytes, etc.
  - **Character-based streams** output and input data as a *sequence of characters* in which every character is two bytes—the number of bytes for a given value depends on the number of characters in that value.
- Files created using byte-based streams are referred to as **binary files**.
- Files created using character-based streams are referred to as **text files**. Text files can be read by text editors.
- Binary files are read by programs that understand the specific content of the file and the ordering of that content.

15.2 Files and Streams (cont.)

- A Java program **opens** a file by creating an object and associating a stream of bytes or characters with it.
  - Can also associate streams with different devices.
- Java creates three stream objects when a program begins executing
  - `System.in` (standard input stream) object normally inputs bytes from the keyboard
  - Object `System.out` (the standard output stream object) normally outputs character data to the screen
  - Object `System.err` (the standard error stream object) normally outputs character-based error messages to the screen.
- Class `System` provides methods **`setIn`**, **`setOut`** and **`setErr`** to **redirect** the standard input, output and error streams, respectively.

15.2 Files and Streams (cont.)

- Java programs perform file processing by using classes from package `java.io` and the subpackages of `java.nio`.
- Character-based input and output can be performed with classes `Scanner` and `Formatter`.
  - Class `Scanner` is used extensively to input data from the keyboard. This class can also read data from a file.
  - Class `Formatter` enables formatted data to be output to any text-based stream in a manner similar to method `System.out.printf`.

15.2 Files and Streams (cont.)

Java SE 8 Adds Another Type of Stream

- Chapter 17, Java SE 8 Lambdas and Streams, introduces a new type of stream that's used to process collections of elements (like arrays and `ArrayList`s), rather than the streams of bytes we discuss in this chapter's file-processing examples.

15.3 Using NIO Classes and Interfaces to Get File and Directory Information

- Interfaces `Path` and `DirectoryStream` and classes `Paths` and `Files` (all from package `java.nio.file`) are useful for retrieving information about files and directories on disk:
  - `Path` interface—Objects of classes that implement this interface represent the location of a file or directory. `Path` objects do not open files or provide any file-processing capabilities.
  - `Paths` class—Provides static methods used to get a Path object representing a file or directory location.

15.3 Using NIO Classes and Interfaces to Get File and Directory Information (Cont.)

- `Files` class—Provides `static` methods for common file and directory manipulations, such as copying files; creating and deleting files and directories; getting information about files and directories; reading the contents of files; getting objects that allow you to manipulate the contents of files and directories; and more
- `DirectoryStream` interface—Objects of classes that implement this interface enable a program to iterate through the contents of a directory.

15.3 Using NIO Classes and Interfaces to Get File and Directory Information (Cont.)

- A file or directory's path specifies its location on disk. The path includes some or all of the directories leading to the file or directory.
- An **absolute path** contains *all* directories, starting with the **root directory**, that lead to a specific file or directory.
- Every file or directory on a particular disk drive has the *same* root directory in its path.
- A **relative path** is "relative" to another directory—for example, a path relative to the directory in which the application began executing.

15.3 Using NIO Classes and Interfaces to Get File and Directory Information (Cont.)

- An overloaded version of Files static method get uses a URI object to locate the file or directory.
- A **Uniform Resource Identifier (URI)** is a more general form of the **Uniform Resource Locators (URLs)** that are used to locate websites.
- On Windows platforms, the URI
  - `file://C:/data.txt`
- identifies the file `data.txt` stored in the root directory of the C: drive. On UNIX/Linux platforms, the URI
  - `file:/home/student/data.txt`
- identifies the file `data.txt` stored in the home directory of the user student.

15.3 Using NIO Classes and Interfaces to Get File and Directory Information (Cont.)

- Figure 15.2 prompts the user to enter a file or directory name, then uses classes `Paths`, `Path`, `Files` and `DirectoryStream` to output information about that file or directory.

15.3 Using NIO Classes and Interfaces to Get File and Directory Information (Cont.)

- A **separator character** is used to separate directories and files in a path.
  - On a Windows computer, the *separator character* is a backslash (\).
  - On a Linux or Mac OS X system, it's a forward slash (/).
- Java processes both characters identically in a path name.
- For example, if we were to use the path
  - `c:\Program Files\Java\jdk1.6.0_11\demo/jfc`
- which employs each separator character, Java would still process the path properly.

```java
// Fig. 15.2: FileAndDirectoryInfo.java
// File class used to obtain file and directory information.
import java.io.IOException;
import java.nio.file.DirectoryStream;
import java.nio.file.Files;
import java.nio.file.Path;
import java.nio.file.Paths;
import java.util.Scanner;

public class FileAndDirectoryInfo
{
   public static void main(String[] args) throws IOException
   {
      Scanner input = new Scanner(System.in);

      System.out.println("Enter file or directory name:");

      // create Path object based on user input
      Path path = Paths.get(input.nextLine());

```

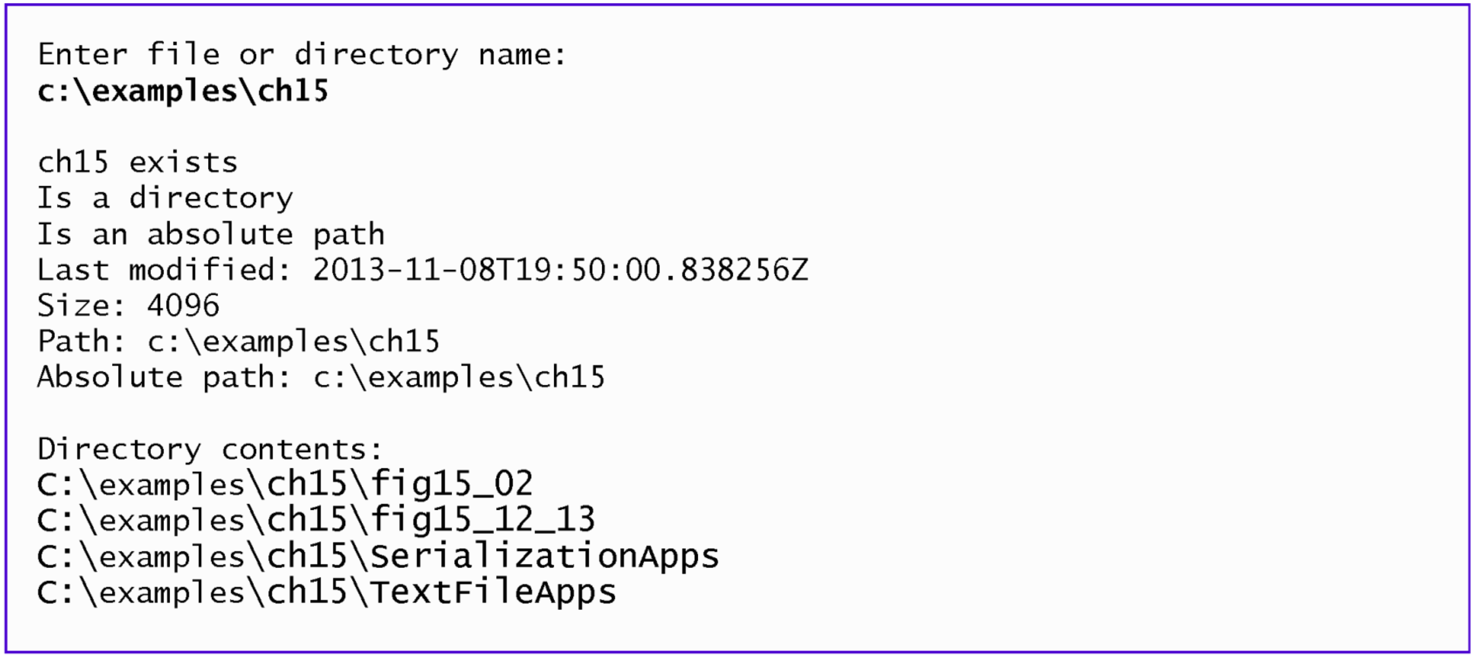
Fig. 15.2 | File class used to obtain file and directory information. (Part 1 of 5.)

```java
      if (Files.exists(path)) // if path exists, output info about it
      {
         // display file (or directory) information
         System.out.printf("%n%s exists%n", path.getFileName());
         System.out.printf("%s a directory%n",
            Files.isDirectory(path) ? "Is" : "Is not");
         System.out.printf("%s an absolute path%n",
            path.isAbsolute() ? "Is" : "Is not");
         System.out.printf("Last modified: %s%n",
            Files.getLastModifiedTime(path));
         System.out.printf("Size: %s%n", Files.size(path));
         System.out.printf("Path: %s%n", path);
         System.out.printf("Absolute path: %s%n", path.toAbsolutePath());

         if (Files.isDirectory(path)) // output directory listing
         {
            System.out.printf("%nDirectory contents:%n");

            // object for iterating through a directory's contents
            DirectoryStream<Path> directoryStream =
               Files.newDirectoryStream(path);

```

Fig. 15.2 | `File` class used to obtain file and directory information. (Part 2 of 5.)

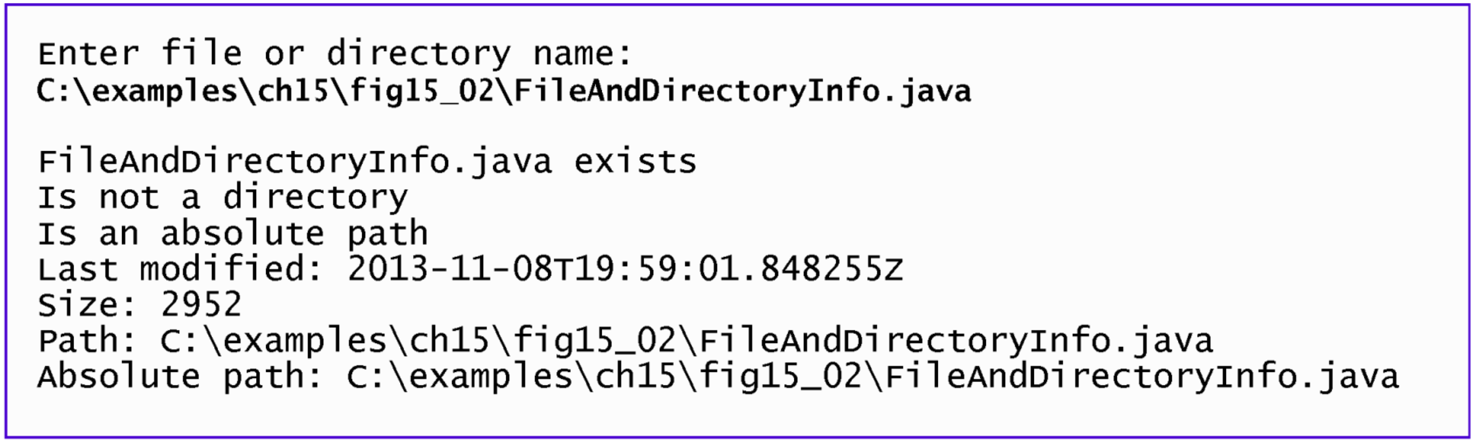
```java
            for (Path p : directoryStream)
               System.out.println(p);
         }
      }
      else // not file or directory, output error message
      {
         System.out.printf("%s does not exist%n", path);
      }
   } // end main
} // end class FileAndDirectoryInfo
```

Fig. 15.2 | File class used to obtain file and directory information. (Part 3 of 5.)



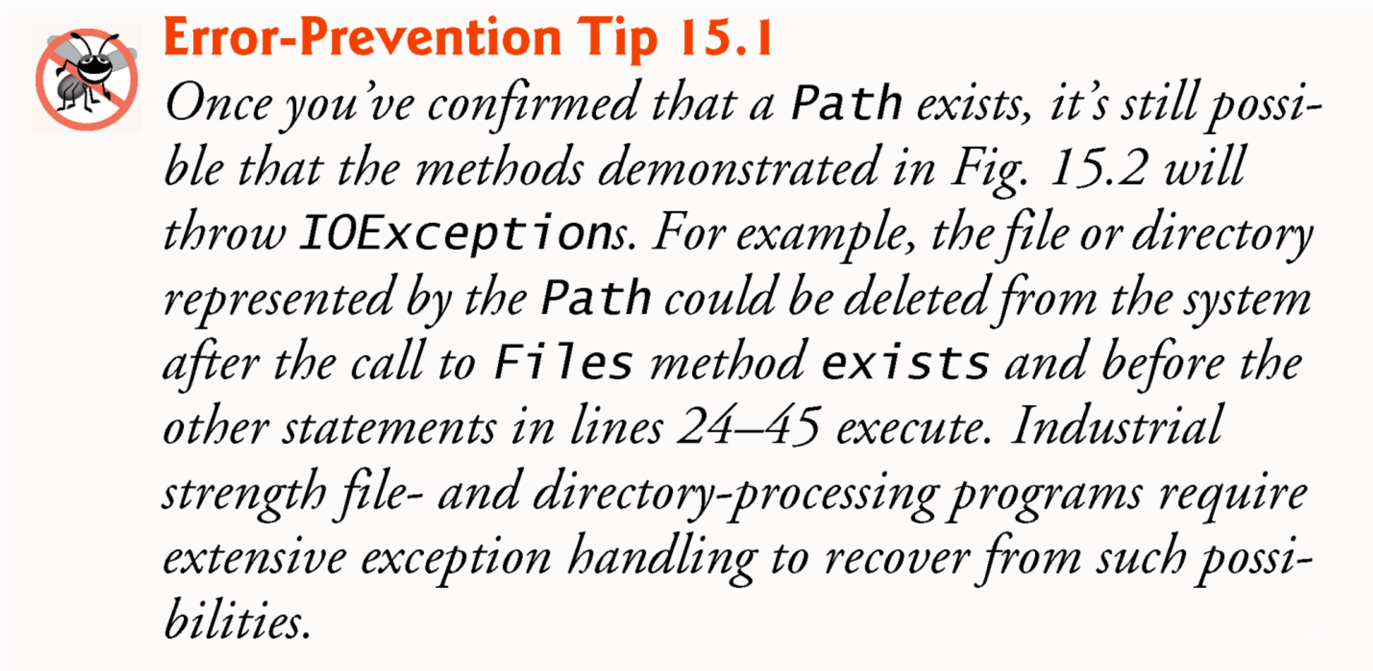
```
Enter file or directory name:
c:\examples\ch15

ch15 exists
Is a directory
Is an absolute path
Last modified: 2013-11-08T19:50:00.838256Z
Size: 4096
Path: c:\examples\ch15
Absolute path: c:\examples\ch15

Directory contents:
C:\examples\ch15\fig15_02
C:\examples\ch15\fig15_12_13
C:\examples\ch15\SerializationApps
C:\examples\ch15\TextFileApps
```

Fig. 15.2 | `File` class used to obtain file and directory information. (Part 4 of 5.)



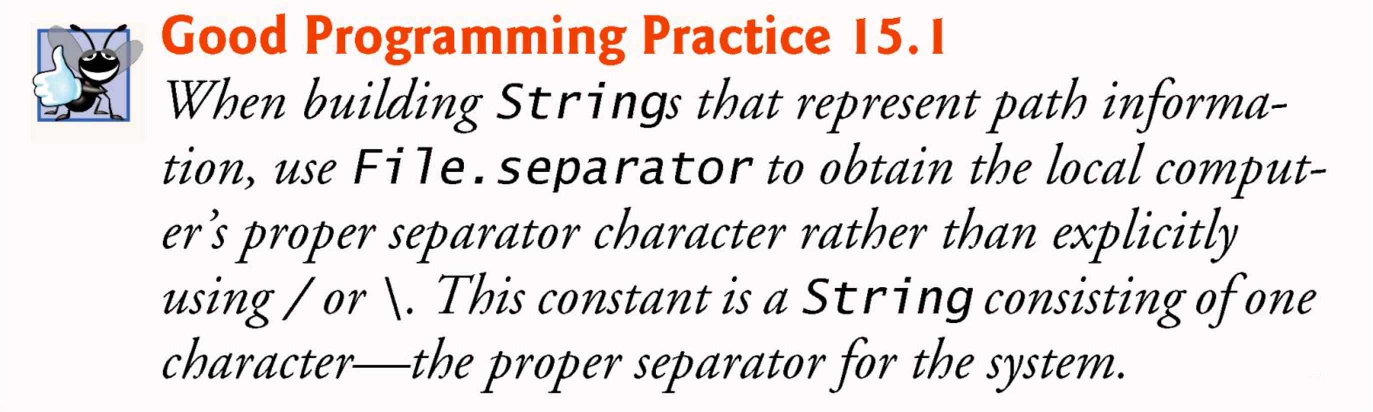
```
Enter file or directory name:
C:\examples\ch15\fig15_02\FileAndDirectoryInfo.java

FileAndDirectoryInfo.java exists
Is not a directory
Is an absolute path
Last modified: 2013-11-08T19:59:01.848255Z
Size: 2952
Path: C:\examples\ch15\fig15_02\FileAndDirectoryInfo.java
Absolute path: C:\examples\ch15\fig15_02\FileAndDirectoryInfo.java
```

Fig. 15.2 | `File` class used to obtain file and directory information. (Part 5 of 5.)



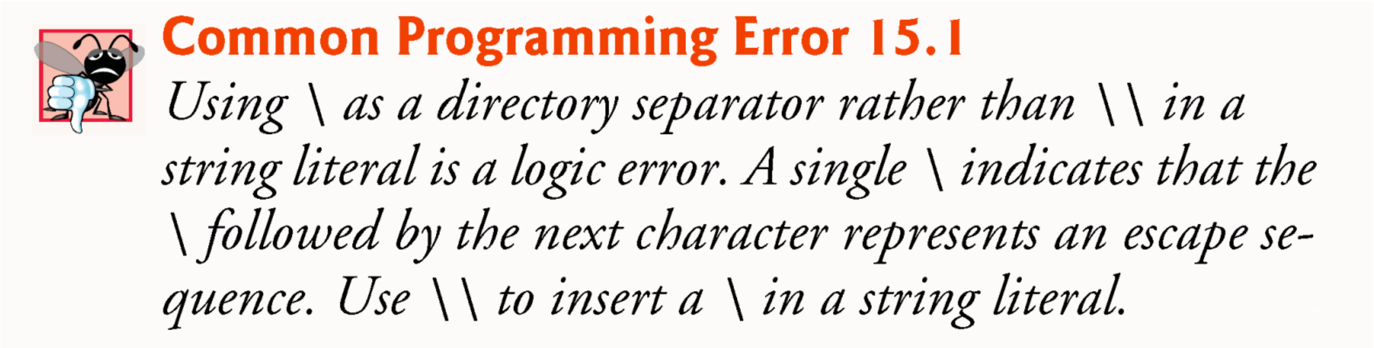
Error-Prevention Tip 15.1

Once you’ve confirmed that a `Path` *exists, it’s still possible that the methods demonstrated in Fig. 15.2 will throw* `IOException`*s. For example, the file or directory represented by the* `Path` *could be deleted from the system after the call to* `Files` *method* `exists` *and before the other statements in lines 24–45 execute. Industrial strength file- and directory-processing programs require extensive exception handling to recover from such possibilities.*



Good Programming Practice 15.1

When building `String`s that represent path information, use `File.separator` to obtain the local computer's proper separator character rather than explicitly using / or \. This constant is a `String` consisting of one character—the proper separator for the system.



Common Programming Error 15.1

Using \ as a directory separator rather than \\ in a string literal is a logic error. A single \ indicates that the \ followed by the next character represents an escape sequence. Use \\ to insert a \ in a string literal.

15.4 Sequential-Access Text Files

- Sequential-access files store records in order by the record-key field.
- Text files are human-readable files.

15.4.1 Creating a Sequential-Access Text File

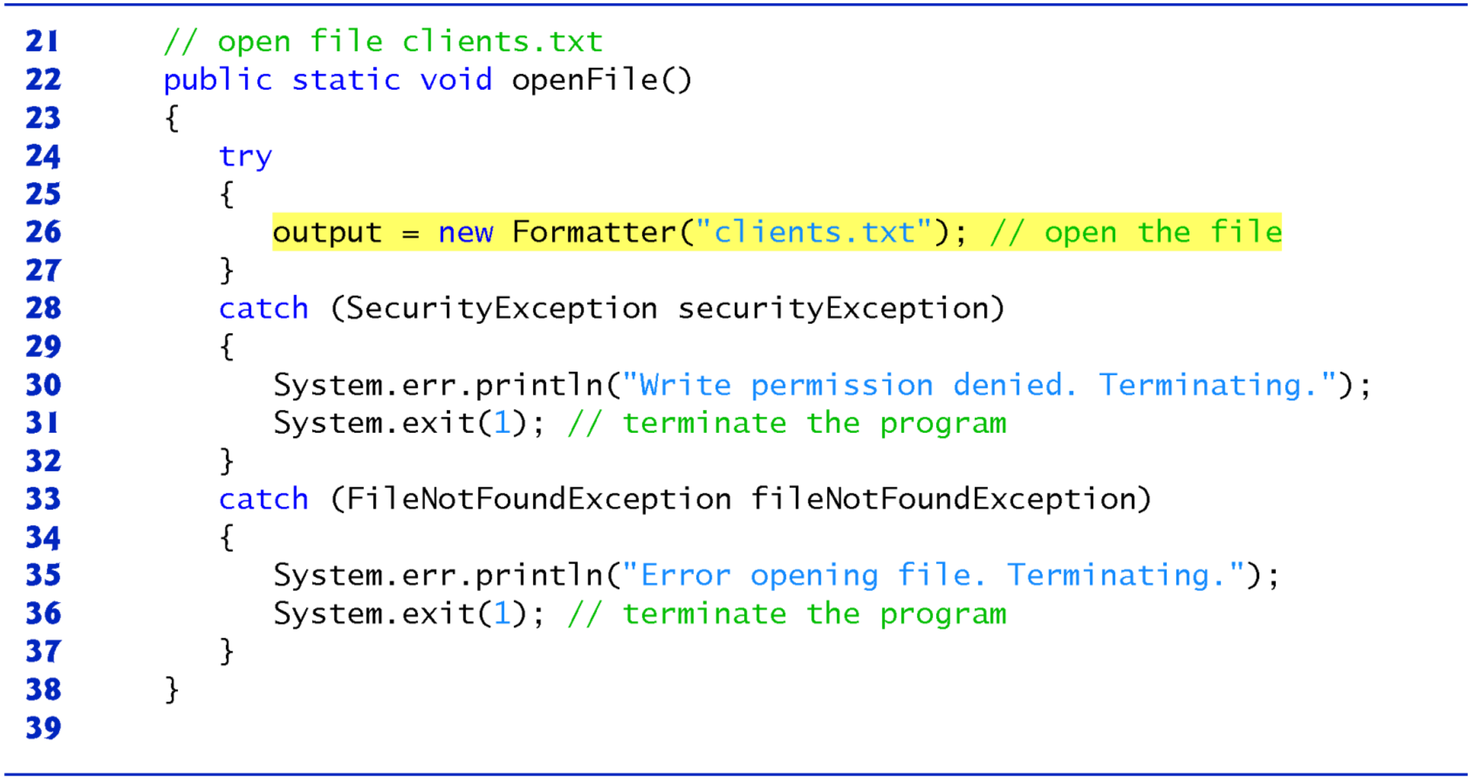
- Java imposes no structure on a file
  - Notions such as records do not exist as part of the Java language.
  - You must structure files to meet the requirements of your applications.

15.4.1 Creating a Sequential-Access Text File (cont.)

- `Formatter` outputs formatted `String`s to the specified stream.
- The constructor with one `String` argument receives the name of the file, including its path.
  - If a path is not specified, the JVM assumes that the file is in the directory from which the program was executed.
- If the file does not exist, it will be created.
- If an existing file is opened, its contents are **truncated**.

```java
// Fig. 15.3: CreateTextFile.java
// Writing data to a sequential text file with class Formatter.
import java.io.FileNotFoundException;
import java.lang.SecurityException;
import java.util.Formatter;
import java.util.FormatterClosedException;
import java.util.NoSuchElementException;
import java.util.Scanner;

public class CreateTextFile
{
   private static Formatter output; // outputs text to a file

   public static void main(String[] args)
   {
      openFile();
      addRecords();
      closeFile();
   }

```

Fig. 15.3 | Writing data to a sequential text file with class Formatter. (Part 1 of 5.)



```
    // open file clients.txt
    public static void openFile()
    {
       try
       {
          output = new Formatter("clients.txt"); // open the file
       }
       catch (SecurityException securityException)
       {
          System.err.println("Write permission denied. Terminating.");
          System.exit(1); // terminate the program
       }
       catch (FileNotFoundException fileNotFoundException)
       {
          System.err.println("Error opening file. Terminating.");
          System.exit(1); // terminate the program
       }
    }

```

Fig. 15.3 | Writing data to a sequential text file with class Formatter. (Part 2 of 5.)

```
   // add records to file
   public static void addRecords()
   {
      Scanner input = new Scanner(System.in);
      System.out.printf("%s%n%s%n? ",
         "Enter account number, first name, last name and balance.",
         "Enter end-of-file indicator to end input.");

      while (input.hasNext()) // loop until end-of-file indicator
      {
         try
         {
```

Fig. 15.3 | Writing data to a sequential text file with class `Formatter`. (Part 3 of 5.)

```
            // output new record to file; assumes valid input
            output.format("%d %s %s %.2f%n", input.nextInt(),
               input.next(), input.next(), input.nextDouble());
         }
         catch (FormatterClosedException formatterClosedException)
         {
            System.err.println("Error writing to file. Terminating.");
            break;
         }
         catch (NoSuchElementException elementException)
         {
            System.err.println("Invalid input. Please try again.");
            input.nextLine(); // discard input so user can try again
         }

         System.out.print("? ");
      } // end while
   } // end method addRecords

```

Fig. 15.3 | Writing data to a sequential text file with class `Formatter`. (Part 4 of 5.)

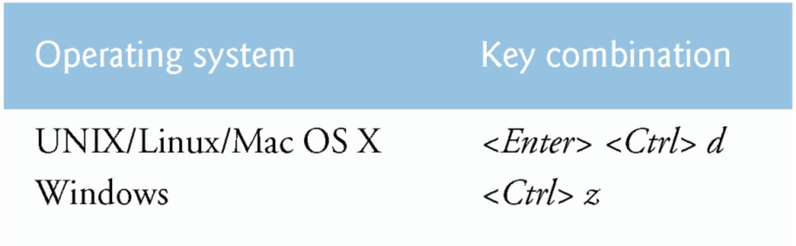
```java
   // close file
   public static void closeFile()
   {
      if (output != null)
         output.close();
   }
} // end class CreateTextFile
```

```
Enter account number, first name, last name and balance.
Enter end-of-file indicator to end input.
? 100 Bob Blue 24.98
? 200 Steve Green -345.67
? 300 Pam White 0.00
? 400 Sam Red -42.16
? 500 Sue Yellow 224.62
? ^Z
```

Fig. 15.3 | Writing data to a sequential text file with class `Formatter`. (Part 5 of 5.)

15.4.1 Creating a Sequential-Access Text File (cont.)

- A `SecurityException` occurs if the user does not have permission to write data to the file.
- A `FileNotFoundException` occurs if the file does not exist and a new file cannot be created.
- `static` method `System.exit` terminates an application.
  - An argument of `0` indicates *successful* program termination.
  - A nonzero value, normally indicates that an error has occurred.
  - The argument is useful if the program is executed from a **batch file** on Windows or a **shell script** on UNIX/Linux/Mac OS X.

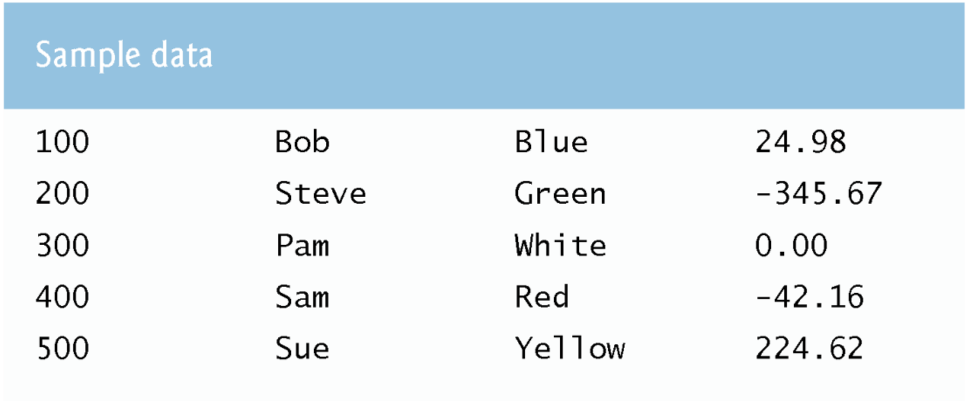


Operating system	Key combination
UNIX/Linux/Mac OS X	*<Enter> <Ctrl> d*
Windows	*<Ctrl> z*

Fig. 15.4 | End-of-file key combinations.

15.4.1 Creating a Sequential-Access Text File (cont.)

- `Scanner` method `hasNext` determines whether the end-of-file key combination has been entered.
- A `NoSuchElementException` occurs if the data being read by a `Scanner` method is in the wrong format or if there is no more data to input.
- `Formatter` method `format` works like `System.out.printf`
- A `FormatterClosedException` occurs if the `Formatter` is closed when you attempt to output.
- `Formatter` method `close` closes the file.
  - If method `close` is not called explicitly, the operating sys-tem normally will close the file when program execution terminates.



Sample data			
100	Bob	Blue	24.98
200	Steve	Green	-345.67
300	Pam	White	0.00
400	Sam	Red	-42.16
500	Sue	Yellow	224.62

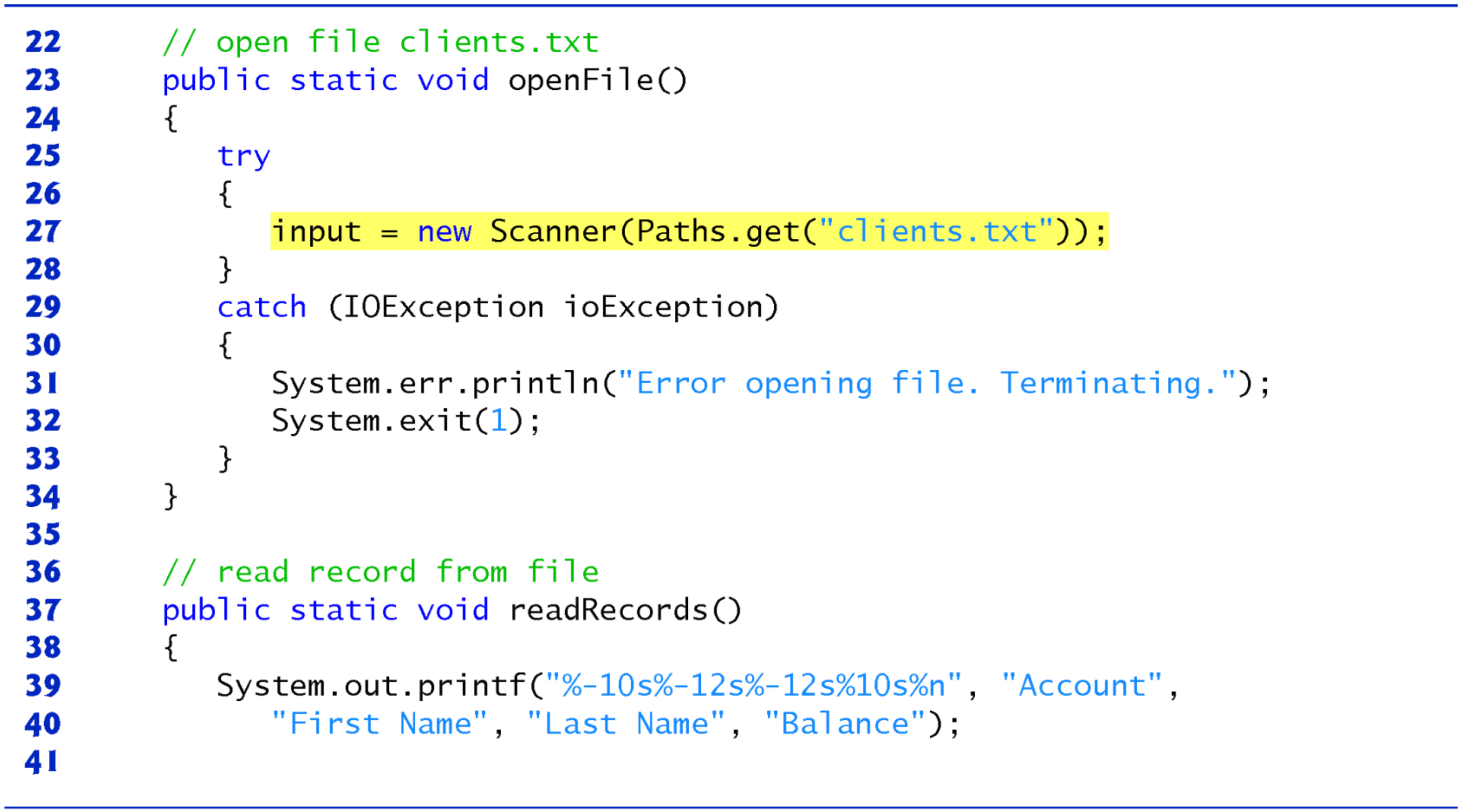
Fig. 15.5 | Sample data for the program in Fig. 15.3.

15.4.2 Reading Data from a Sequential-Access Text File

- The application (Fig. 15.6) reads records from the file `"clients.txt"` created by the application of Section 15.4.1 and displays the record contents.

```java
// Fig. 15.6: ReadTextFile.java
// This program reads a text file and displays each record.
import java.io.IOException;
import java.lang.IllegalStateException;
import java.nio.file.Files;
import java.nio.file.Path;
import java.nio.file.Paths;
import java.util.NoSuchElementException;
import java.util.Scanner;

public class ReadTextFile
{
   private static Scanner input;

   public static void main(String[] args)
   {
      openFile();
      readRecords();
      closeFile();
   }

```

Fig. 15.6 | Sequential file reading using a `Scanner`. (Part 1 of 4.)



```java
    // open file clients.txt
    public static void openFile()
    {
       try
       {
          input = new Scanner(Paths.get("clients.txt"));
       }
       catch (IOException ioException)
       {
          System.err.println("Error opening file. Terminating.");
          System.exit(1);
       }
    }

    // read record from file
    public static void readRecords()
    {
       System.out.printf("%-10s%-12s%-12s%10s%n", "Account",
          "First Name", "Last Name", "Balance");

```

Fig. 15.6 | Sequential file reading using a Scanner. (Part 2 of 4.)

```java
      try
      {
         while (input.hasNext()) // while there is more to read
         {
            // display record contents
            System.out.printf("%-10d%-12s%-12s%10.2f%n", input.nextInt(),
               input.next(), input.next(), input.nextDouble());
         }
      }
      catch (NoSuchElementException elementException)
      {
         System.err.println("File improperly formed. Terminating.");
      }
      catch (IllegalStateException stateException)
      {
         System.err.println("Error reading from file. Terminating.");
      }
   } // end method readRecords

```

Fig. 15.6 | Sequential file reading using a Scanner. (Part 3 of 4.)

```
   // close file and terminate application
   public static void closeFile()
   {
      if (input != null)
         input.close();
   }
} // end class ReadTextFile
```

```
Account   First Name  Last Name      Balance
100       Bob         Blue             24.98
200       Steve       Green          -345.67
300       Pam         White             0.00
400       Sam         Red             -42.16
500       Sue         Yellow          224.62
```

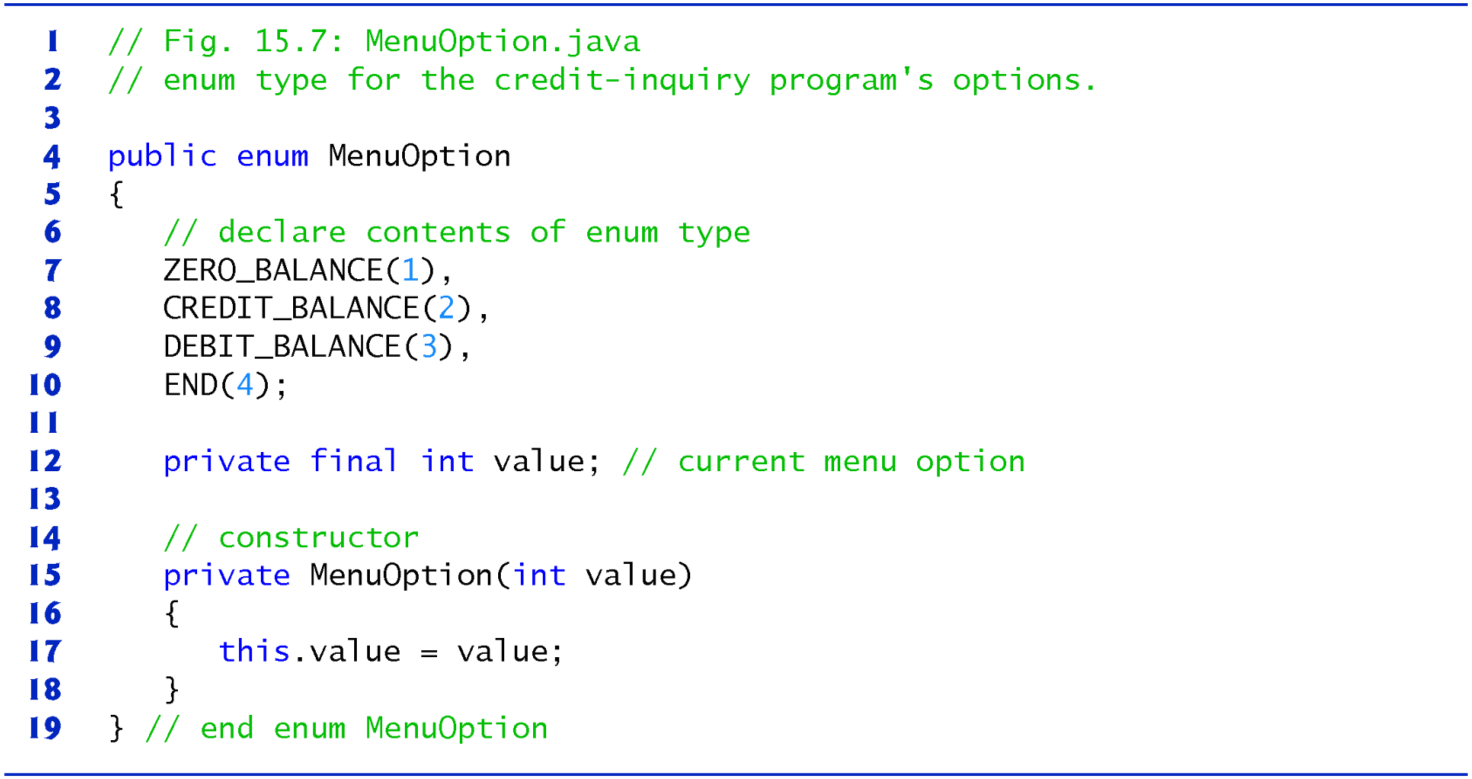
Fig. 15.6 | Sequential file reading using a `Scanner`. (Part 4 of 4.)

15.4.2 Reading Data from a Sequential-Access Text File

- If a `Scanner` is closed before data is input, an `IllegalStateException` **occurs.**

15.4.3 Case Study: A Credit-Inquiry Program

- To retrieve data sequentially from a file, programs start from the beginning of the file and read *all* the data consecutively until the desired information is found.
- It might be necessary to process the file sequentially several times (from the beginning of the file) during the execution of a program.
- Class `Scanner` does *not* allow repositioning to the beginning of the file.
  - The program must *close* the file and *reopen* it.



```java
// Fig. 15.7: MenuOption.java
// enum type for the credit-inquiry program's options.

public enum MenuOption
{
   // declare contents of enum type
   ZERO_BALANCE(1),
   CREDIT_BALANCE(2),
   DEBIT_BALANCE(3),
   END(4);

   private final int value; // current menu option

   // constructor
   private MenuOption(int value)
   {
      this.value = value;
   }
} // end enum MenuOption
```

Fig. 15.7 | `enum` type for the credit-inquiry program's menu options.

```java
// Fig. 15.8: CreditInquiry.java
// This program reads a file sequentially and displays the
// contents based on the type of account the user requests
// (credit balance, debit balance or zero balance).
import java.io.IOException;
import java.lang.IllegalStateException;
import java.nio.file.Paths;
import java.util.NoSuchElementException;
import java.util.Scanner;

public class CreditInquiry
{
   private final static MenuOption[] choices = MenuOption.values();

   public static void main(String[] args)
   {
      // get user's request (e.g., zero, credit or debit balance)
      MenuOption accountType = getRequest();

```

Fig. 15.8 | Credit-inquiry program. (Part 1 of 8.)

```
      while (accountType != MenuOption.END)
      {
         switch (accountType)
         {
            case ZERO_BALANCE:
               System.out.printf("%nAccounts with zero balances:%n");
               break;
            case CREDIT_BALANCE:
               System.out.printf("%nAccounts with credit balances:%n");
               break;
            case DEBIT_BALANCE:
               System.out.printf("%nAccounts with debit balances:%n");
               break;
         }

         readRecords(accountType);
         accountType = getRequest(); // get user's request
      }
   }

```

Fig. 15.8 | Credit-inquiry program. (Part 2 of 8.)

```java
   // obtain request from user
   private static MenuOption getRequest()
   {
      int request = 4;

      // display request options
      System.out.printf("%nEnter request%n%s%n%s%n%s%n%s%n",
         " 1 - List accounts with zero balances",
         " 2 - List accounts with credit balances",
         " 3 - List accounts with debit balances",
         " 4 - Terminate program");

      try
      {
         Scanner input = new Scanner(System.in);

         do // input user request
         {
            System.out.printf("%n? ");
            request = input.nextInt();
         } while ((request < 1) || (request > 4));
      }
```

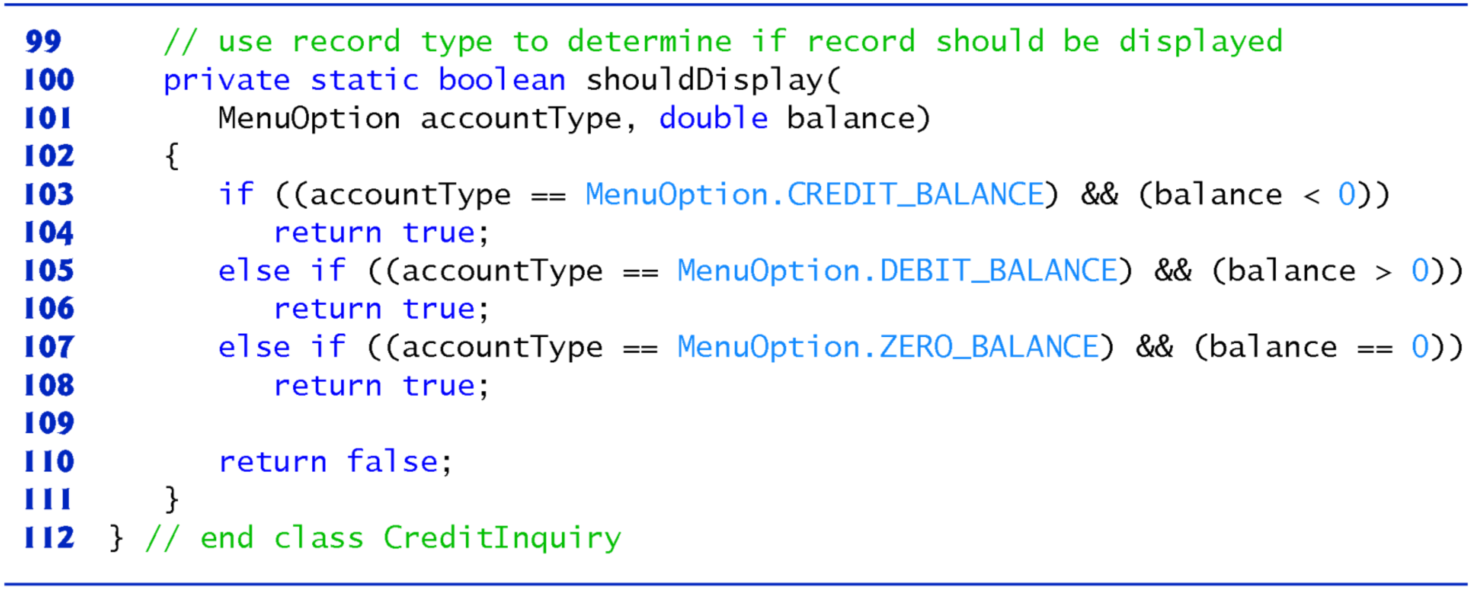
Fig. 15.8 | Credit-inquiry program. (Part 3 of 8.)

```
      catch (NoSuchElementException noSuchElementException)
      {
         System.err.println("Invalid input. Terminating.");
      }

      return choices[request - 1]; // return enum value for option
   }

   // read records from file and display only records of appropriate type
   private static void readRecords(MenuOption accountType)
   {
      // open file and process contents
      try (Scanner input = new Scanner(Paths.get("clients.txt")))
      {
         while (input.hasNext()) // more data to read
         {
            int accountNumber = input.nextInt();
            String firstName = input.next();
            String lastName = input.next();
            double balance = input.nextDouble();

```

Fig. 15.8 | Credit-inquiry program. (Part 4 of 8.)

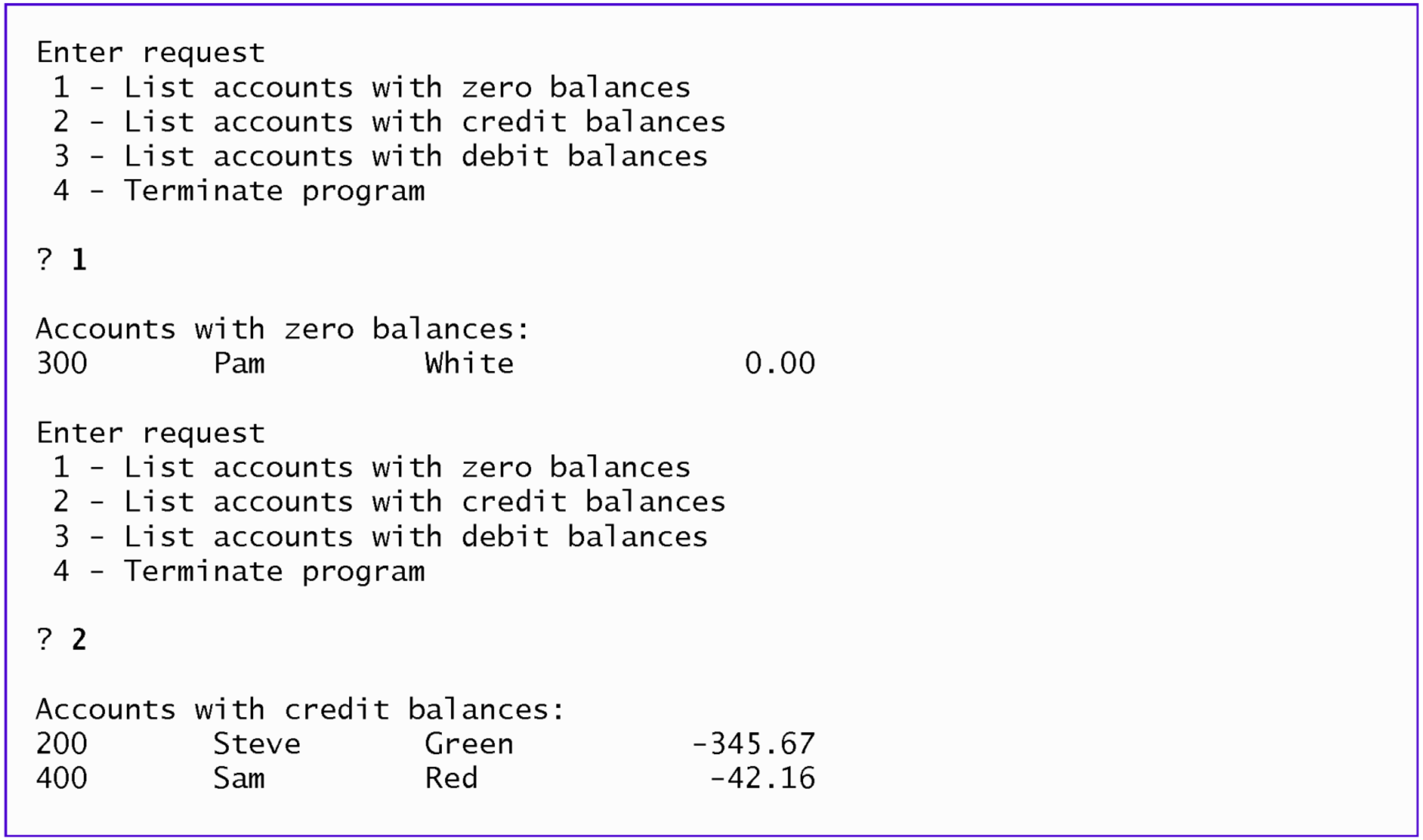
```java
            // if proper acount type, display record
            if (shouldDisplay(accountType, balance))
               System.out.printf("%-10d%-12s%-12s%10.2f%n", accountNumber,
                  firstName, lastName, balance);
            else
               input.nextLine(); // discard the rest of the current record
         }
      }
      catch (NoSuchElementException |
         IllegalStateException | IOException e)
      {
         System.err.println("Error processing file. Terminating.");
         System.exit(1);
      }
   } // end method readRecords

```

Fig. 15.8 | Credit-inquiry program. (Part 5 of 8.)



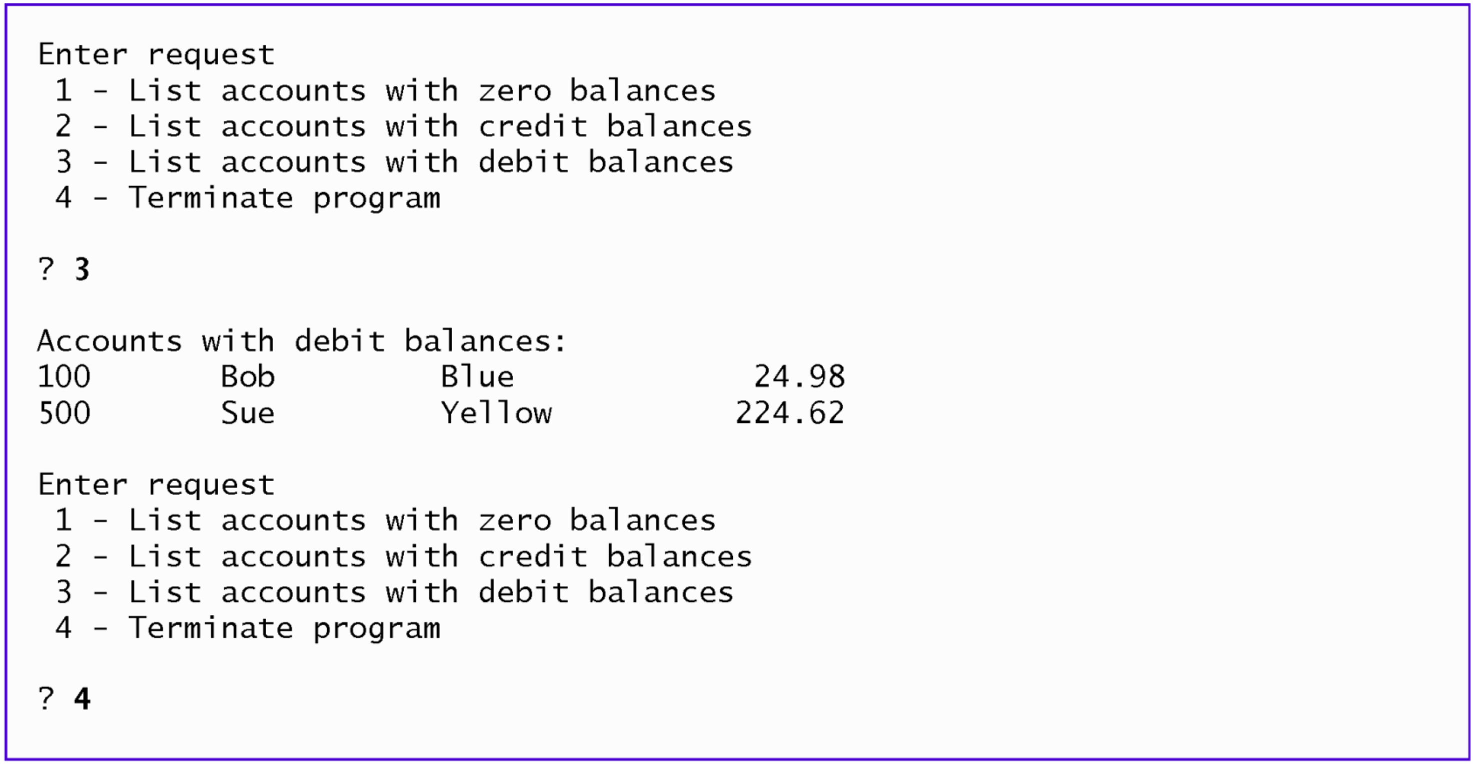
```java
   // use record type to determine if record should be displayed
   private static boolean shouldDisplay(
      MenuOption accountType, double balance)
   {
      if ((accountType == MenuOption.CREDIT_BALANCE) && (balance < 0))
         return true;
      else if ((accountType == MenuOption.DEBIT_BALANCE) && (balance > 0))
         return true;
      else if ((accountType == MenuOption.ZERO_BALANCE) && (balance == 0))
         return true;

      return false;
   }
} // end class CreditInquiry
```

Fig. 15.8 | Credit-inquiry program. (Part 6 of 8.)



```
Enter request
 1 - List accounts with zero balances
 2 - List accounts with credit balances
 3 - List accounts with debit balances
 4 - Terminate program

? 1

Accounts with zero balances:
300       Pam         White              0.00

Enter request
 1 - List accounts with zero balances
 2 - List accounts with credit balances
 3 - List accounts with debit balances
 4 - Terminate program

? 2

Accounts with credit balances:
200       Steve       Green           -345.67
400       Sam         Red              -42.16
```

Fig. 15.8 | Credit-inquiry program. (Part 7 of 8.)



```
Enter request
 1 - List accounts with zero balances
 2 - List accounts with credit balances
 3 - List accounts with debit balances
 4 - Terminate program

? 3

Accounts with debit balances:
100       Bob         Blue             24.98
500       Sue         Yellow          224.62

Enter request
 1 - List accounts with zero balances
 2 - List accounts with credit balances
 3 - List accounts with debit balances
 4 - Terminate program

? 4
```

Fig. 15.8 | Credit-inquiry program. (Part 8 of 8.)

15.4.4 Updating Sequential-Access Files

- The data in many sequential files cannot be modified without the risk of destroying other data in the file.
- If the name "`White`" needed to be changed to "`Worthington`," the old name cannot simply be overwritten, because the new name requires more space.
- Fields in a text file—and hence records—can vary in size.
- Records in a sequential-access file are not usually updated in place. Instead, the entire file is rewritten.
- Rewriting the entire file is uneconomical to update just one record, but reasonable if a substantial number of records need to be updated.

15.5 Object Serialization

- To read an entire object from or write an entire object to a file, Java provides **object serialization.**
- A **serialized object** is represented as a sequence of bytes that includes the object's data and its type information.
- After a serialized object has been written into a file, it can be read from the file and **deserialized** to recreate the object in memory.

15.5 Object Serialization (cont.)

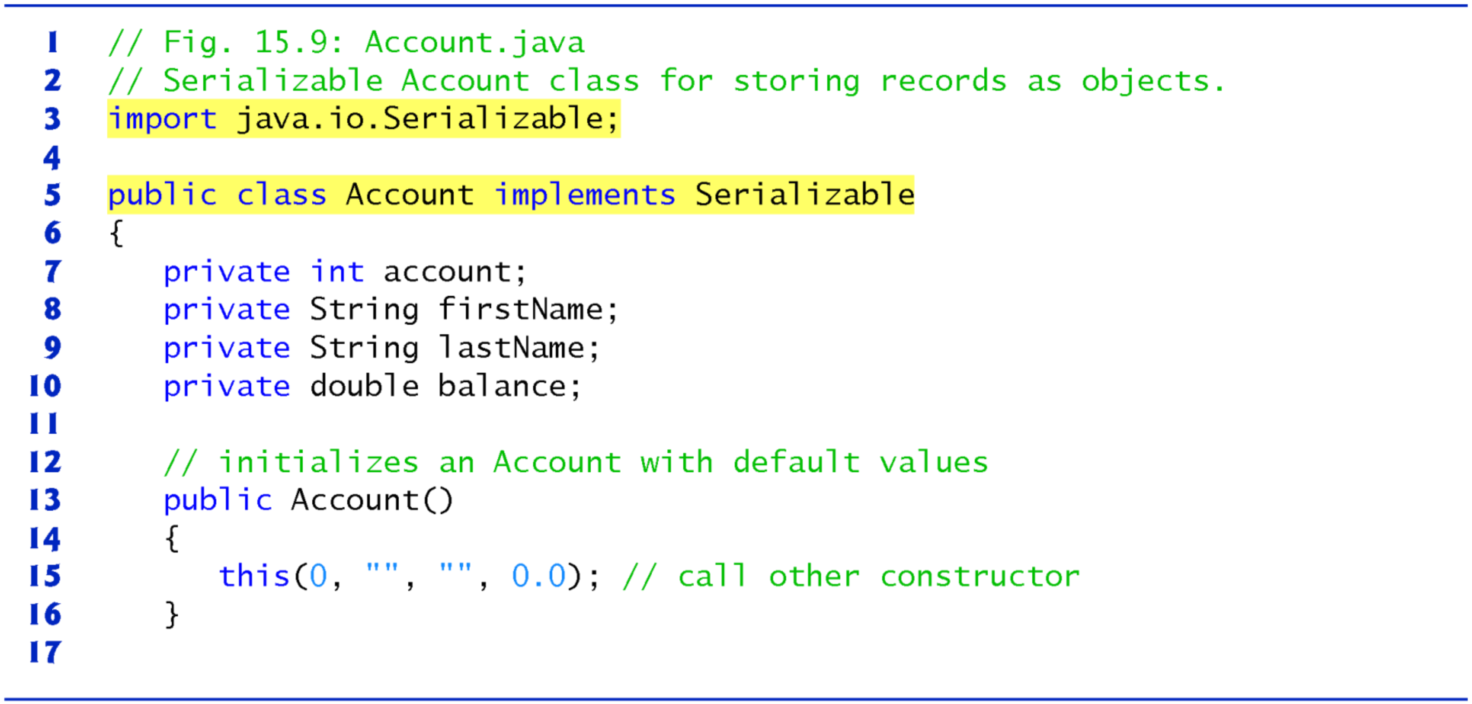
- Classes `ObjectInputStream` and `ObjectOutputStream` (package `java.io`). which respectively implement the **`ObjectInput`** and **`ObjectOutput`** interfaces, enable entire objects to be read from or written to a stream.
- To use serialization with files, initialize `ObjectInputStream` and `ObjectOutputStream` objects that read from and write to files.

15.5 Object Serialization (cont.)

- ObjectOutput interface method **writeObject** takes an Object as an argument and writes its information to an OutputStream.
- A class that implements ObjectOuput (such as ObjectOutputStream) declares this method and ensures that the object being output implements Serializable.
- ObjectInput interface method **readObject** reads and returns a reference to an Object from an InputStream.
  - After an object has been read, its reference can be cast to the object's actual type.

15.5.1 Creating a Sequential-Access File Using Object Serialization

- Objects of classes that implement interface `Serializable` can be *serialized* and *deserialized* with `ObjectOutputStream`s and `ObjectInputStream`s.
- Interface `Serializable` is a **tagging interface**.
  - It does not contain methods.
- A class that implements `Serializable` is *tagged* as being a `Serializable` object.
- An `ObjectOutputStream` will not output an object unless it *is a* `Serializable` object.

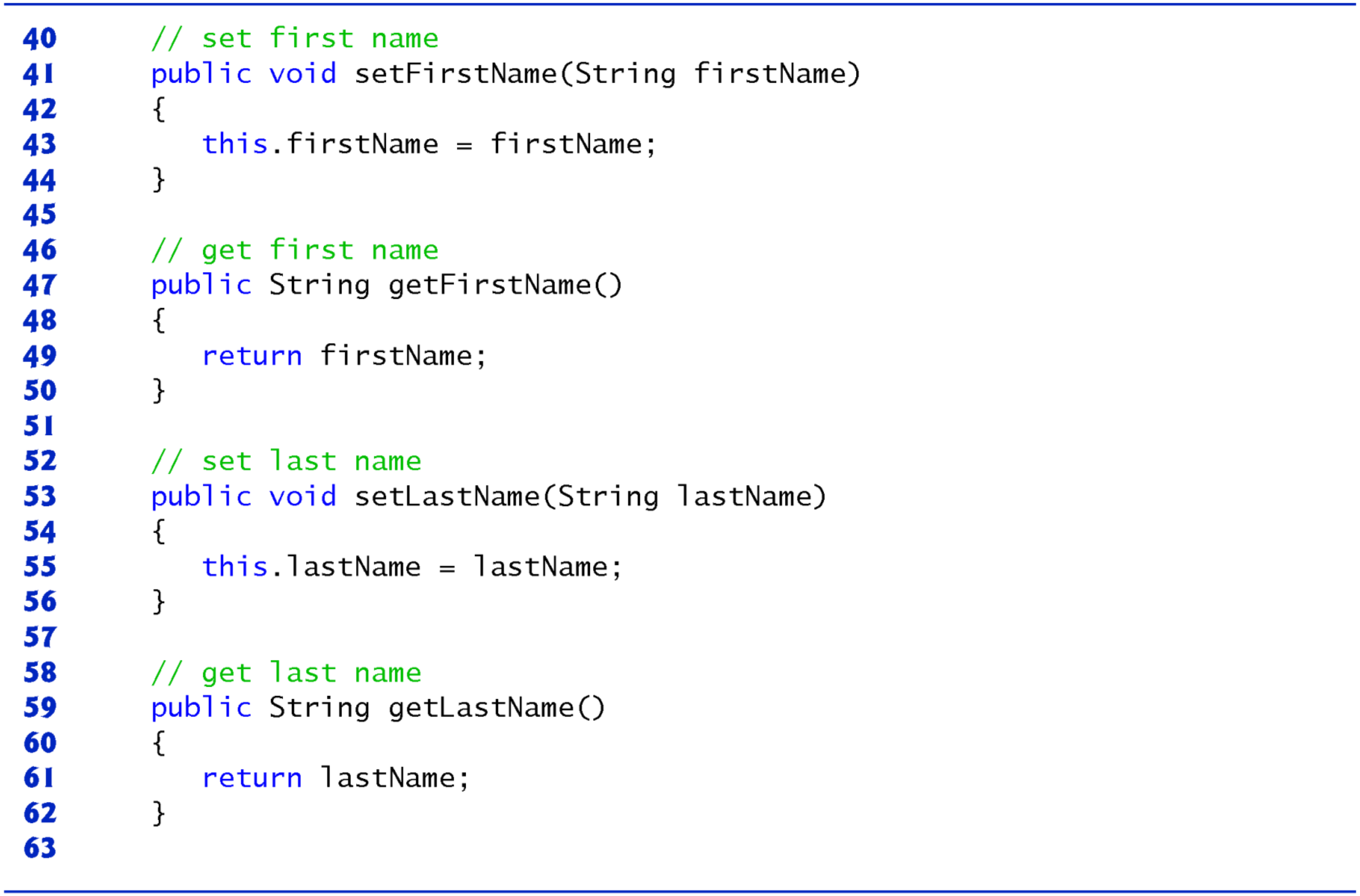


```java
// Fig. 15.9: Account.java
// Serializable Account class for storing records as objects.
import java.io.Serializable;

public class Account implements Serializable
{
   private int account;
   private String firstName;
   private String lastName;
   private double balance;

   // initializes an Account with default values
   public Account()
   {
      this(0, "", "", 0.0); // call other constructor
   }

```

Fig. 15.9 | Account class for serializable objects. (Part 1 of 4.)

```java
   // initializes an Account with provided values
   public Account(int account, String firstName,
      String lastName, double balance)
   {
      this.account = account;
      this.firstName = firstName;
      this.lastName = lastName;
      this.balance = balance;
   }

   // set account number
   public void setAccount(int acct)
   {
      this.account = account;
   }

   // get account number
   public int getAccount()
   {
      return account;
   }

```

Fig. 15.9 | Account class for serializable objects. (Part 2 of 4.)



```java
   // set first name
   public void setFirstName(String firstName)
   {
      this.firstName = firstName;
   }

   // get first name
   public String getFirstName()
   {
      return firstName;
   }

   // set last name
   public void setLastName(String lastName)
   {
      this.lastName = lastName;
   }

   // get last name
   public String getLastName()
   {
      return lastName;
   }

```

Fig. 15.9 | Account class for serializable objects. (Part 3 of 4.)

```java
   // set balance
   public void setBalance(double balance)
   {
      this.balance = balance;
   }

   // get balance
   public double getBalance()
   {
      return balance;
   }
} // end class Account
```

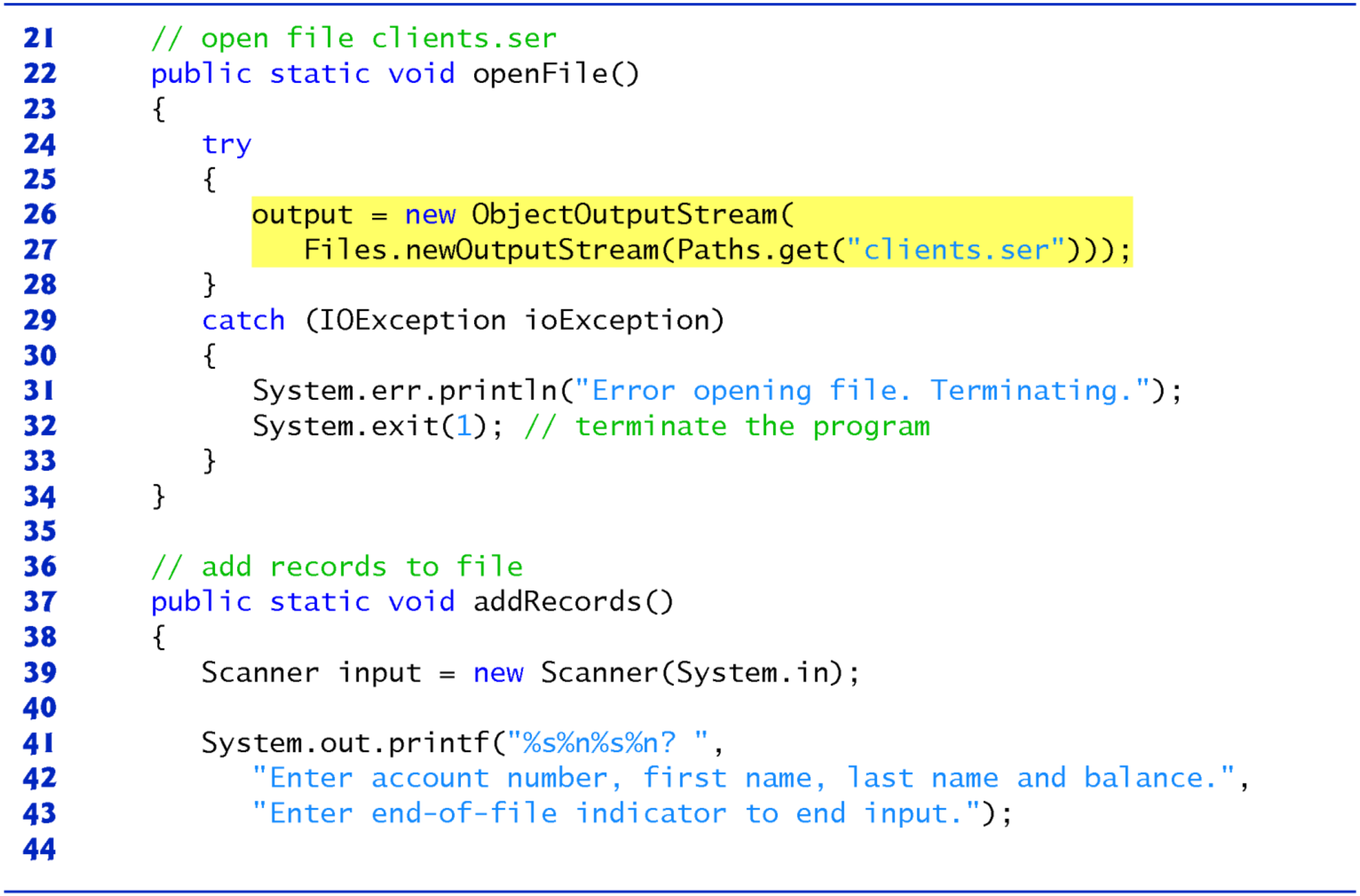
Fig. 15.9 | Account class for serializable objects. (Part 4 of 4.)

15.5.1 Creating a Sequential-Access File Using Object Serialization (cont.)

- In a class that implements `Serializable`, every variable must be `Serializable`.
- Any one that is not must be declared **`transient`** so it will be ignored during the serialization process.
- *All primitive-type variables are serializable.*
- For reference-type variables, check the class's documentation (and possibly its superclasses) to ensure that the type is `Serializable`.

```java
// Fig. 15.10: CreateSequentialFile.java
// Writing objects sequentially to a file with class ObjectOutputStream.
import java.io.IOException;
import java.io.ObjectOutputStream;
import java.nio.file.Files;
import java.nio.file.Paths;
import java.util.NoSuchElementException;
import java.util.Scanner;

public class CreateSequentialFile
{
   private static ObjectOutputStream output; // outputs data to file

   public static void main(String[] args)
   {
      openFile();
      addRecords();
      closeFile();
   }

```

Fig. 15.10 | Sequential file created using `ObjectOutputStream`. (Part 1 of 5.)

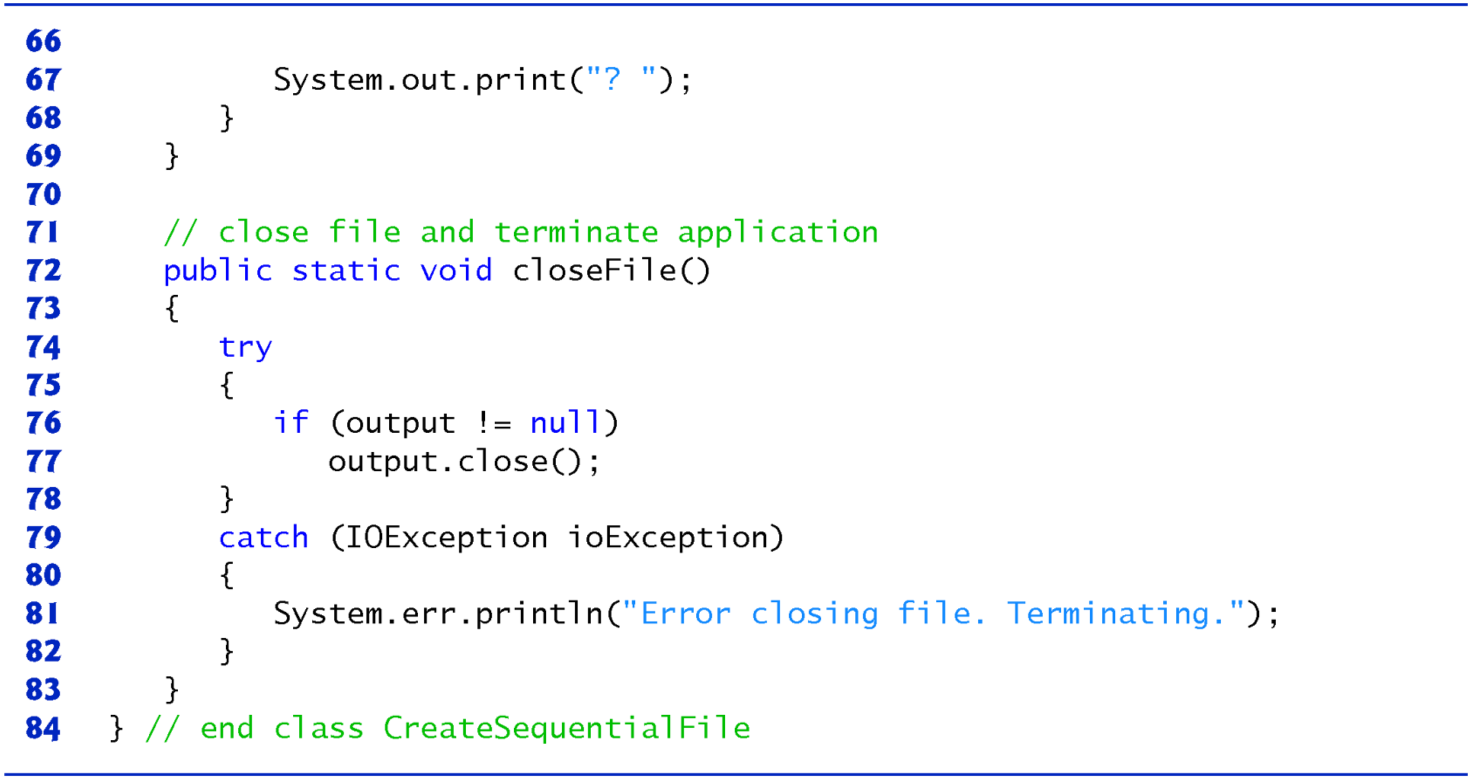


```
    // open file clients.ser
    public static void openFile()
    {
       try
       {
          output = new ObjectOutputStream(
             Files.newOutputStream(Paths.get("clients.ser")));
       }
       catch (IOException ioException)
       {
          System.err.println("Error opening file. Terminating.");
          System.exit(1); // terminate the program
       }
    }

    // add records to file
    public static void addRecords()
    {
       Scanner input = new Scanner(System.in);

       System.out.printf("%s%n%s%n? ",
          "Enter account number, first name, last name and balance.",
          "Enter end-of-file indicator to end input.");

```

Fig. 15.10 | Sequential file created using `ObjectOutputStream`. (Part 2 of 5.)

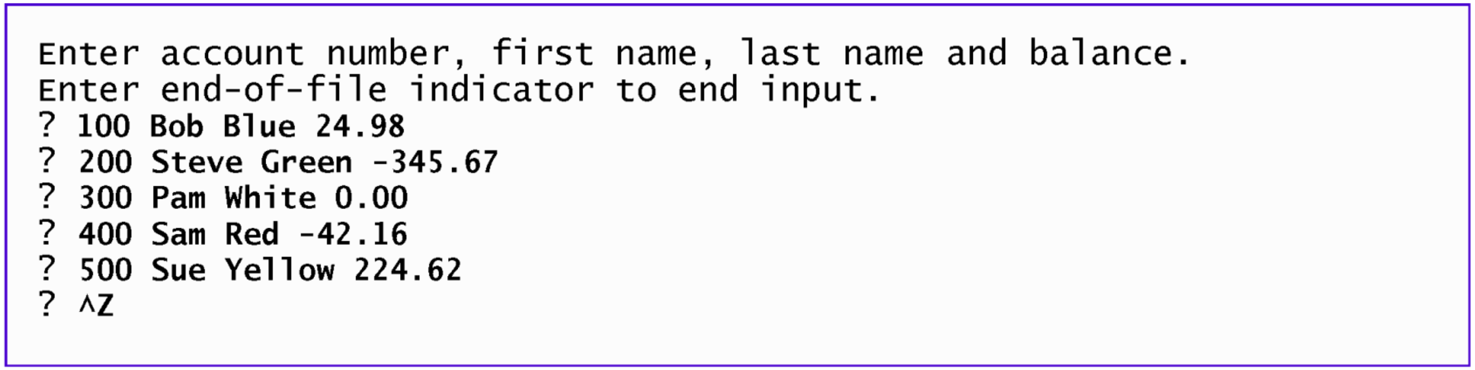
```java
      while (input.hasNext()) // loop until end-of-file indicator
      {
         try
         {
            // create new record; this example assumes valid input
            Account record = new Account(input.nextInt(),
               input.next(), input.next(), input.nextDouble());

            // serialize record object into file
            output.writeObject(record);
         }
         catch (NoSuchElementException elementException)
         {
            System.err.println("Invalid input. Please try again.");
            input.nextLine(); // discard input so user can try again
         }
         catch (IOException ioException)
         {
            System.err.println("Error writing to file. Terminating.");
            break;
         }
```

Fig. 15.10 | Sequential file created using `ObjectOutputStream`. (Part 3 of 5.)



```java

         System.out.print("? ");
      }
   }

   // close file and terminate application
   public static void closeFile()
   {
      try
      {
         if (output != null)
            output.close();
      }
      catch (IOException ioException)
      {
         System.err.println("Error closing file. Terminating.");
      }
   }
} // end class CreateSequentialFile
```

Fig. 15.10 | Sequential file created using `ObjectOutputStream`. (Part 4 of 5.)

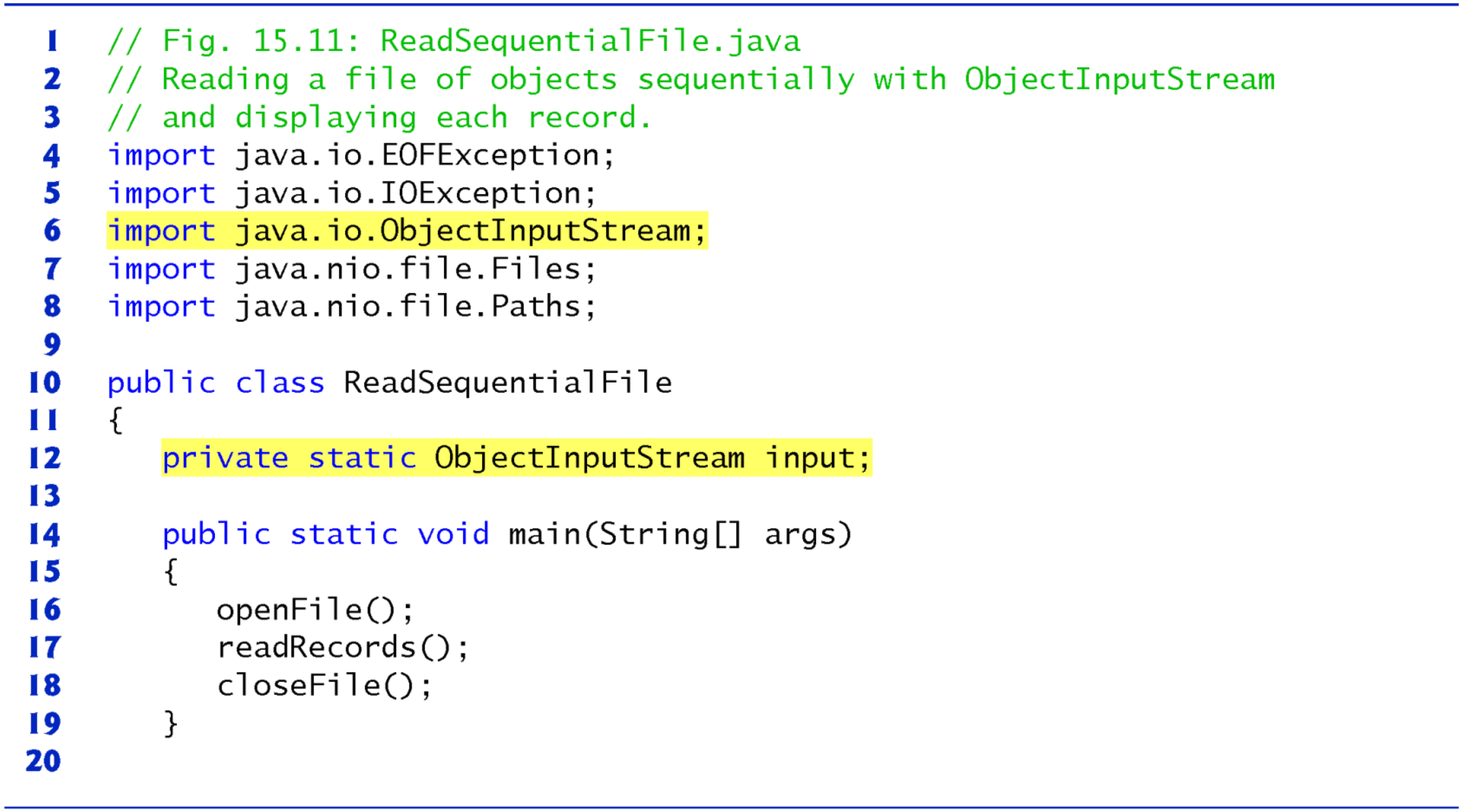


```
Enter account number, first name, last name and balance.
Enter end-of-file indicator to end input.
? 100 Bob Blue 24.98
? 200 Steve Green -345.67
? 300 Pam White 0.00
? 400 Sam Red -42.16
? 500 Sue Yellow 224.62
? ^Z
```

Fig. 15.10 | Sequential file created using `ObjectOutputStream`. (Part 5 of 5.)

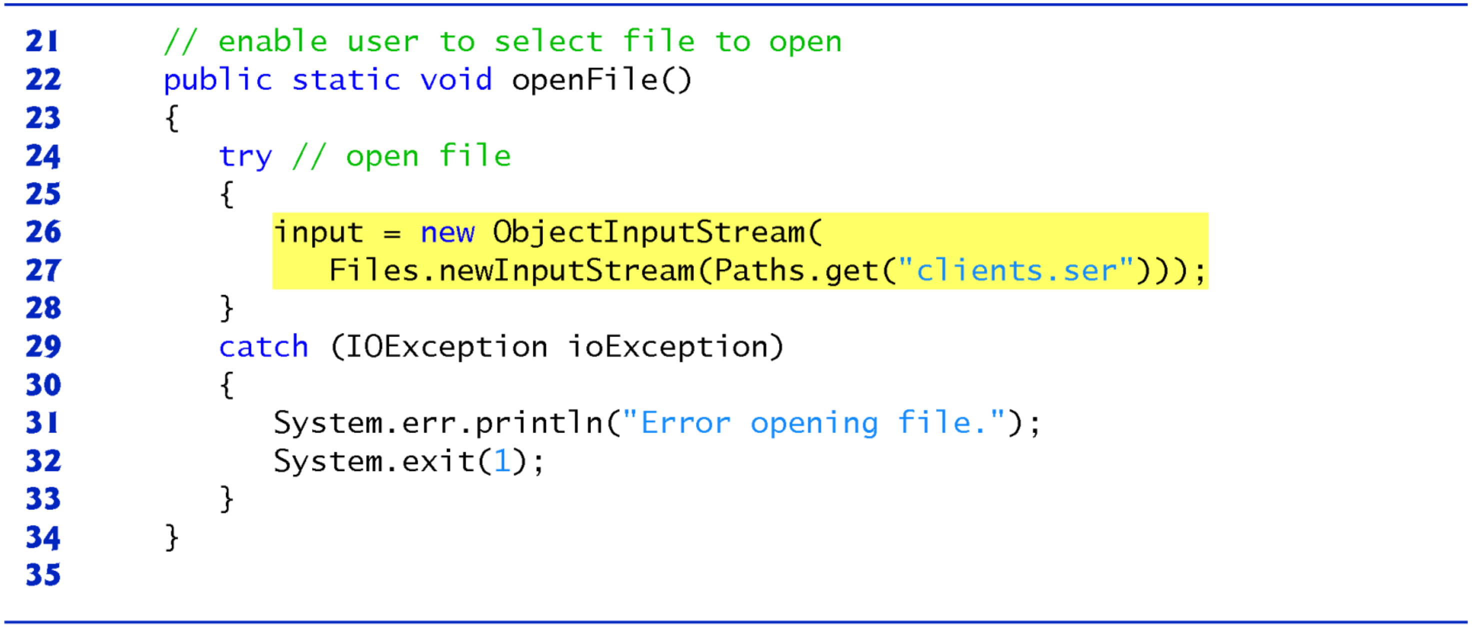
15.5.2 Reading and Deserializing Data from a Sequential-Access File

- The program in Fig. 15.11 reads records from a file created by the program in Section 15.5.1 and displays the contents.



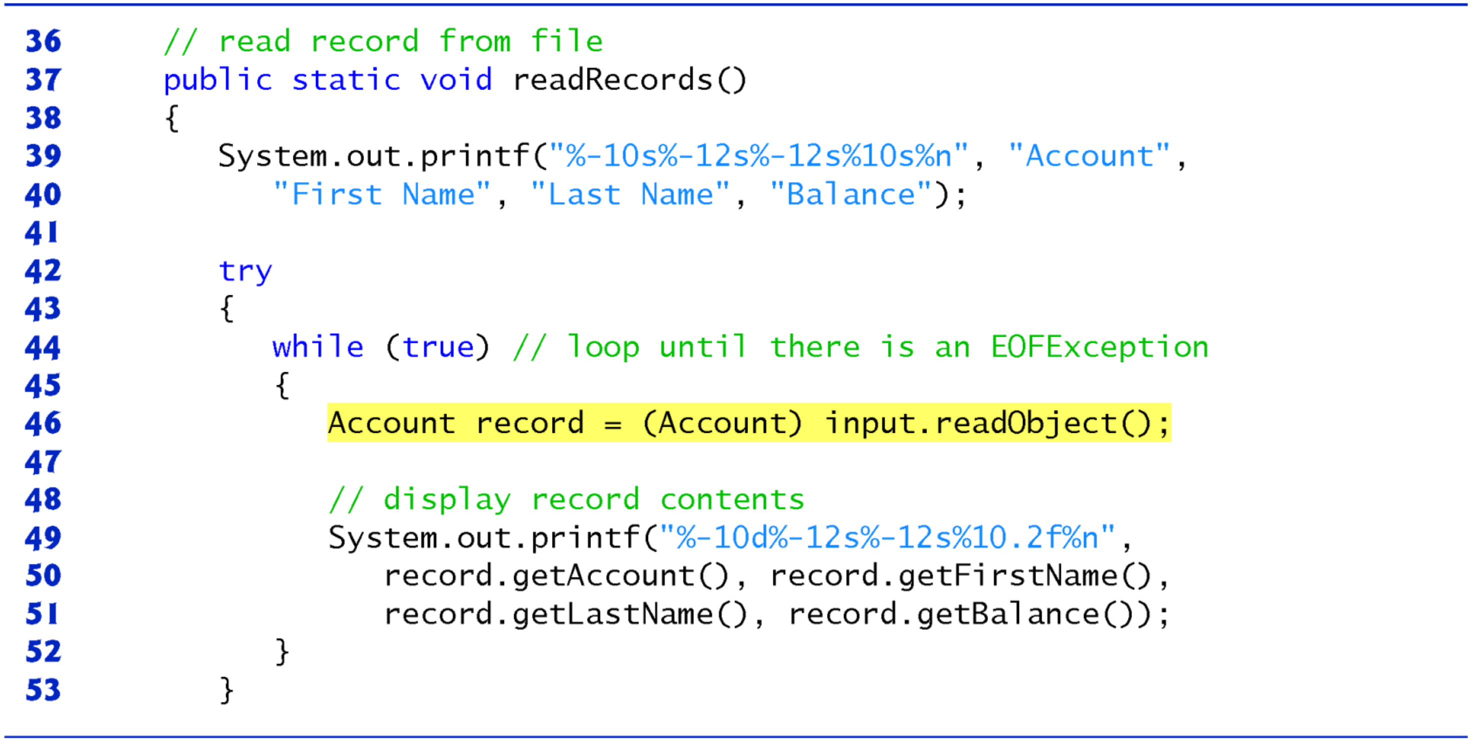
```java
// Fig. 15.11: ReadSequentialFile.java
// Reading a file of objects sequentially with ObjectInputStream
// and displaying each record.
import java.io.EOFException;
import java.io.IOException;
import java.io.ObjectInputStream;
import java.nio.file.Files;
import java.nio.file.Paths;

public class ReadSequentialFile
{
   private static ObjectInputStream input;

   public static void main(String[] args)
   {
      openFile();
      readRecords();
      closeFile();
   }

```

Fig. 15.11 | Reading a file of objects sequentially with `ObjectInputStream` and displaying each record. (Part 1 of 6.)



```java
    // enable user to select file to open
    public static void openFile()
    {
       try // open file
       {
          input = new ObjectInputStream(
             Files.newInputStream(Paths.get("clients.ser")));
       }
       catch (IOException ioException)
       {
          System.err.println("Error opening file.");
          System.exit(1);
       }
    }

```

Fig. 15.11 | Reading a file of objects sequentially with `ObjectInputStream` and displaying each record. (Part 2 of 6.)



```java
   // read record from file
   public static void readRecords()
   {
      System.out.printf("%-10s%-12s%-12s%10s%n", "Account",
         "First Name", "Last Name", "Balance");

      try
      {
         while (true) // loop until there is an EOFException
         {
            Account record = (Account) input.readObject();

            // display record contents
            System.out.printf("%-10d%-12s%-12s%10.2f%n",
               record.getAccount(), record.getFirstName(),
               record.getLastName(), record.getBalance());
         }
      }
```

Fig. 15.11 | Reading a file of objects sequentially with `ObjectInputStream` and displaying each record. (Part 3 of 6.)

```
      catch (EOFException endOfFileException)
      {
         System.out.printf("%No more records%n");
      }
      catch (ClassNotFoundException classNotFoundException)
      {
         System.err.println("Invalid object type. Terminating.");
      }
      catch (IOException ioException)
      {
         System.err.println("Error reading from file. Terminating.");
      }
   } // end method readRecords

```

Fig. 15.11 | Reading a file of objects sequentially with `ObjectInputStream` and displaying each record. (Part 4 of 6.)

```java
   // close file and terminate application
   public static void closeFile()
   {
      try
      {
         if (input != null)
            input.close();
      }
      catch (IOException ioException)
      {
         System.err.println("Error closing file. Terminating.");
         System.exit(1);
      }
   }
} // end class ReadSequentialFile
```

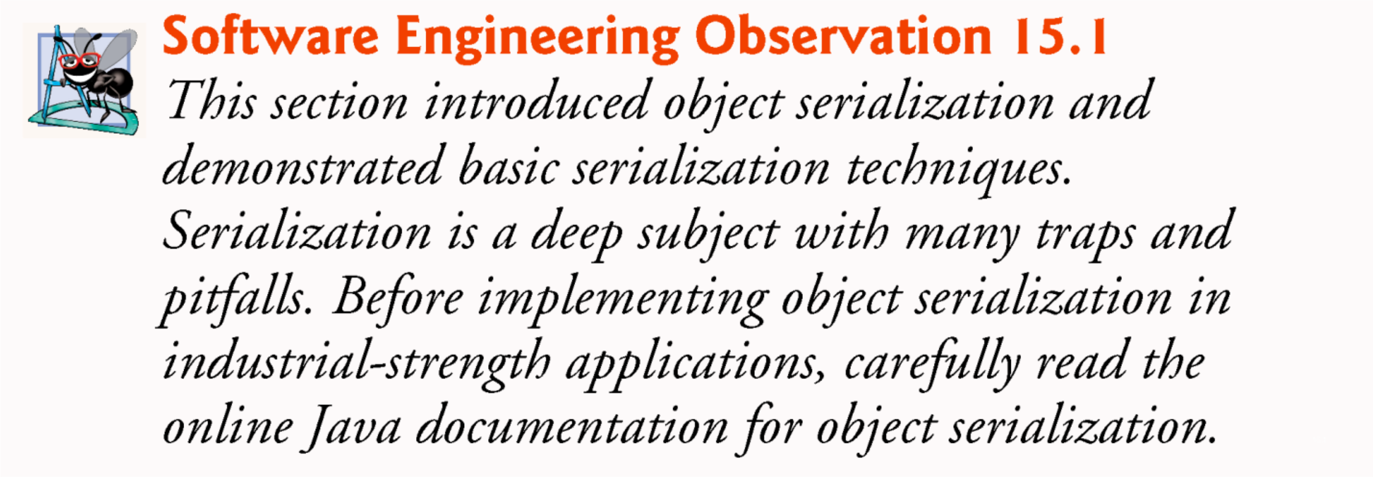
Fig. 15.11 | Reading a file of objects sequentially with `ObjectInputStream` and displaying each record. (Part 5 of 6.)

```
Account    First Name  Last Name       Balance
100        Bob         Blue              24.98
200        Steve       Green           -345.67
300        Pam         White              0.00
400        Sam         Red              -42.16
500        Sue         Yellow           224.62

No more records
```

Fig. 15.11 | Reading a file of objects sequentially with `ObjectInputStream` and displaying each record. (Part 6 of 6.)

15.5.2 Reading and Deserializing Data from a Sequential-Access File (cont.)

- `ObjectInputStream` method `readObject` reads an `Object` from a file.
- Method `readObject` throws an **`EOFException`** if an attempt is made to read beyond the end of the file.
- Method `readObject` throws a `ClassNotFoundException` if the class for the object being read cannot be located.



Software Engineering Observation 15.1

This section introduced object serialization and demonstrated basic serialization techniques. Serialization is a deep subject with many traps and pitfalls. Before implementing object serialization in industrial-strength applications, carefully read the online Java documentation for object serialization.

15.6 Opening Files with JFileChooser

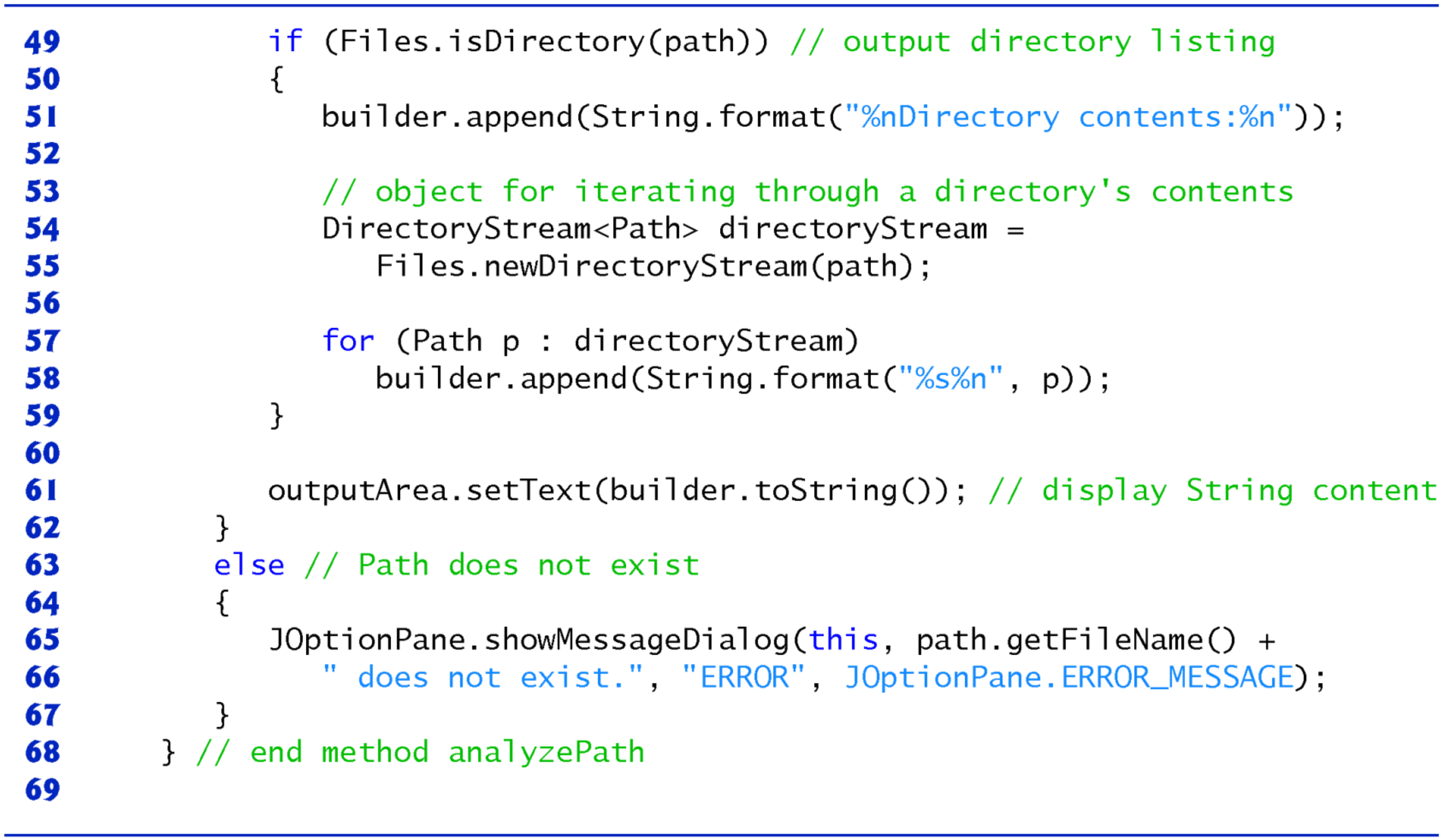
- Class **JFileChooser** displays a dialog that enables the user to easily select files or directories.
- To demonstrate JFileChooser, we enhance the example in Section 15.3, as shown in Figs. 15.12–15.13.
- Call method **setFileSelectionMode** specifies what the user can select from the fileChooser. For this program, we use JFileChooser static constant **FILES_AND_DIRECTORIES** to indicate that files and directories can be selected. Other static constants include **FILES_ONLY** (the default) and **DIRECTORIES_ONLY**.

```java
// Fig. 15.12: JFileChooserDemo.java
// Demonstrating JFileChooser.
import java.io.IOException;
import java.nio.file.DirectoryStream;
import java.nio.file.Files;
import java.nio.file.Path;
import java.nio.file.Paths;
import javax.swing.JFileChooser;
import javax.swing.JFrame;
import javax.swing.JOptionPane;
import javax.swing.JScrollPane;
import javax.swing.JTextArea;

public class JFileChooserDemo extends JFrame
{
   private final JTextArea outputArea; // displays file contents

   // set up GUI
   public JFileChooserDemo() throws IOException
   {
      super("JFileChooser Demo");
      outputArea = new JTextArea();
      add(new JScrollPane(outputArea)); // outputArea is scrollable
      analyzePath(); // get Path from user and display info
   }
```

Fig. 15.12 | Demonstrating JFileChooser. (Part 1 of 4.)

```java
   // display information about file or directory user specifies
   public void analyzePath() throws IOException
   {
      // get Path to user-selected file or directory
      Path path = getFileOrDirectoryPath();

      if (path != null && Files.exists(path)) // if exists, display info
      {
         // gather file (or directory) information
         StringBuilder builder = new StringBuilder();
         builder.append(String.format("%s:%n", path.getFileName()));
         builder.append(String.format("%s a directory%n",
            Files.isDirectory(path) ? "Is" : "Is not"));
         builder.append(String.format("%s an absolute path%n",
            path.isAbsolute() ? "Is" : "Is not"));
         builder.append(String.format("Last modified: %s%n",
            Files.getLastModifiedTime(path)));
         builder.append(String.format("Size: %s%n", Files.size(path)));
         builder.append(String.format("Path: %s%n", path));
         builder.append(String.format("Absolute path: %s%n",
            path.toAbsolutePath()));
```

Fig. 15.12 | Demonstrating JFileChooser. (Part 2 of 4.)



```java
         if (Files.isDirectory(path)) // output directory listing
         {
            builder.append(String.format("%nDirectory contents:%n"));

            // object for iterating through a directory's contents
            DirectoryStream<Path> directoryStream =
               Files.newDirectoryStream(path);

            for (Path p : directoryStream)
               builder.append(String.format("%s%n", p));
         }

         outputArea.setText(builder.toString()); // display String content
      }
      else // Path does not exist
      {
         JOptionPane.showMessageDialog(this, path.getFileName() +
            " does not exist.", "ERROR", JOptionPane.ERROR_MESSAGE);
      }
   } // end method analyzePath

```

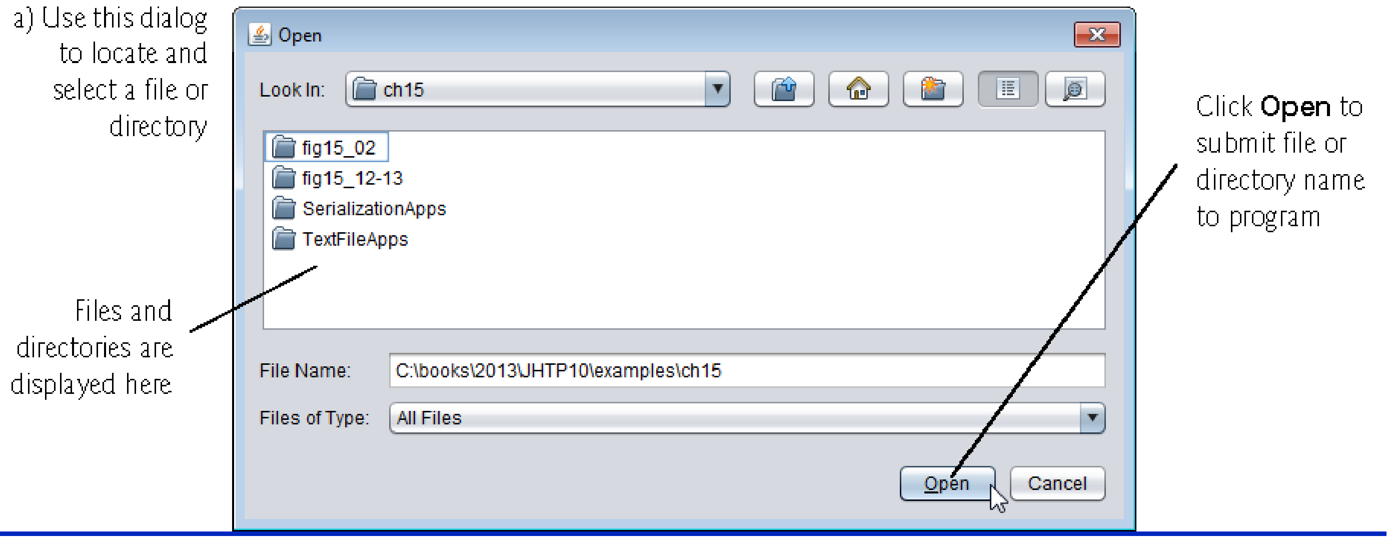
Fig. 15.12 | Demonstrating `JFileChooser`. (Part 3 of 4.)

```
   // allow user to specify file or directory name
   private Path getFileOrDirectoryPath()
   {
      // configure dialog allowing selection of a file or directory
      JFileChooser fileChooser = new JFileChooser();
      fileChooser.setFileSelectionMode(
         JFileChooser.FILES_AND_DIRECTORIES);
      int result = fileChooser.showOpenDialog(this);

      // if user clicked Cancel button on dialog, return
      if (result == JFileChooser.CANCEL_OPTION)
         System.exit(1);

      // return Path representing the selected file
      return fileChooser.getSelectedFile().toPath();
   }
} // end class JFileChooserDemo
```

Fig. 15.12 | Demonstrating `JFileChooser`. (Part 4 of 4.)

```java
// Fig. 15.13: JFileChooserTest.java
// Tests class JFileChooserDemo.
import java.io.IOException;
import javax.swing.JFrame;

public class JFileChooserTest
{
   public static void main(String[] args) throws IOException
   {
      JFileChooserDemo application = new JFileChooserDemo();
      application.setSize(400, 400);
      application.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
      application.setVisible(true);
   }
} // end class JFileChooserTest
```

Fig. 15.13 | Testing class `FileDemonstration`. (Part 1 of 3.)



a) Use this dialog to locate and select a file or directory

Files and directories are displayed here

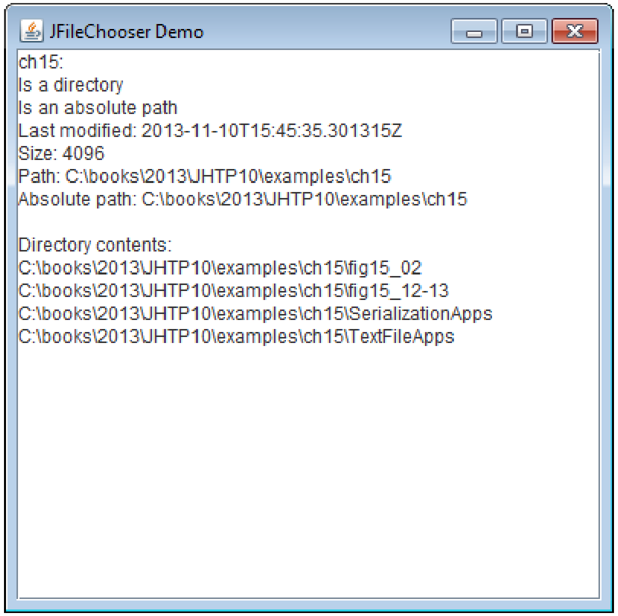
Click **Open** to submit file or directory name to program

File Name: C:\books\2013\JHTP10\examples\ch15

Files of Type: All Files

Fig. 15.13 | Testing class `FileDemonstration`. (Part 2 of 3.)

b) Selected file's or directory's information; if it's a directory, the contents of that directory are displayed



```
ch15:
Is a directory
Is an absolute path
Last modified: 2013-11-10T15:45:35.301315Z
Size: 4096
Path: C:\books\2013\JHTP10\examples\ch15
Absolute path: C:\books\2013\JHTP10\examples\ch15

Directory contents:
C:\books\2013\JHTP10\examples\ch15\fig15_02
C:\books\2013\JHTP10\examples\ch15\fig15_12-13
C:\books\2013\JHTP10\examples\ch15\SerializationApps
C:\books\2013\JHTP10\examples\ch15\TextFileApps
```

Fig. 15.13 | Testing class `FileDemonstration`. (Part 3 of 3.)

15.7 (Optional) Additional `java.io` Classes

- This section overviews additional interfaces and classes (from package `java.io`).

15.7.1 Interfaces and Classes for Byte-Based Input and Output

- **InputStream** and **OutputStream** are abstract classes that declare methods for performing byte-based input and output, respectively.
- **Pipes** are synchronized communication channels between threads.
  - **PipedOutputStream** (a subclass of OutputStream) and **PipedInputStream** (a subclass of InputStream) establish pipes between two threads in a program.
  - One thread sends data to another by writing to a PipedOutputStream.
  - The target thread reads information from the pipe via a PipedInputStream.

15.7.1 Interfaces and Classes for Byte-Based Input and Output (cont.)

- A `FilterInputStream` filters an `InputStream`, and a `FilterOutputStream` filters an `OutputStream`.
- **Filtering** means simply that the filter stream provides additional functionality, such as aggregating bytes into meaningful primitive-type units.
- `FilterInputStream` and `FilterOutputStream` are typically used as superclasses, so some of their filtering capabilities are provided by their subclasses.

15.7.1 Interfaces and Classes for Byte-Based Input and Output (cont.)

- A `PrintStream` (a subclass of `FilterOutputStream`) performs text output to the specified stream.
- `System.out` and `System.err` are `PrintStream` objects.

15.7.1 Interfaces and Classes for Byte-Based Input and Output (cont.)

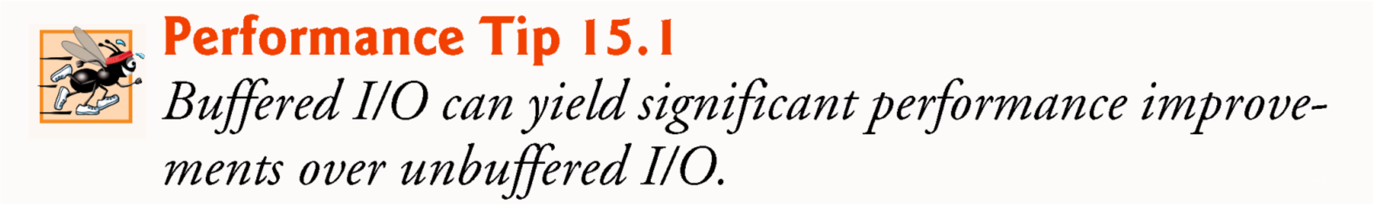
- Usually, programs read data as aggregates of bytes that form `int`s, `float`s, `double`s and so on.
- Java programs can use several classes to input and output data in aggregate form.
- Interface `DataInput` describes methods for reading primitive types from an input stream.
- Classes **`DataInputStream`** and `RandomAccessFile` each implement this interface to read sets of bytes and process them as primitive-type values.

15.7.1 Interfaces and Classes for Byte-Based Input and Output (cont.)

- Interface `DataOutput` describes a set of methods for writing primitive types to an output stream.
- Classes **`DataOutputStream`** (a subclass of `FilterOutputStream`) and `RandomAccessFile` each implement this interface to write primitive-type values as bytes.

15.7.1 Interfaces and Classes for Byte-Based Input and Output (cont.)

- **Buffering** is an I/O-performance-enhancement technique.
- With a **`BufferedOutputStream`**, each output operation is directed to a **buffer**
  - holds the data of many output operations
- Transfer to the output device is performed in one large **physical output operation** each time the buffer fills.
- The output operations directed to the output buffer in memory are often called **logical output operations.**
- A partially filled buffer can be forced out to the device at any time by invoking the stream object's **`flush`** method.
- Using buffering can greatly increase the performance of an application.



Performance Tip 15.1

Buffered I/O can yield significant performance improvements over unbuffered I/O.

15.7.1 Interfaces and Classes for Byte-Based Input and Output (cont.)

- With a `BufferedInputStream`, many “logical” chunks of data from a file are read as one large **physical input operation** into a memory buffer.
- As a program requests each new chunk of data, it’s taken from the buffer.
- This procedure is sometimes referred to as a **logical input operation**.
- When the buffer is empty, the next actual physical input operation from the input device is performed.

15.7.1 Interfaces and Classes for Byte-Based Input and Output (cont.)

- Java stream I/O includes capabilities for inputting from `byte` arrays in memory and outputting to `byte` arrays in memory.
- A `ByteArrayInputStream` (a subclass of `InputStream`) reads from a `byte` array in memory.
- A `ByteArrayOutputStream` (a subclass of `OutputStream`) outputs to a `byte` array in memory.

15.7.1 Interfaces and Classes for Byte-Based Input and Output (cont.)

- A `SequenceInputStream` (a subclass of `InputStream`) logically concatenates several `InputStream`s
- The program sees the group as one continuous `InputStream`.
- When the program reaches the end of one input stream, that stream closes, and the next stream in the sequence opens.

15.7.2 Interfaces and Classes for Character-Based Input and Output

- The `Reader` and `Writer` `abstract` classes are Unicode two-byte, character-based streams.
- Most of the byte-based streams have corresponding character-based concrete `Reader` or `Writer` classes.

15.7.2 Interfaces and Classes for Character-Based Input and Output (cont.)

- Classes `BufferedReader` (a subclass of `abstract` class `Reader`) and `BufferedWriter` (a subclass of `abstract` class `Writer`) enable buffering for character-based streams.
- Classes `CharArrayReader` and `CharArrayWriter` read and write, respectively, a stream of characters to a `char` array.
- A `LineNumberReader` (a subclass of `BufferedReader`) is a buffered character stream that keeps track of the number of lines read.

15.7.2 Interfaces and Classes for Character-Based Input and Output (cont.)

- An InputStream can be converted to a Reader via class **InputStreamReader**.
- An OuputStream can be converted to a Writer via class **OutputStreamWriter**.
- Class File-Reader and class FileWriter read characters from and write characters to a file.
- Class **PipedReader** and class **PipedWriter** implement piped-character streams for transfering data between threads.
- Class **StringReader** b**StringWriter** read characters from and write characters to Strings.
- A PrintWriter writes characters to a stream.