File Handling

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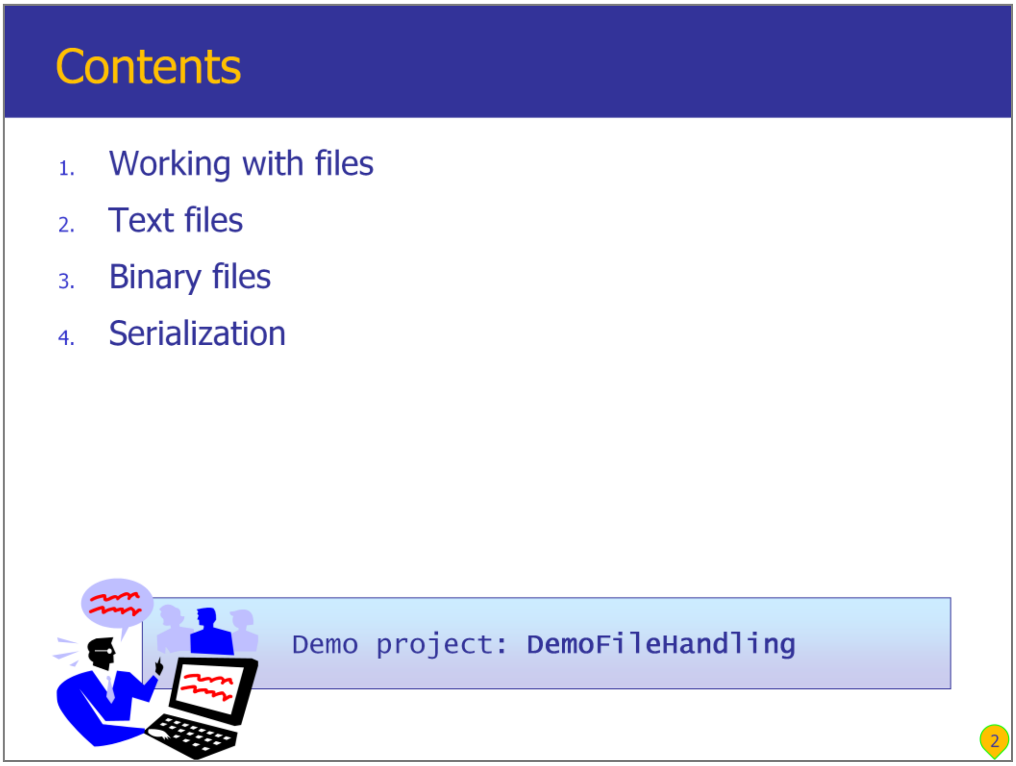
Java has extensive support for file handling. There are many classes and interfaces available, mostly defined in the `java.io` package. This chapter gives an overview of what's available, and then explores some of the most commonly used IO features.



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1. Working with files
2. Text files
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4. Serialization

Demo project: `DemoFileHandling`

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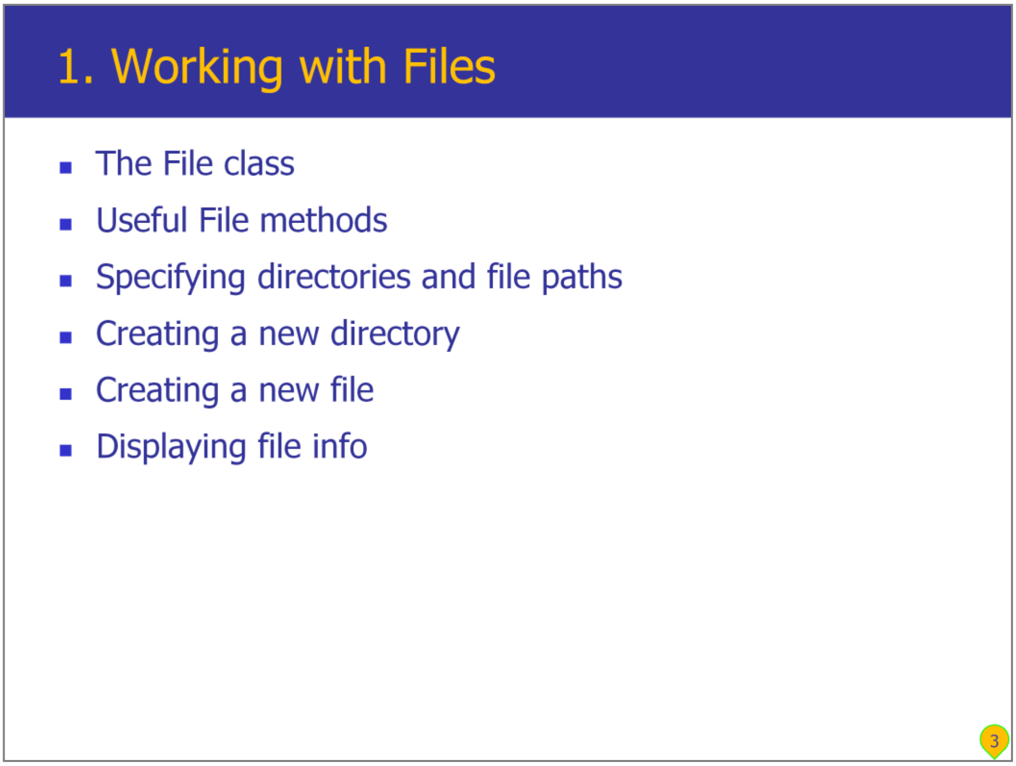
Section 1 introduces you to the File I/O API in Java, focussing on the `File` class in particular. You can use this class to perform common file and directory management tasks, such as determining if a file exists, creating a file, enumerating the files in a directory, etc.

Sections 2 and 3 describe how to read and write content in text files and binary files, respectively.

Section 4 introduces the concept of serialization, whereby you can convert an object into a flat byte stream (and then back again). This is useful if you want to pass objects over a network, for example.

The demos for chapter are located in the `DemoFileHandling` project.

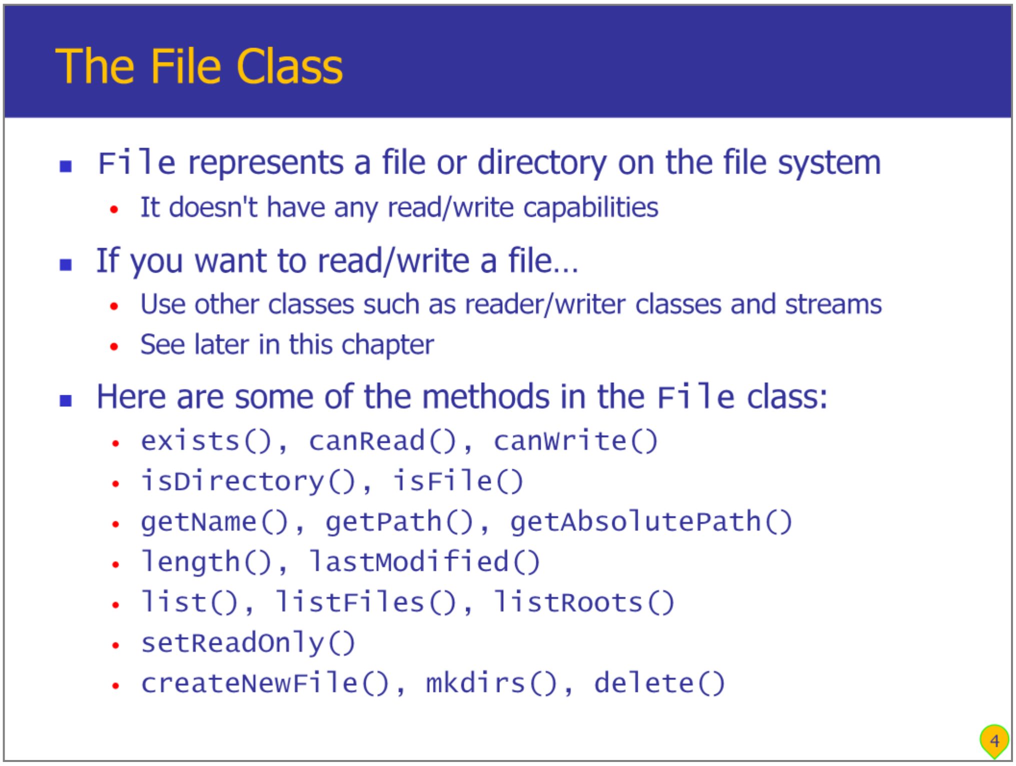


1. Working with Files

- The File class
- Useful File methods
- Specifying directories and file paths
- Creating a new directory
- Creating a new file
- Displaying file info

Java provides a rich set of classes and interfaces for manipulating files and data. These classes and interfaces are located in the `java.io` package. Many exceptions can occur during file handling; all of these IO exception classes inherit from `java.io.IOException`.

We begin by seeing how to perform whole-file and whole-directory operations using the `File` class. Note that there is no `Directory` class.



The File Class

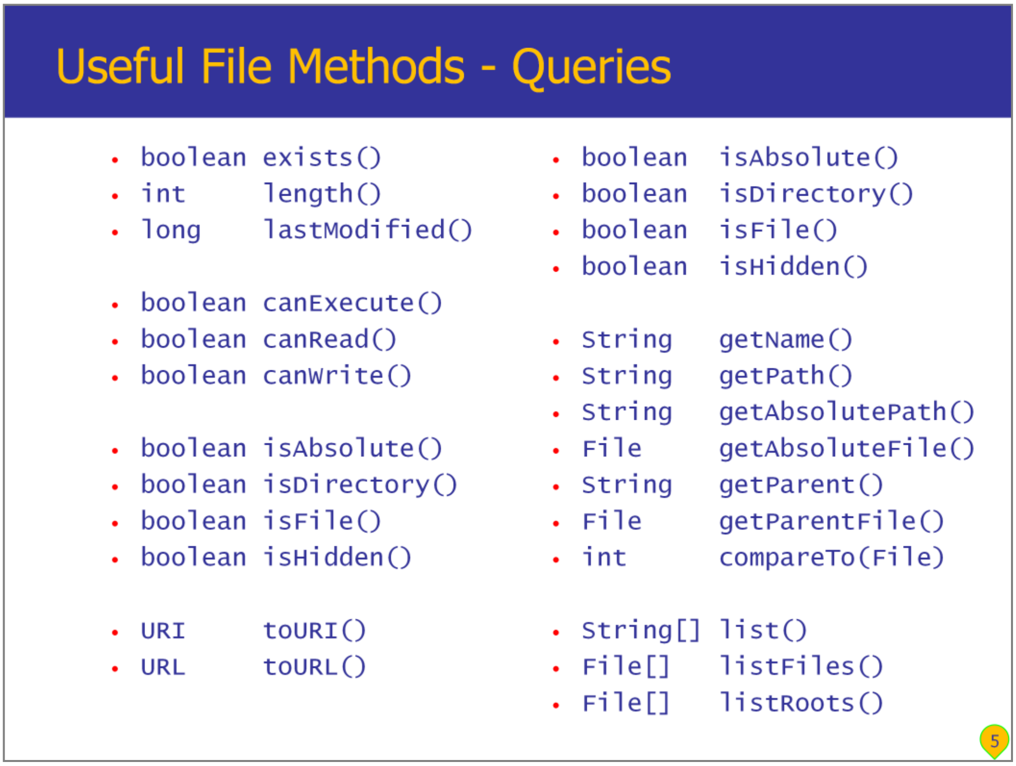
- `File` represents a file or directory on the file system
  - It doesn't have any read/write capabilities
- If you want to read/write a file…
  - Use other classes such as reader/writer classes and streams
  - See later in this chapter
- Here are some of the methods in the `File` class:
  - `exists(), canRead(), canWrite()`
  - `isDirectory(), isFile()`
  - `getName(), getPath(), getAbsolutePath()`
  - `length(), lastModified()`
  - `list(), listFiles(), listRoots()`
  - `setReadOnly()`
  - `createNewFile(), mkdirs(), delete()`

You can use the `File` class to perform operations on a file or a directory as a whole. The slide above lists some of the common methods in the `File` class.

Note that the `File` class doesn't have any methods for reading or writing the contents of a file. To do that, you must use a stream class or a reader/writer class, as discussed later in the chapter.

For full information about the `File` class, consult the JavaDoc documentation:

- http://docs.oracle.com/javase/7/docs/api/java/io/File.html



Useful File Methods - Queries

```
• boolean exists()
• int     length()
• long    lastModified()

• boolean canExecute()
• boolean canRead()
• boolean canWrite()

• boolean isAbsolute()
• boolean isDirectory()
• boolean isFile()
• boolean isHidden()

• URI     toURI()
• URL     toURL()
```

```
• boolean  isAbsolute()
• boolean  isDirectory()
• boolean  isFile()
• boolean  isHidden()

• String   getName()
• String   getPath()
• String   getAbsolutePath()
• File     getAbsoluteFile()
• String   getParent()
• File     getParentFile()
• int      compareTo(File)

• String[] list()
• File[]   listFiles()
• File[]   listRoots()
```

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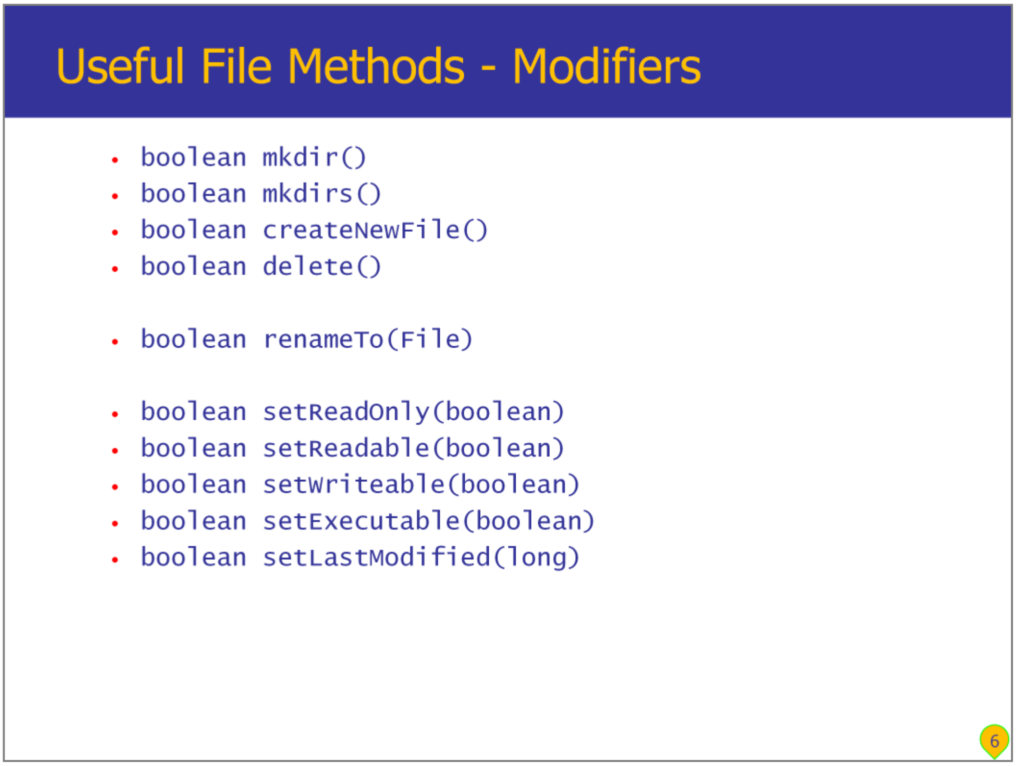
This slide lists some additional useful methods in the `File` class, for querying information about the file and directory attributes. As you can see, the `File` class provides all the capabilities you could ever need!



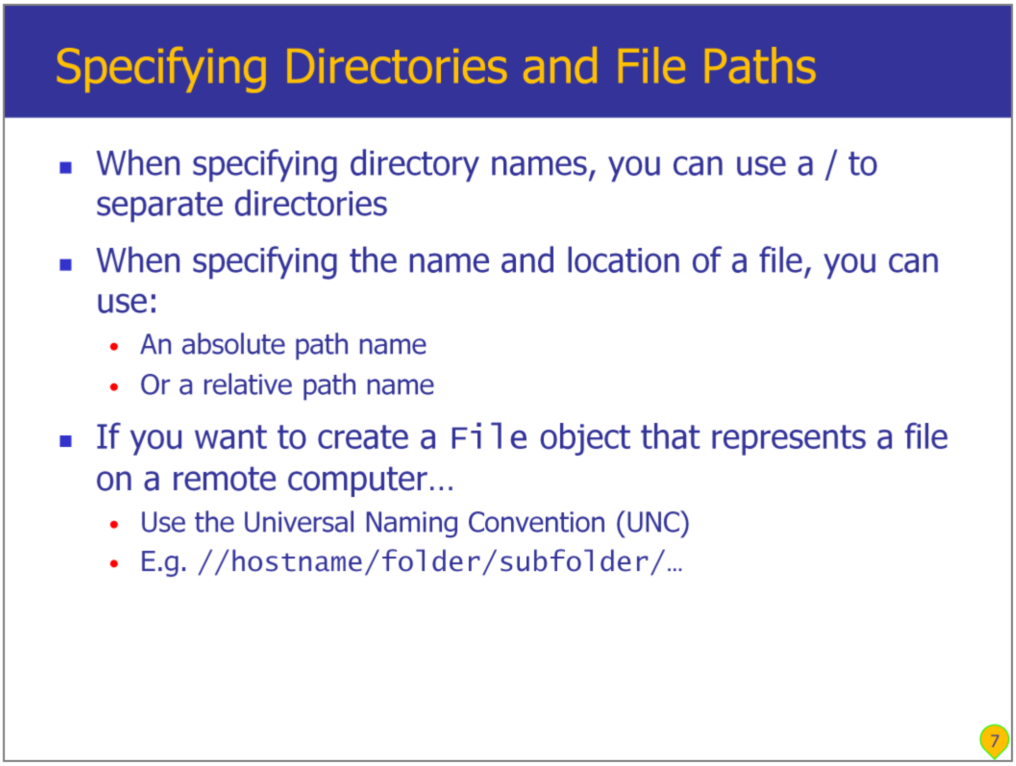
Useful File Methods - Modifiers

- `boolean mkdir()`
- `boolean mkdirs()`
- `boolean createNewFile()`
- `boolean delete()`

- `boolean renameTo(File)`

- `boolean setReadOnly(boolean)`
- `boolean setReadable(boolean)`
- `boolean setWriteable(boolean)`
- `boolean setExecutable(boolean)`
- `boolean setLastModified(long)`

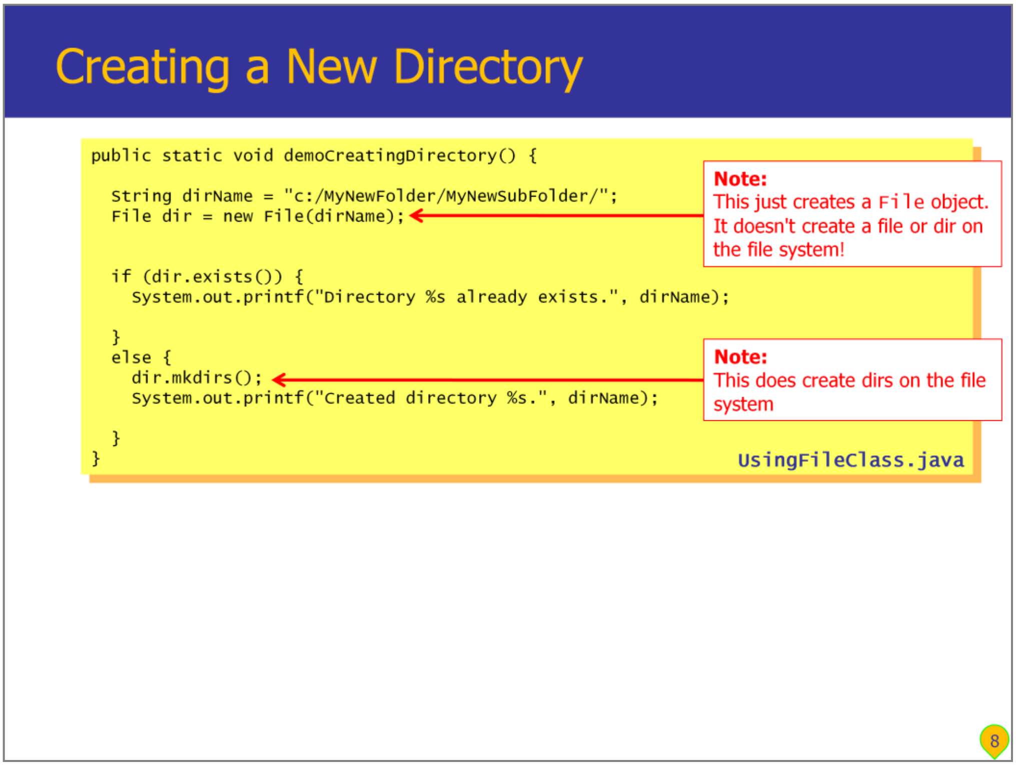
The File class provides methods that allow you to modify attributes on a file or directory, create a new file or directory, rename a file or directory, delete a file or directory, and so on.



Specifying Directories and File Paths

- When specifying directory names, you can use a / to separate directories
- When specifying the name and location of a file, you can use:
  - An absolute path name
  - Or a relative path name
- If you want to create a `File` object that represents a file on a remote computer…
  - Use the Universal Naming Convention (UNC)
  - E.g. `//hostname/folder/subfolder/…`

Java uses a forward slash / as the directory specifier, which is consistent with Unix and also allowable in Windows. You can also use UNC file names to represent remote files and directories on a network drive.



Creating a New Directory

```
public static void democreatingDirectory() {

  String dirName = "c:/MyNewFolder/MyNewSubFolder/";
  File dir = new File(dirName);


  if (dir.exists()) {
    System.out.printf("Directory %s already exists.", dirName);

  }
  else {
    dir.mkdirs();
    System.out.printf("Created directory %s.", dirName);

  }
}
```

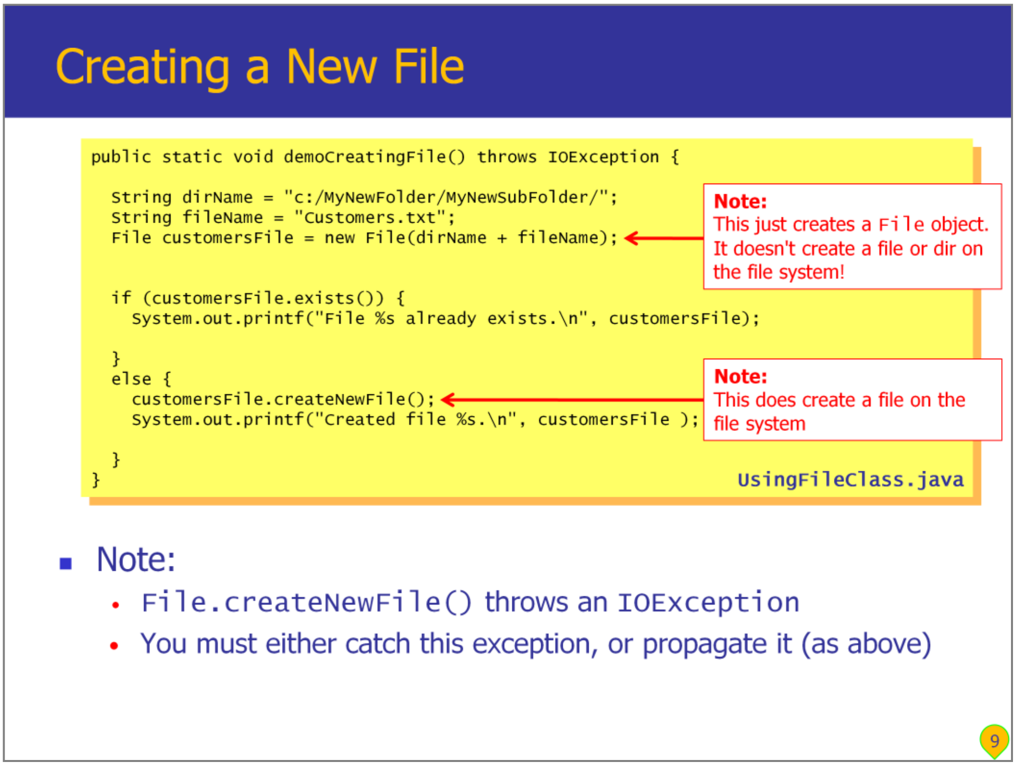
Note:
This just creates a `File` object. It doesn't create a file or dir on the file system!

Note:
This does create dirs on the file system

UsingFileClass.java

This slide shows how to use the `File` class to work with directories. Note that we can use a `File` class to represent a directory or a file; there isn't a separate `Directory` class.

The code first checks if the specified directory already exists. If it doesn't, the code proceeds to create the directory (plus all intermediate directories) by using the `mkdirs()` method.



Creating a New File

```
public static void demoCreatingFile() throws IOException {

  String dirName = "c:/MyNewFolder/MyNewSubFolder/";
  String fileName = "Customers.txt";
  File customersFile = new File(dirName + fileName);

  if (customersFile.exists()) {
    System.out.printf("File %s already exists.\n", customersFile);

  }
  else {
    customersFile.createNewFile();
    System.out.printf("Created file %s.\n", customersFile );

  }
}
```

Note: This just creates a `File` object. It doesn't create a file or dir on the file system!

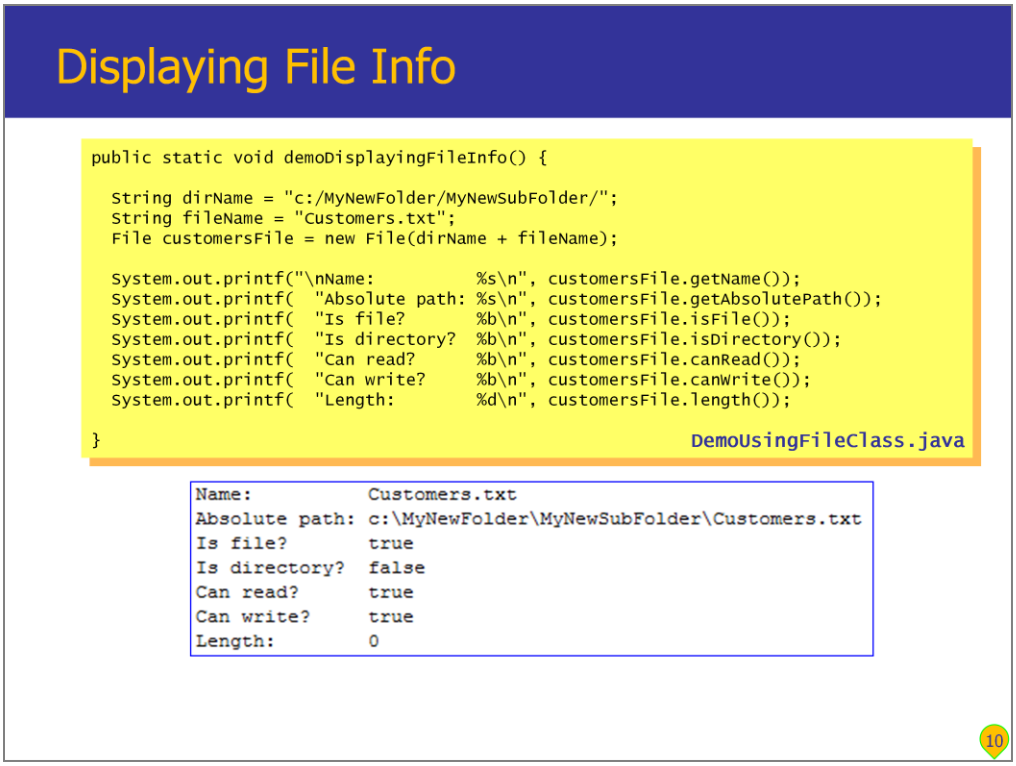
Note: This does create a file on the file system

UsingFileClass.java

- Note:
  - `File.createNewFile()` throws an `IOException`
  - You must either catch this exception, or propagate it (as above)

In a similar vein, this example shows how to use the `File` class to create a file.

Note that the `createNewFile()` method can throw an `IOException`, so you must either catch this exception yourself, or decorate your method with a `throws` clause to indicate to the calling method that it must handle the exception.



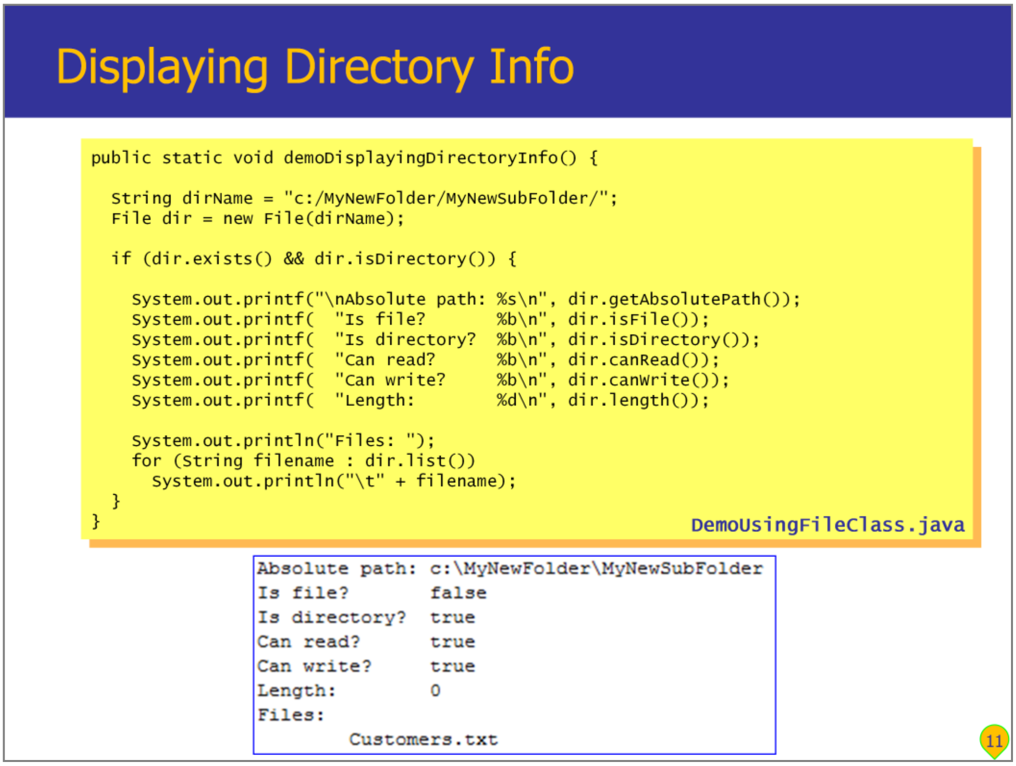
Displaying File Info

```
public static void demoDisplayingFileInfo() {

  String dirName = "c:/MyNewFolder/MyNewSubFolder/";
  String fileName = "Customers.txt";
  File customersFile = new File(dirName + fileName);

  System.out.printf("\nName:          %s\n", customersFile.getName());
  System.out.printf(  "Absolute path: %s\n", customersFile.getAbsolutePath());
  System.out.printf(  "Is file?       %b\n", customersFile.isFile());
  System.out.printf(  "Is directory?  %b\n", customersFile.isDirectory());
  System.out.printf(  "Can read?      %b\n", customersFile.canRead());
  System.out.printf(  "Can write?     %b\n", customersFile.canWrite());
  System.out.printf(  "Length:        %d\n", customersFile.length());

}
```

DemoUsingFileClass.java

```
Name:          Customers.txt
Absolute path: c:\MyNewFolder\MyNewSubFolder\Customers.txt
Is file?       true
Is directory?  false
Can read?      true
Can write?     true
Length:        0
```

In this example, we show how to use the `File` class to obtain information about an existing file on the file system. You can use these methods to interrogate the system for information about a file, before you proceed to perform operations upon the file.



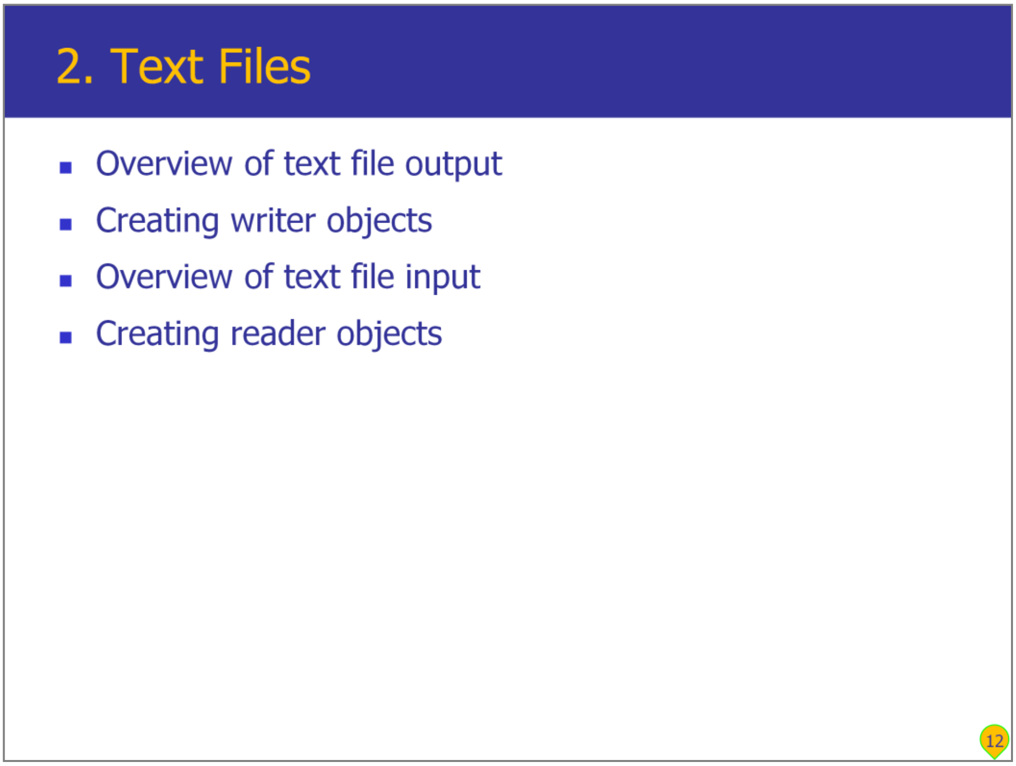
Displaying Directory Info

```
public static void demoDisplayingDirectoryInfo() {

  String dirName = "c:/MyNewFolder/MyNewSubFolder/";
  File dir = new File(dirName);

  if (dir.exists() && dir.isDirectory()) {

    System.out.printf("\nAbsolute path: %s\n", dir.getAbsolutePath());
    System.out.printf(  "Is file?       %b\n", dir.isFile());
    System.out.printf(  "Is directory?  %b\n", dir.isDirectory());
    System.out.printf(  "Can read?      %b\n", dir.canRead());
    System.out.printf(  "Can write?     %b\n", dir.canWrite());
    System.out.printf(  "Length:        %d\n", dir.length());

    System.out.println("Files: ");
    for (String filename : dir.list())
      System.out.println("\t" + filename);
  }
}
```

DemoUsingFileClass.java

```
Absolute path: c:\MyNewFolder\MyNewSubFolder
Is file?       false
Is directory?  true
Can read?      true
Can write?     true
Length:        0
Files:
        Customers.txt
```

This example is similar to the previous slide, except that it obtains information about a directory rather than a file. Notice that most of this code is the same as on the previous slide, i.e. we're using the `File` class again.



2. Text Files

- Overview of text file output
- Creating writer objects
- Overview of text file input
- Creating reader objects

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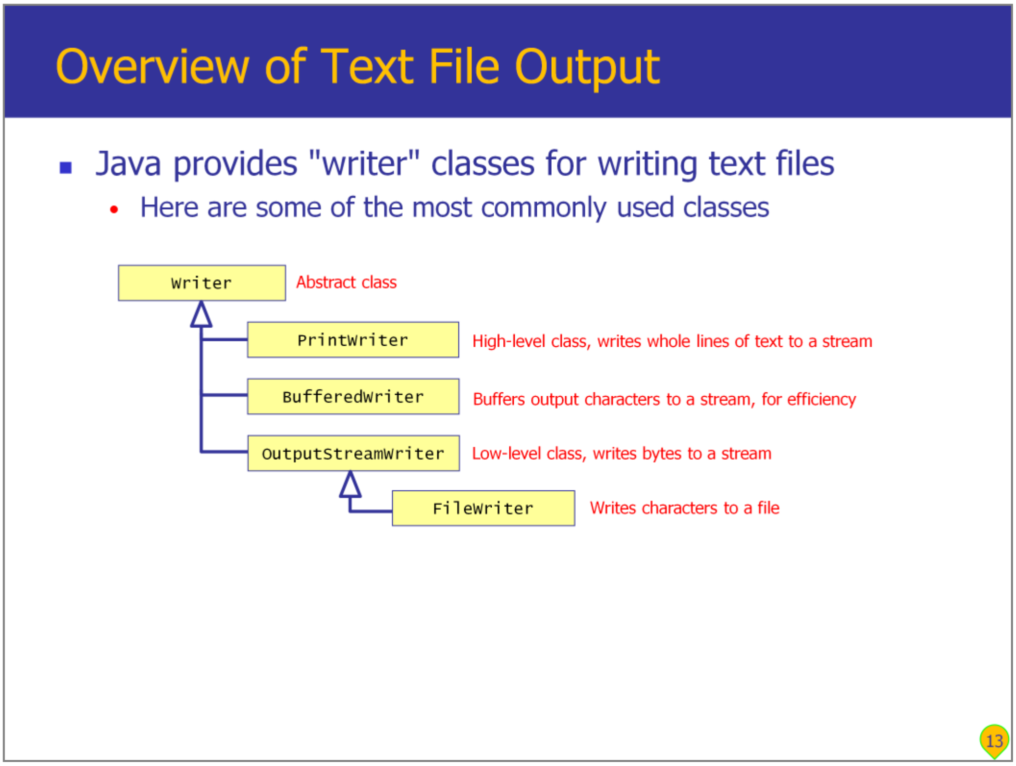
If you want to read or write the content of a text file, you must create a reader or writer object. The reader or writer object provides methods that allow you to get at the content of the file; this is in stark contrast to the `File` class discussed in the previous section, which just lets you manipulate the file entity on the file system without accessing its content.

Note: if you want to read or write the content of a binary file, you must use a stream object. We discuss stream objects in the next section.



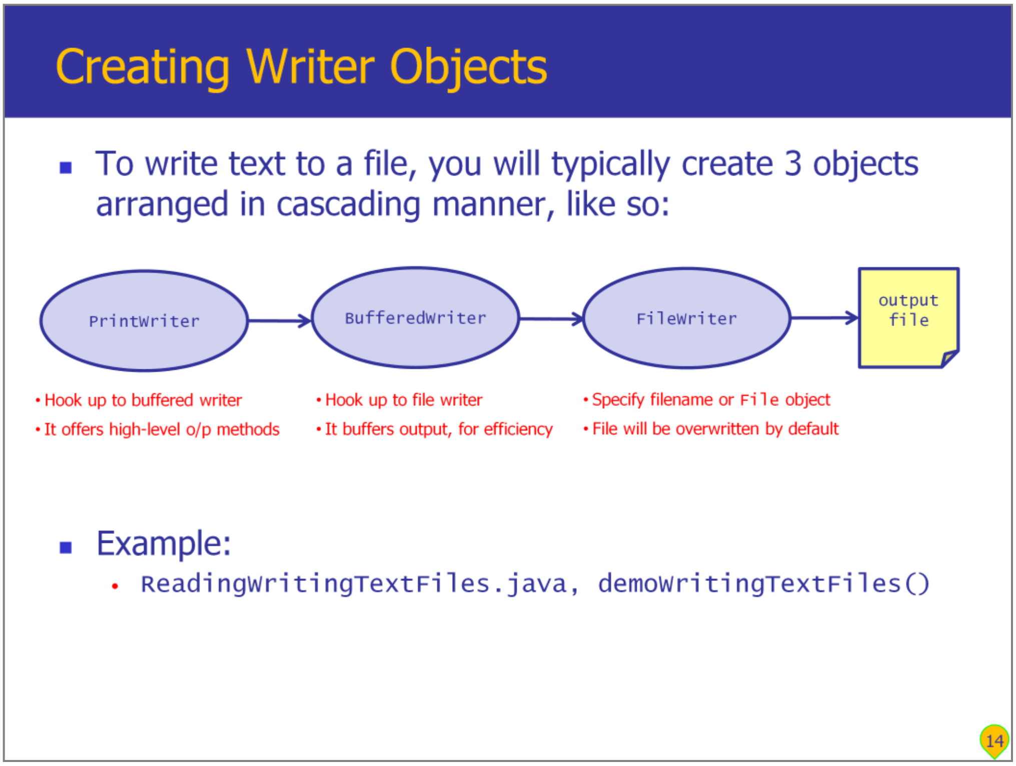
Overview of Text File Output

- Java provides "writer" classes for writing text files
  - Here are some of the most commonly used classes

Writer
Abstract class
PrintWriter
High-level class, writes whole lines of text to a stream
BufferedWriter
Buffers output characters to a stream, for efficiency
OutputStreamWriter
Low-level class, writes bytes to a stream
FileWriter
Writes characters to a file

The `java.io` package contains various writer classes that allow you to write text content to a file. These classes are arranged in a hierarchy as shown in the slide above; the `Writer` base class defines basic capabilities, and then each subclass adds additional capabilities.

The following slide shows how to use these classes in a typical scenario.



Creating Writer Objects

- To write text to a file, you will typically create 3 objects arranged in cascading manner, like so:

PrintWriter → BufferedWriter → FileWriter → output file

- Hook up to buffered writer
- It offers high-level o/p methods

- Hook up to file writer
- It buffers output, for efficiency

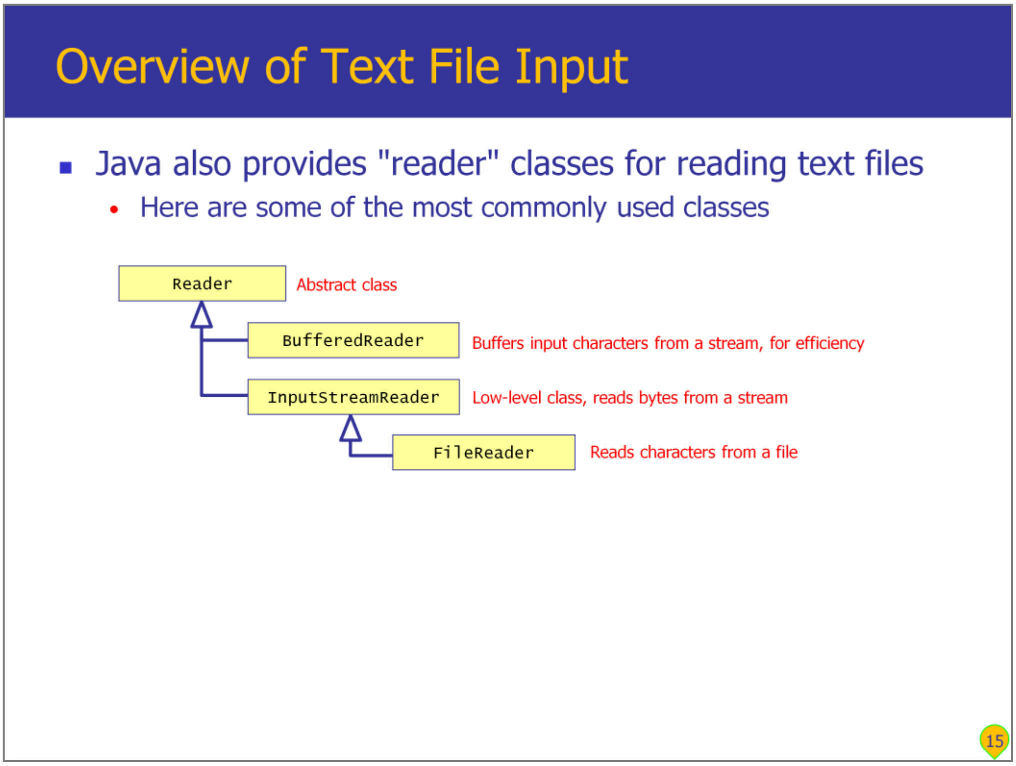
- Specify filename or `File` object
- File will be overwritten by default

- Example:
  - `ReadingWritingTextFiles.java, demoWritingTextFiles()`

The writer classes are a good example of the Decorator pattern. According to this pattern, you can create a series of objects that hook up to each other; each object adds another layer of capability, over-and-above what's on offer from the existing object in the chain.

Here's a description of what's going on in the slide, starting from the right-hand-side of the diagram:

- The first object we create is a `FileWriter` object, which will allow us to write to an output file. The `FileWriter` class is very primitive; it only provides methods to write strings and character arrays.
- Next up, we create a `BufferedWriter` object and initialize it with a reference to the existing `FileWriter` object. `BufferedWriter` has all the capabilities of `FileWriter`, but buffers content in memory for efficiency. This results in fewer disk I/O hits.
- Finally, we create a `PrintWriter` object and initialize it with a reference to the existing `BufferedWriter` object. `PrintWriter` offers a lot of extra methods that perform a much higher-level API for writing data to a file. For example, it has heavily overloaded `print()` and `println()` methods to print different types of value to the file.



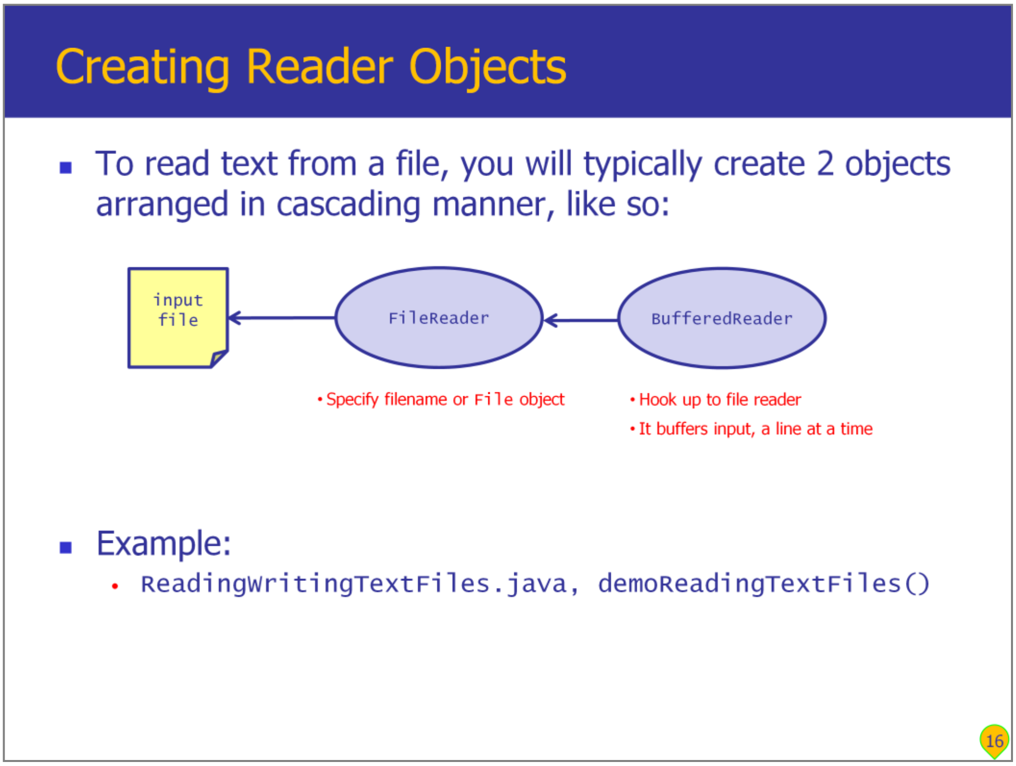
Overview of Text File Input

- Java also provides "reader" classes for reading text files
  - Here are some of the most commonly used classes

Reader
Abstract class
BufferedReader
Buffers input characters from a stream, for efficiency
InputStreamReader
Low-level class, reads bytes from a stream
FileReader
Reads characters from a file

As you would expect, the `java.io` package also contains various reader classes that allow you to read text content from a file. These classes are arranged in a hierarchy as shown in the slide above; the `Reader` base class defines basic capabilities, and then each subclass adds additional capabilities.

The following slide shows how to use these classes in a typical scenario.



Creating Reader Objects

- To read text from a file, you will typically create 2 objects arranged in cascading manner, like so:

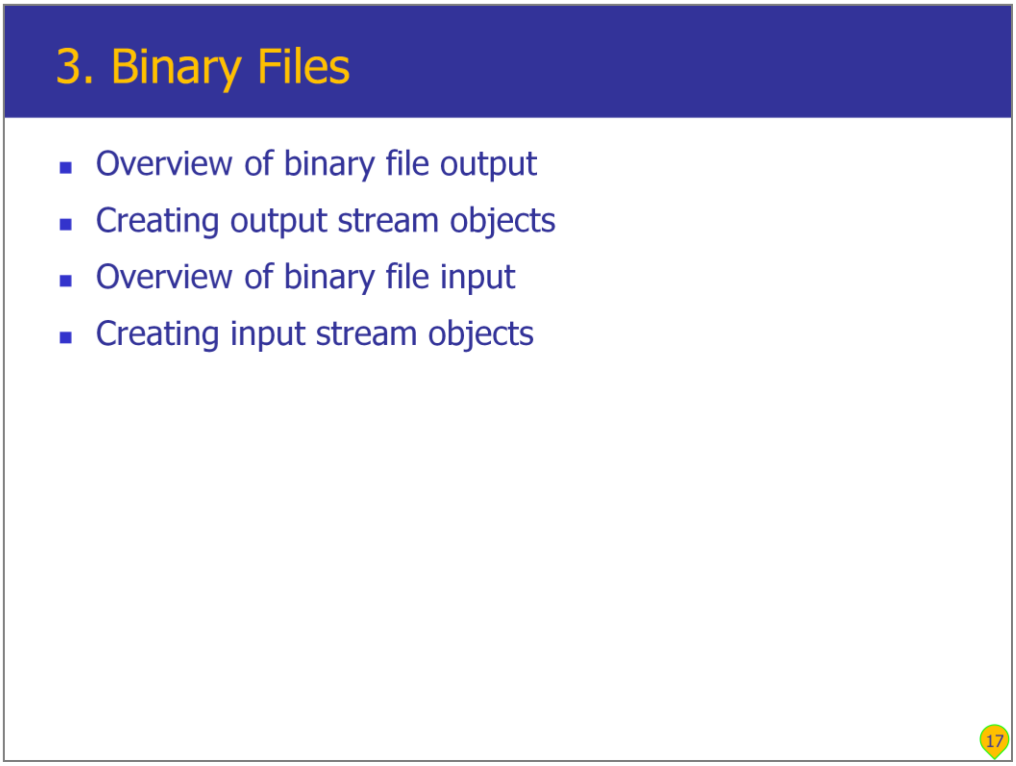
input file
FileReader
BufferedReader

- Specify filename or `File` object
- Hook up to file reader
- It buffers input, a line at a time

- Example:
  - `ReadingWritingTextFiles.java, demoReadingTextFiles()`

The reader classes are another good example of the Decorator pattern. Here's a description of what's going on in the slide, starting from the left-hand-side of the diagram this time:

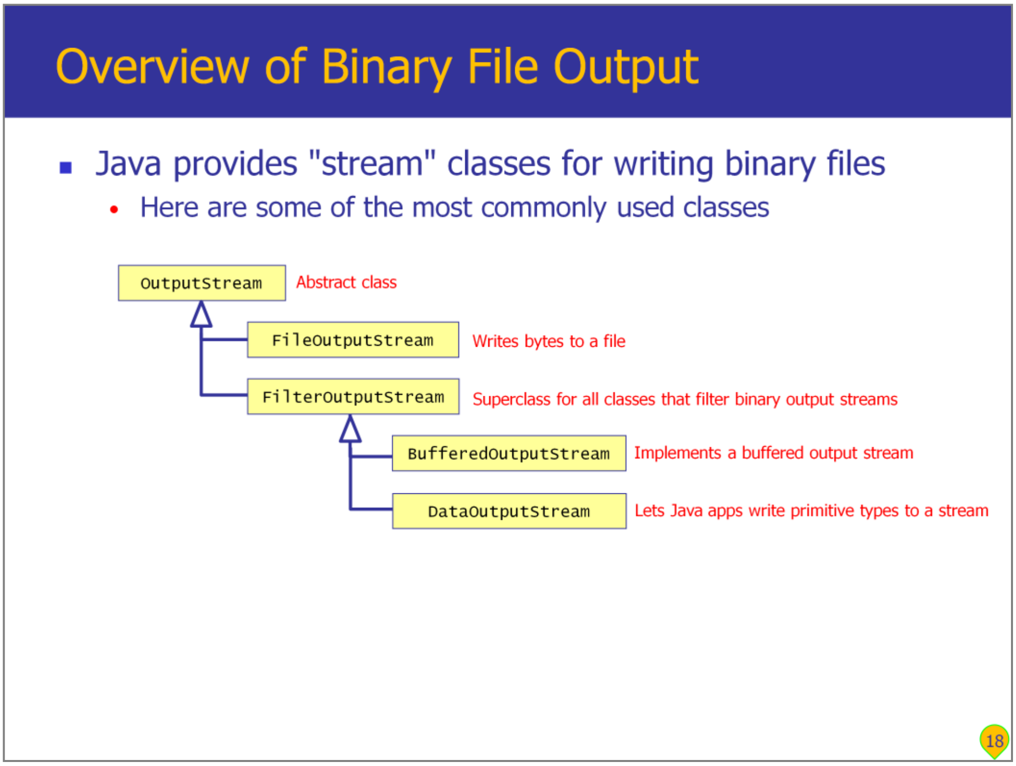
- The first object we create is a `FileReader` object, which will allow us to read from an existing file. The `FileReader` class is very primitive; it only provides methods to read characters.
- We then create a `BufferedReader` object and initialize it with a reference to the existing `FileReader` object. `BufferedReader` has all the capabilities of `FileReader`, but reads a whole line of text into memory at a time. The class has a `readLine()` method, which makes it easier to process a text file. The class also has methods that allow you to mark a position in a file, and then reset the current position in the file to the mark position.



3. Binary Files

- Overview of binary file output
- Creating output stream objects
- Overview of binary file input
- Creating input stream objects

This section shows how to read and write binary content in a file, by using stream classes in the `java.io` package.



Overview of Binary File Output

- Java provides "stream" classes for writing binary files
  - Here are some of the most commonly used classes

OutputStream
Abstract class
FileOutputStream
Writes bytes to a file
FilterOutputStream
Superclass for all classes that filter binary output streams
BufferedOutputStream
Implements a buffered output stream
DataOutputStream
Lets Java apps write primitive types to a stream
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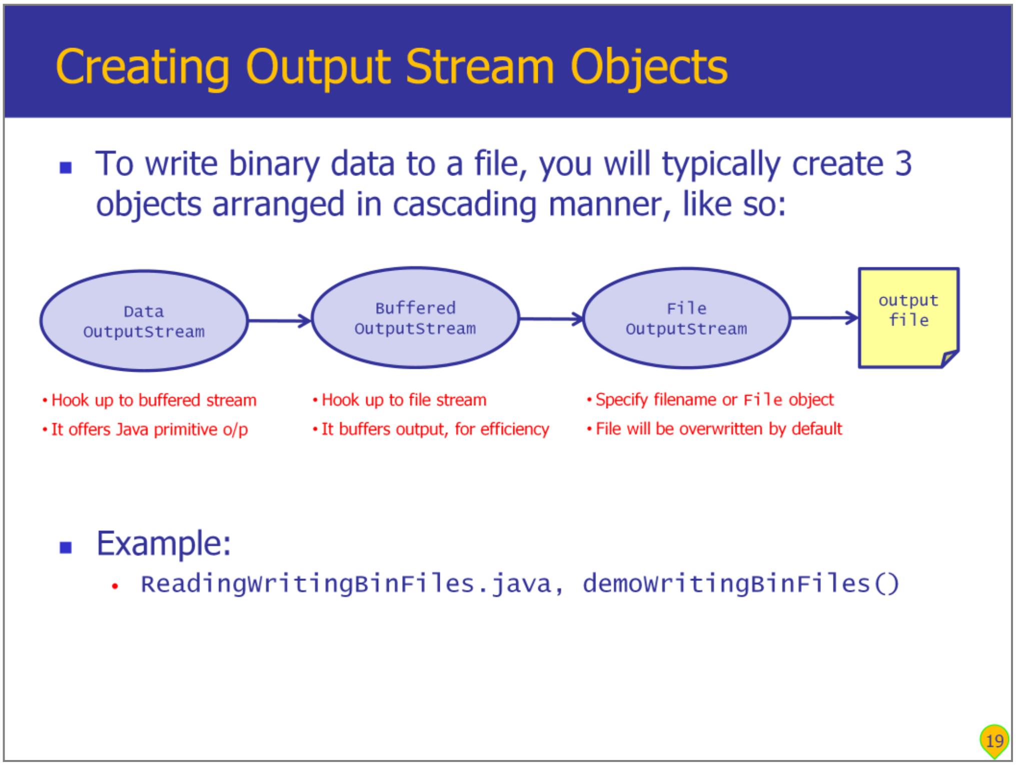
The `java.io` package contains various "output stream" classes that allow you to write binary content to a file. These classes are arranged in a hierarchy as shown in the slide above; the `OutputStream` base class defines basic capabilities, and then each subclass adds additional capabilities.

The following slide shows how to use these classes in a typical scenario.



Creating Output Stream Objects

- To write binary data to a file, you will typically create 3 objects arranged in cascading manner, like so:

Data OutputStream → Buffered OutputStream → File OutputStream → output file

- Hook up to buffered stream
- It offers Java primitive o/p

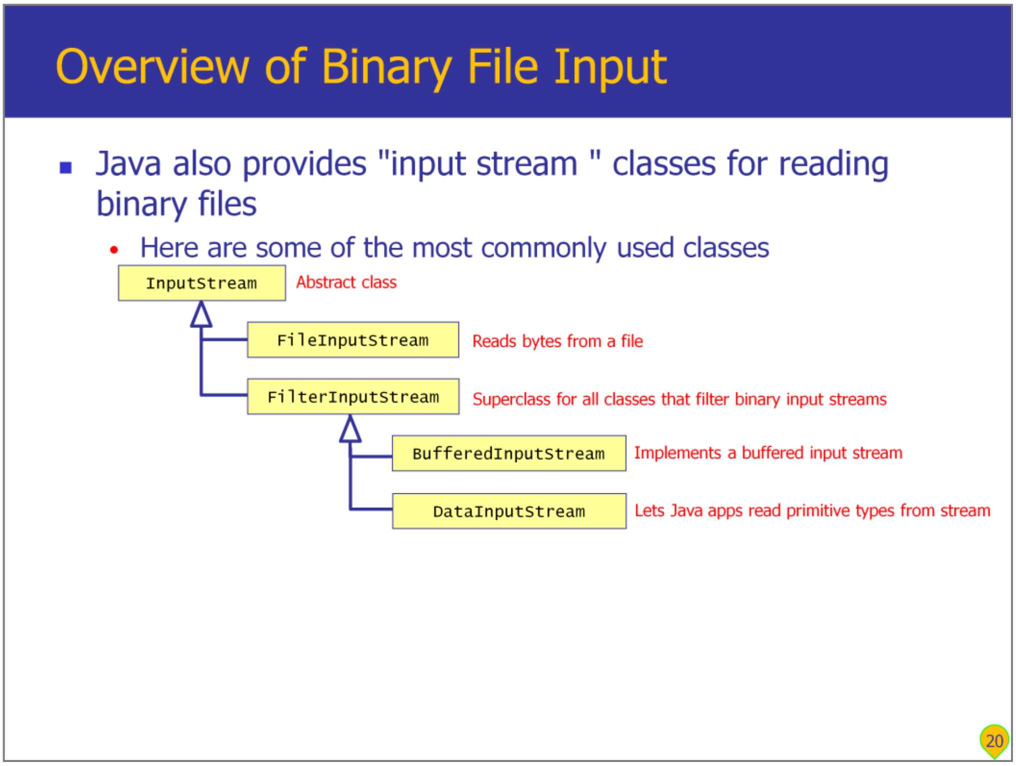
- Hook up to file stream
- It buffers output, for efficiency

- Specify filename or `File` object
- File will be overwritten by default

- Example:
  - `ReadingWritingBinFiles.java, demoWritingBinFiles()`

Here's a description of the objects involved in this diagram, starting from the right-hand-side of the diagram:

- The first object we create is a `FileOutputStream` object, which will allow us to write binary data to a file. We specify the file either by its filename or by a `File` object.
- Next up, we create a `BufferedOutputStream` object and initialize it with a reference to the existing `FileOutputStream` object. As you might expect, `BufferedOutputStream` has all the capabilities of `FileOutputStream`, but buffers content in memory for efficiency.
- Finally, we create a `DataOutputStream` object and initialize it with a reference to the `BufferedOutputStream` object. `DataOutputStream` offers a lot of extra methods that perform a much higher-level API for writing primitive types to a file. For example, it has methods such `writeBoolean()`, `writeByte()`, `writeShort()`, `writeInt()`, etc.



Overview of Binary File Input

- Java also provides "input stream " classes for reading binary files
  - Here are some of the most commonly used classes

`InputStream` Abstract class

`FileInputStream` Reads bytes from a file

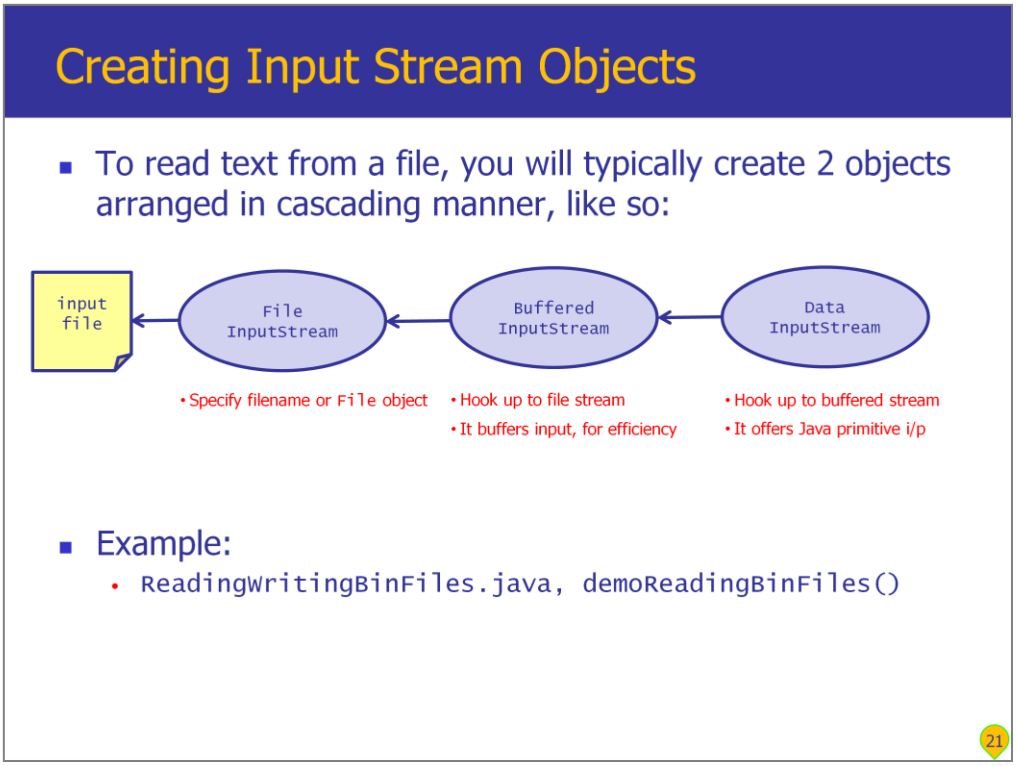
`FilterInputStream` Superclass for all classes that filter binary input streams

`BufferedInputStream` Implements a buffered input stream

`DataInputStream` Lets Java apps read primitive types from stream

The `java.io` package also contains various "input stream" classes that allow you to read binary content from a file. These classes are arranged in a hierarchy as shown in the slide above; the `InputStream` base class defines basic capabilities, and then each subclass adds additional capabilities.

The following slide shows how to use these classes in a typical scenario.



Creating Input Stream Objects

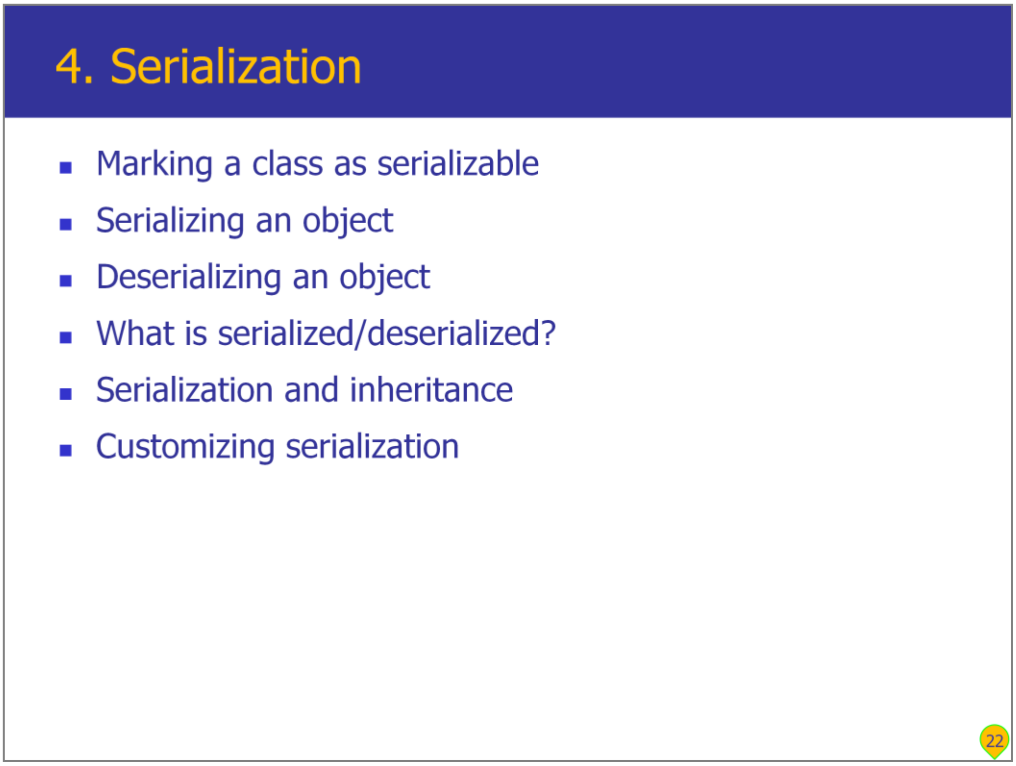
- To read text from a file, you will typically create 2 objects arranged in cascading manner, like so:

- Specify filename or `File` object
- Hook up to file stream
- It buffers input, for efficiency
- Hook up to buffered stream
- It offers Java primitive i/p

- Example:
  - `ReadingWritingBinFiles.java, demoReadingBinFiles()`

Here's a description of the objects involved in this diagram, starting from the left-hand-side of the diagram:

- The first object we create is a `FileInputStream` object, which will allow us to read binary data from a file. As before, we specify the file either by its filename or by a `File` object.
- Next up, we create a `BufferedInputStream` object and initialize it with a reference to the existing `FileInputStream` object. This gives us the performance benefit of buffering.
- Finally, we create a `DataInputStream` object and initialize it with a reference to the `BufferedInputStream` object. `DataInputStream` has methods for reading primitive types from a file. For example, it has methods such `readBoolean()`, `readByte()`, `readShort()`, `readInt()`, etc.

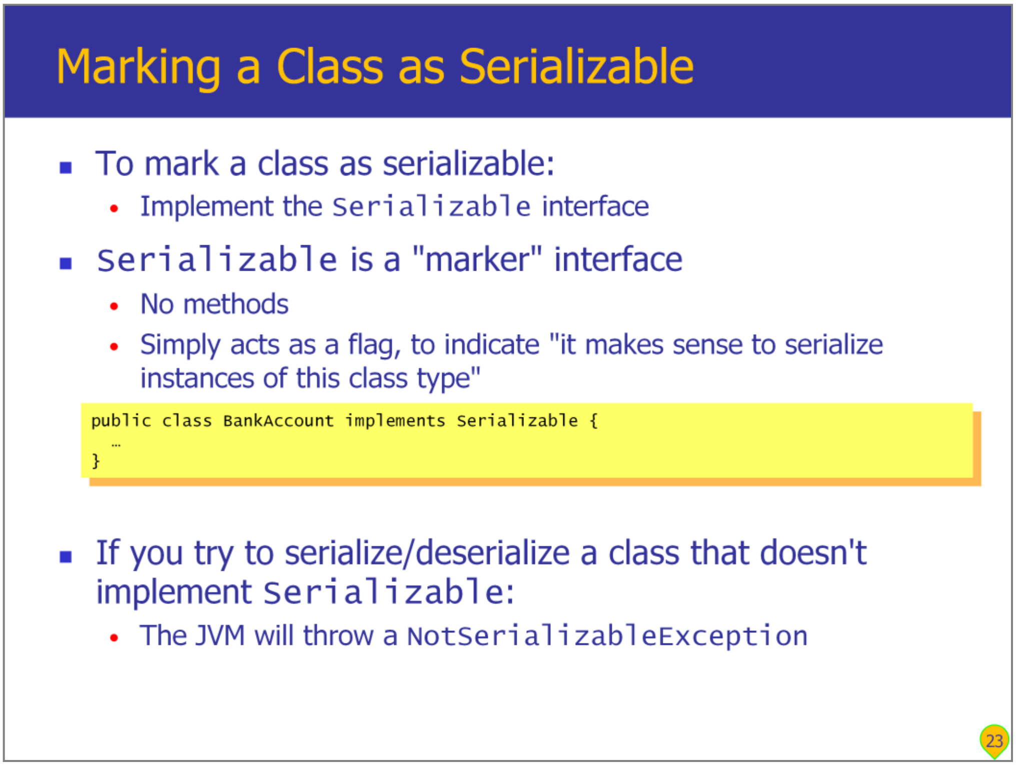


4. Serialization

- Marking a class as serializable
- Serializing an object
- Deserializing an object
- What is serialized/deserialized?
- Serialization and inheritance
- Customizing serialization

Java provides automatic support for object serialization and deserialization. Serialization is the process whereby an object is written out as a byte stream, and deserialization is the process whereby a byte stream is read back in again, to recreate a copy of the original object.

Serialization and deserialization are useful for transmitting objects over networks, between Java apps, and for saving and restoring objects in web applications.



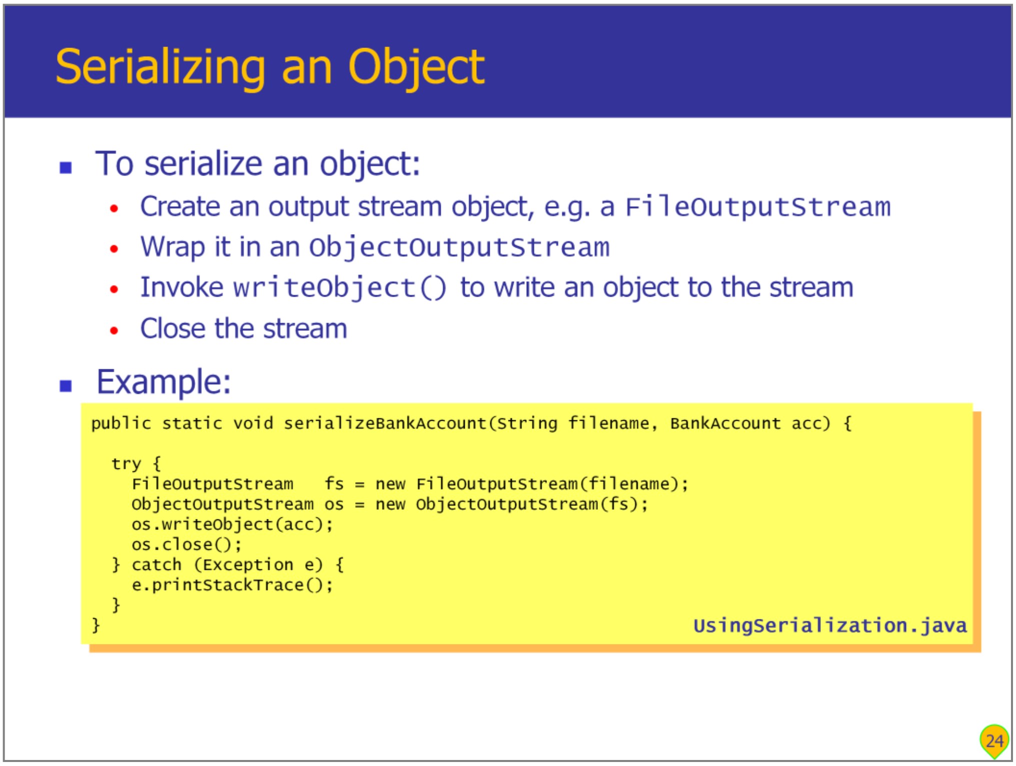
Marking a Class as Serializable

- To mark a class as serializable:
  - Implement the `Serializable` interface
- `Serializable` is a "marker" interface
  - No methods
  - Simply acts as a flag, to indicate "it makes sense to serialize instances of this class type"

```
public class BankAccount implements Serializable {
  …
}
```

- If you try to serialize/deserialize a class that doesn't implement `Serializable`:
  - The JVM will throw a `NotSerializableException`

To indicate that the JVM is allowed to serialize/deserialize instances of a class, the class must implement the `Serializable` interface. This is a marker interface; it has no members, so you don't need to implement any specific behaviour in your class.



Serializing an Object

- To serialize an object:
  - Create an output stream object, e.g. a `FileOutputStream`
  - Wrap it in an `ObjectOutputStream`
  - Invoke `writeObject()` to write an object to the stream
  - Close the stream
- Example:

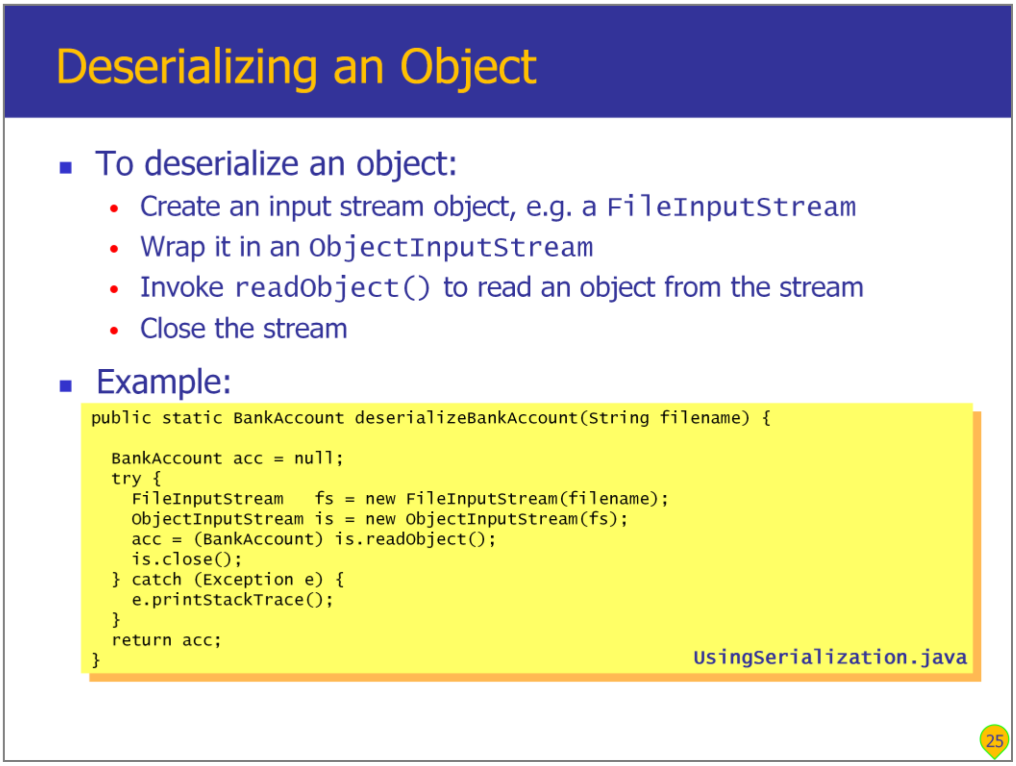
```
public static void serializeBankAccount(String filename, BankAccount acc) {

  try {
    FileOutputStream   fs = new FileOutputStream(filename);
    ObjectOutputStream os = new ObjectOutputStream(fs);
    os.writeObject(acc);
    os.close();
  } catch (Exception e) {
    e.printStackTrace();
  }
}
```

UsingSerialization.java

This slide shows how to serialize an object to a byte stream. In this example, the byte stream is actually written to a file, although this isn't strictly necessary.

Note the use of the `ObjectOutputStream` class, which has a `writeObject()` method to serialize the specified object. If the object in question doesn't implement the `Serializable` interface, a `NotSerializableException` will occur at this point.



Deserializing an Object

- To deserialize an object:
  - Create an input stream object, e.g. a `FileInputStream`
  - Wrap it in an `ObjectInputStream`
  - Invoke `readObject()` to read an object from the stream
  - Close the stream
- Example:

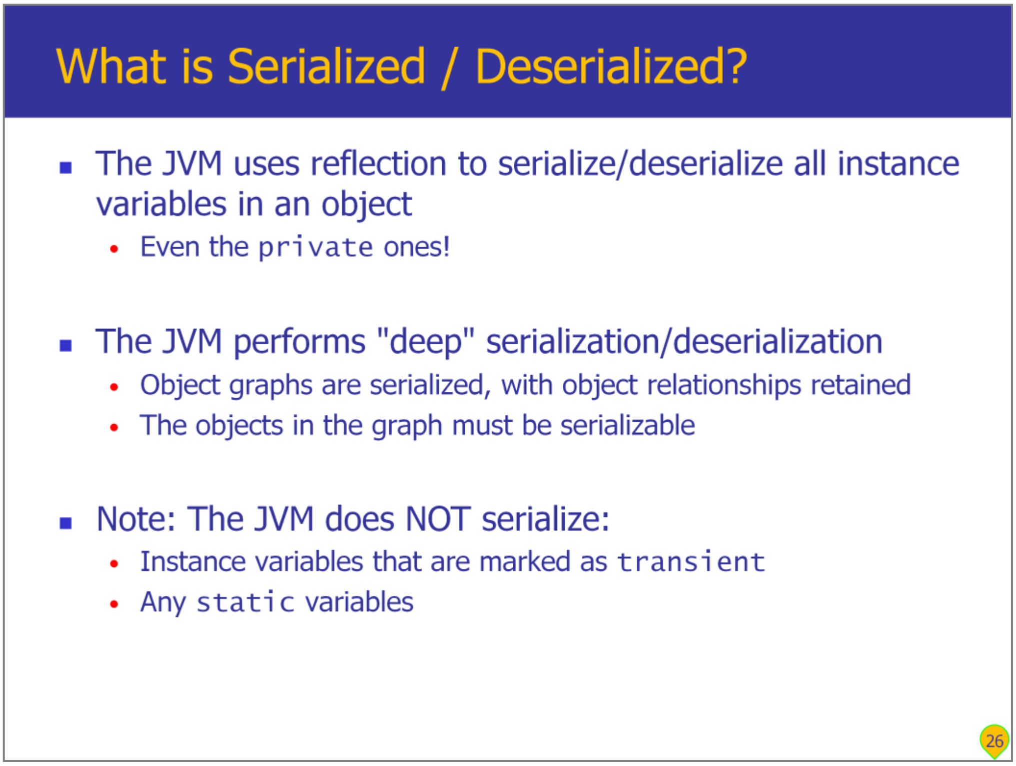
```
public static BankAccount deserializeBankAccount(String filename) {

  BankAccount acc = null;
  try {
    FileInputStream   fs = new FileInputStream(filename);
    ObjectInputStream is = new ObjectInputStream(fs);
    acc = (BankAccount) is.readObject();
    is.close();
  } catch (Exception e) {
    e.printStackTrace();
  }
  return acc;
}
```

`UsingSerialization.java`

This slide shows how to deserialize an object from a byte stream. In this example, the byte stream is retrieved from a file, although this isn't strictly necessary.

Note the use of the `ObjectInputStream` class, which has a `readObject()` method to deserialize a byte stream to create a copy of the original object. The `readObject()` method's stated return type is `Object`, so we must cast this to the correct type of object that we expect to retrieve from the stream.



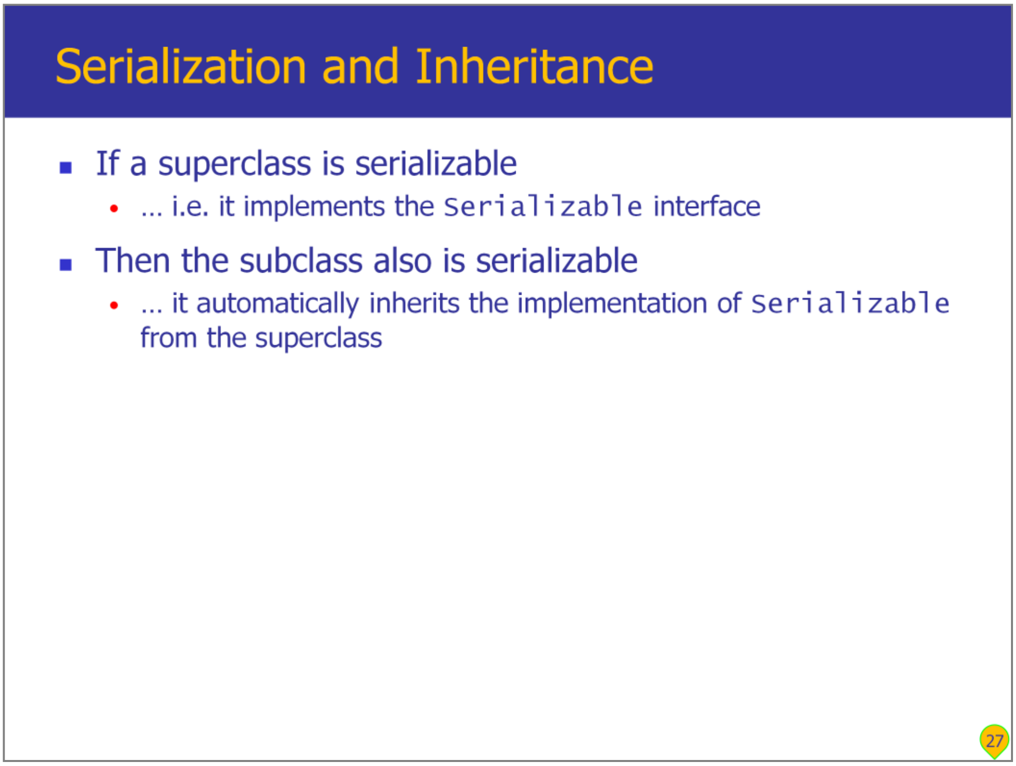
What is Serialized / Deserialized?

- The JVM uses reflection to serialize/deserialize all instance variables in an object
  - Even the `private` ones!
- The JVM performs "deep" serialization/deserialization
  - Object graphs are serialized, with object relationships retained
  - The objects in the graph must be serializable
- Note: The JVM does NOT serialize:
  - Instance variables that are marked as `transient`
  - Any `static` variables

Under the covers, the Java serialization mechanism serializes all the instance variables in an object, even those that are declared as `private`. Furthermore, the mechanism is robust enough to handle complex object graphs, where an object has references to other objects.

If there is a data member in your class that doesn't need to be serialized, you must declare the instance variable as `transient`. This indicates the variable holds temporary data that probably won’t have any relevance when the object is deserialized in the future.

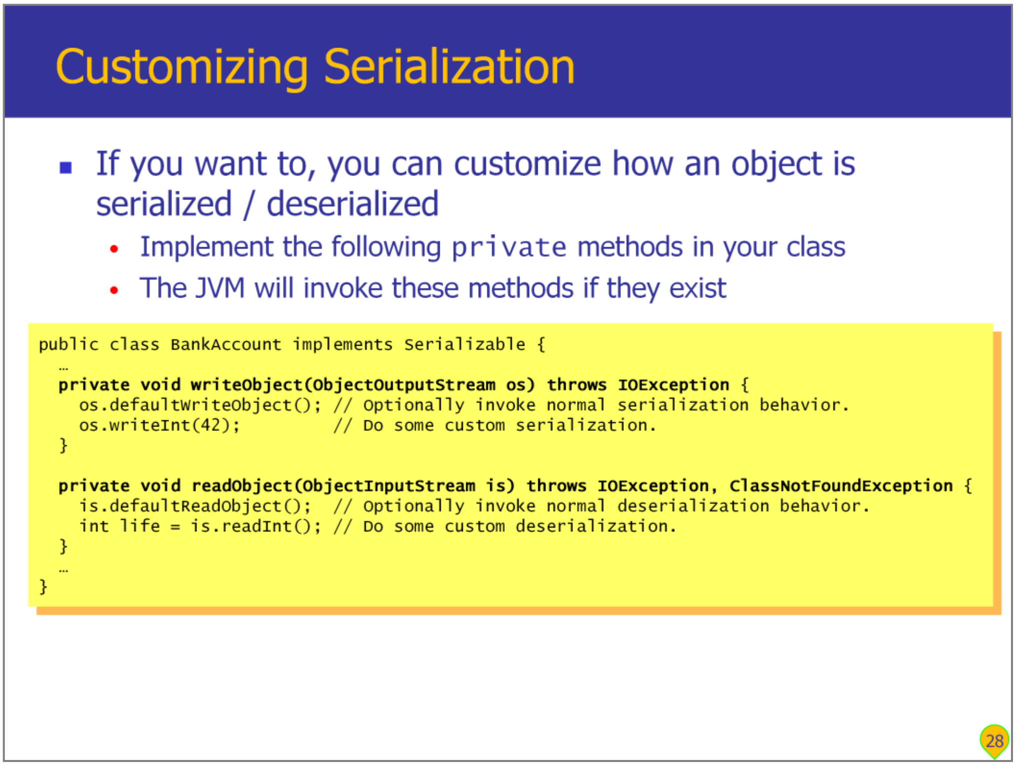
Also note that `static` members are not serialized.



Serialization and Inheritance

- If a superclass is serializable
  - … i.e. it implements the `Serializable` interface
- Then the subclass also is serializable
  - … it automatically inherits the implementation of `Serializable` from the superclass

This slide summarizes how serialization works if you have an inheritance hierarchy. Basically, if you declare that the superclass implements `Serializable`, then all the subclasses will also be serializable as well.



Customizing Serialization

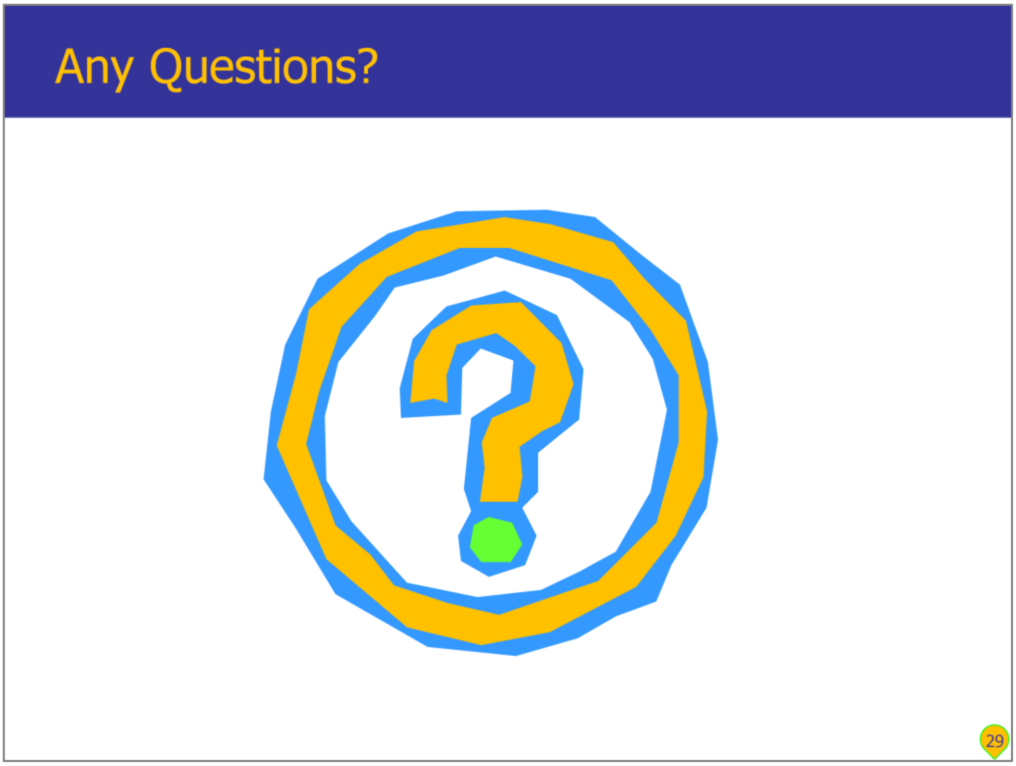
- If you want to, you can customize how an object is serialized / deserialized
  - Implement the following `private` methods in your class
  - The JVM will invoke these methods if they exist

```
public class BankAccount implements Serializable {
  …
  private void writeObject(ObjectOutputStream os) throws IOException {
    os.defaultWriteObject(); // Optionally invoke normal serialization behavior.
    os.writeInt(42);         // Do some custom serialization.
  }

  private void readObject(ObjectInputStream is) throws IOException, ClassNotFoundException {
    is.defaultReadObject();  // Optionally invoke normal deserialization behavior.
    int life = is.readInt(); // Do some custom deserialization.
  }
  …
}
```

To finish the chapter, here's an advanced technique… You can customize the serialization and deserialization mechanism for a class. This is an optimization measure, if you have some inside knowledge of how to perform serialization and deserialization more efficiently than the built-in mechanism.

Note: You shouldn't need to do this very often. Only consider doing this if you're sure the built-in mechanism is too slow.



Any Questions?

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