Localization 18

Chapter Topics

- Understanding localization of applications
- Understanding the role and purpose of locales as embodied by the `java.util.Locale` class
- Understanding how to specify a properties file
- Creating and using resource bundles with the `java.util.Resource-Bundle` class for storing and retrieving locale-specific information for the purpose of localization
- Using formatters provided by the `java.text.NumberFormat` class and its subclass, `java.text.DecimalFormat`, for locale-specific formatting and parsing of number, currency, and percentage values, including compact number and accounting currency formatting
- Using formatters provided by the `java.time.format.DateTimeFormatter` class for locale-specific formatting and parsing of date and time values
- Using formatters provided by the `java.text.MessageFormat` class for locale-specific formatting and parsing of messages
- Using the `java.text.ChoiceFormat` class for implementing choice patterns for conditional formatting and parsing of messages

Java SE 17 Developer Exam Objectives	
[11.1] Implement localization using locales, resource bundles, parse and format messages, dates, times, and numbers including currency and percentage values	§18.1, p. 1096, *to* §18.7, p. 1139
Java SE 11 Developer Exam Objectives	
[12.1] Implement Localization using Locale, resource bundles, and Java APIs to parse and format messages, dates, and numbers	§18.1, p. 1096, *to* §18.7, p. 1139

Often, applications have to work across borders and cultures, and thus must be capable of adjusting to a variety of local requirements. For example, an accounting system for the US market is obviously not going to function well in the Norwegian market. Not only is the formatting of dates, times, numbers, and currency different, but the languages in the two markets are different as well. Developing programs so that they have global awareness of such differences is called *internationalization*—also known as *i18n* (the 18 refers to the 18 characters deleted in the word *internationalization*).

Java provides the concept of a *locale* to create applications that adhere to cultural and regional preferences necessary in order to make an application truly international—a process called *localization*. Localization of applications enhances the user experience by being culturally sensitive to the user and minimizing misinterpretation of information on the part of the user. The user dialogue is an obvious candidate for localization in an application. Identifying and factorizing to isolate locale-sensitive data and code facilitates localization. Understanding cultural is-

sues is important in this regard. Other examples of resources that might require localization are messages, salutations, graphics, measurement systems, postal codes, and phone numbers. Hard-coding such locale-sensitive information is certainly not a good idea. Once an application is properly set up for internationalization, it is relatively straightforward to localize it for multiple locales without too much effort.

This chapter covers support provided by the Java SE Platform APIs to aid localization of applications: locales to access particular cultural and regional preferences, properties files as resource bundles to store locale-specific information, and formatters to format numbers, currencies, dates, times, and messages according to locale rules.

18.1 Using Locales

A *locale* represents a specific geographical, political, or cultural region. Its two most important attributes are *language* and *country*. Certain classes in the Java standard library provide *locale-sensitive* operations. For example, they provide methods to format values that represent *dates*, *currencies*, and *numbers* according to a specific locale. Adapting a program to a specific locale is called *localization*.

A locale is represented by an instance of the class `java.util.Locale`. A locale object can be created using the following constructors:

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```
Locale(String language)
Locale(String language, String country)
```

The `language` string is normalized to lowercase and the `country` string to upper-case. The language argument is an ISO-639 Language Code (which uses two lowercase letters), and the country argument is an ISO-3166 Country Code (which uses two uppercase letters) or a UN M.49 three-digit area code— although the constructors do not impose any constraint on their length or perform any syntactic checks on the arguments.

For the one-argument constructor, the country remains undefined.

Examples of selected language codes and country codes are given in **Table 18.1** and **Table 18.2**, respectively.

Table 18.1 *Selected Language Codes*

Language code	Language
`"en"`	English
`"no"`	Norwegian
`"fr"`	French

Table 18.2 *Selected Country/Region Codes*

Country/Region code	Country/Region
`"US"`	United States (U.S.)
`"GB"`	Great Britain (GB)
`"NO"`	Norway
`"FR"`	France
`"003"`	North America

The `Locale` class also has predefined locales for certain *languages*, irrespective of the region where they are spoken, as shown in **Table 18.3**.

Table 18.3 *Selected Predefined Locales for Languages*

Constant	Language
`Locale.ENGLISH`	Locale with English (`new Locale("en")`)
`Locale.FRENCH`	Locale with French (`new Locale("fr")`)
`Locale.GERMAN`	Locale with German (`new Locale("de")`)—that is, Deutsch

The `Locale` class also has predefined locales for certain *combinations of countries and languages*, as shown in **Table 18.4**.

Table 18.4 *Selected Predefined Locales for Countries*

Constant	Country
`Locale.US`	Locale for U.S. (`new Locale("en","US")`)
`Locale.UK`	Locale for United Kingdom/Great Britain (`new Locale("en","GB")`)
`Locale.CANADA_FRENCH`	Locale for Canada with French language (`new Locale("fr","CA")`)

Normally a program uses the *default locale* on the platform to provide localization. The `Locale` class provides a get and a set method to manipulate the default locale.

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```
static Locale getDefault()
static void   setDefault(Locale newLocale)
```

The first method returns the default locale, and the second one sets a specific locale as the default locale.

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```
static Locale[] getAvailableLocales()
```

Returns an array of all installed locales.

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```
static Locale forLanguageTag(String languageTag)
```

Returns a locale for the specified IETF BCP 47 language tag string, which allows extended locale properties, such as a calendar or a numeric system. An example would be creating a locale based on the language tag `"zh-cmn-Hans-CN"`, which stands for Mandarin Chinese, Simplified script, as used in China. Note that the *locale qualifiers* (also called *subtags*) in the language tag are separated by hyphens (`-`).

```
String getCountry()
```

Returns the country/region code for this locale, or `null` if the code is not defined for this locale.

```
String getLanguage()
```

Returns the language code of this locale, or `null` if the code is not defined for this locale.

Click here to view code image

```
String getDisplayCountry()
String getDisplayCountry(Locale inLocale)
```

Returns a name for the locale's country that is appropriate for display, depending on the default locale in the first method or the `inLocale` argument in the second method.

Click here to view code image

```
String getDisplayLanguage()
String getDisplayLanguage(Locale inLocale)
```

Return a name for the locale's language that is appropriate for display, depending on the default locale in the first method or the `inLocale` argument in the second method.

Click here to view code image

```
String getDisplayName()
String getDisplayName(Locale inLocale)
```

Return a name for the locale that is appropriate for display.

```
String toString()
```

Returns a text representation of this locale in the format `"LanguageCode_countryCode"`. Language is always lowercase and country is always uppercase. If either of the codes is not specified in the locale, the `_` (underscore) is omitted.

A locale is an immutable object, having *two sets* of get methods to return the *display name* of the country and the language in the locale. The first set returns the display name of the current locale according to the default locale, while the second set returns the display name of the current locale according to the locale specified as an argument in the method call.

Methods that require a locale for their operation are called *locale-sensitive*. Methods for formatting numbers, currencies, dates, and the like use the locale information to determine how such values should be formatted. A locale does not provide such services. Subsequent sections in this chapter provide examples of locale-sensitive classes (**Figure 18.1**, **p. 1115**).

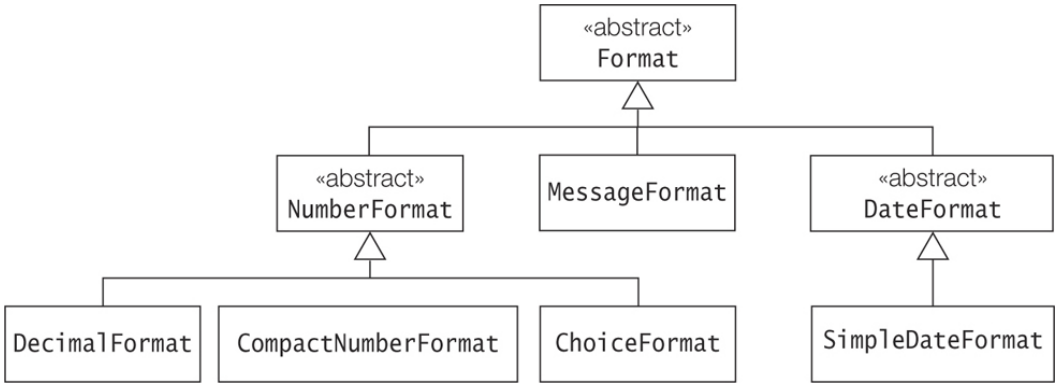

Figure 18.1 *Core Classes for Formatting in the* `java.text` *Package*

Example 18.1 illustrates the use of the get methods in the `Locale` class. The call to the `getDefault()` method at (1) returns the default locale. The method call `locNO.getDisplayCountry()` returns the country display name (`Norwegian`) of the Norwegian locale according to the default locale (which in this case is United States), whereas the method call `locNO.getDisplayCountry(locFR)` returns the country display name (`Norvège`) of the Norwegian locale according to the French locale.

Example 18.1 also illustrates that an application can change its default locale pro-grammatically at any time. The call to the `setDefault()` method at (2) sets the default locale to that of Germany. The name of the Norwegian locale is displayed according to this new default locale.

Example 18.1 *Understanding Locales*

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```
import java.util.Locale;
public class LocalesEverywhere {

  public static void main(String[] args) {

    Locale locDF = Locale.getDefault();              // (1)
    Locale locNO =  new Locale("no", "NO");          // Locale: Norwegian/Norway
    Locale locFR =  new Locale("fr", "FR");          // Locale: French/France

    System.out.println("Default locale is: " + locDF.getDisplayName());
    System.out.println("Display country (language) for Norwegian locale:");

    System.out.printf("In %s: %s (%s)%n", locDF.getDisplayCountry(),
        locNO.getDisplayCountry(locDF), locNO.getDisplayLanguage(locDF));
```

```
    System.out.printf("In %s: %s (%s)%n", locNO.getDisplayCountry(),
        locNO.getDisplayCountry(locNO), locNO.getDisplayLanguage(locNO));

    System.out.printf("In %s: %s (%s)%n", locFR.getDisplayCountry(),
        locNO.getDisplayCountry(locFR), locNO.getDisplayLanguage(locFR));

    System.out.println("\nChanging the default locale.");
    Locale.setDefault(Locale.GERMANY);              // (2) Locale: German/Germany
    locDF = Locale.getDefault();
    System.out.println("Default locale is: " + locDF.getDisplayName());
    System.out.printf("Interpreting %s locale information in %s locale.%n",
                      locNO.getDisplayName(), locDF.getDisplayName());
  }
}
```

Output from the program:

Click here to view code image

```
Default locale is: English (United States)
Display country (language) for Norwegian locale:
In United States: Norway (Norwegian)
In Norway: Norge (norsk)
In France: Norvège (norvégien)

Changing the default locale.
Default locale is: Deutsch (Deutschland)
Interpreting Norwegisch (Norwegen) locale information in Deutsch (Deutschland)
locale.
```

18.2 Properties Files

Applications need to customize their behavior and access information about the runtime environment. This could be about getting configuration data to run the application, tailoring the user interface to a specific locale, accessing the particulars for a database connection, customizing colors and fonts, and many other situations. It is not a good idea to hard-code such information in the application, but instead making it available externally so that the application can access it when needed, and where it can be modified without having to compile the application code.

Creating a Property List in a Properties File

A *property list* contains *key–value pairs* that designate *properties*, where a key is associated with a value, analogous to the entries in a map. Such a list can be created in a *properties file*, where a key–value pair is defined on each line according to the following syntax:

```
<key> = <value>
```

Following are some examples of properties that define information about the Java SE 17 Developer exam:

Click here to view code image

```
cert.name = OCP, Java SE 17 Developer
exam.title = Java SE 17 Developer
```

```
exam.number = 1Z0-829
```

Alternatively, we can use the colon (`:`) instead of the equals sign (`=`). In fact, whitespace can also be used to separate the key and the value. Any leading whitespace on a line is ignored, as is any whitespace around the equals sign (`=`).

Both the key and the value in a properties file are interpreted as `String` objects. The value string comprises all characters on the right-hand side of `=` , beginning with the first non-white-space character and ending with the last non-whitespace character. Here are some examples:

Click here to view code image

```
company = GLOBUS
greeting=Hi!
        gratitude              =Thank you!
```

We do not need to escape the metacharacter `=` or `:` in a value string. However, key names can be specified by escaping any whitespace in the name with the backslash character (`\`). Metacharacters `=` and `:` in a key name can also be escaped in the same way. In the first example below, the key string is `"fake smiley"` and the value string is `":=)"` . In the second example below, the key string is `":=)"` and the value string is `"fake smiley"` .

```
fake\ smiley = :=)
\:\=) = fake smiley
```

A backslash (`\`) at the end of a line can also be used to break the property specification across multiple lines, and any leading whitespace on a continuation line is ignored. The value in the following property specification is `"Au revoir!"` and not `"Au revoir!"` :

Click here to view code image

```
"Au            revoir!":

farewell = Au \
           revoir!
```

If only the key is specified and no value is provided, the empty string (`""`) is returned as the value, as in the following example:

```
KeyWithNoValue
```

If necessary, any conversion of the value string must be explicitly done by the application.

In the case of a duplicate key in a properties file, the last key–value pair with a duplicate key supersedes any previous resource specifications with this key.

If the first non-whitespace character on a line is the hash sign (`#`), the whole line is treated as a comment, and thereby ignored—as are blank lines. The exclamation mark (`!`) can also be used for this purpose.

```
# Any comments so far?
```

If the character encoding of a properties file does not support Unicode characters, then these must be specified using the `\uxxxx` encoding in the file. For example, to specify the property `euro =` €, we can encode it as:

```
euro = \u20AC
```

Since a properties file is a text file, it can conveniently be created in a text editor, and appropriate file permissions set to avoid unauthorized access. Although the name of a properties file can be any valid file name, it is customary to append the file extension `.properties`.

The Java Standard library provides classes to utilize the properties defined in a properties file.

- The `java.util.ResourceBundle` class can be used to implement a *resource bundle* based on the properties in a property (resource) file (p. 1102).
- The `java.util.Properties` class can be used to implement a `Properties` *table* based on the properties defined in a properties file—but this will not be discussed here, as this class is beyond the scope of this book.

18.3 Bundling Resources

Locale-specific data (messages, labels, colors, images, etc.) must be customized according to the conventions and customs for each locale that an application wishes to support. A *resource bundle* is a convenient and efficient way to store and retrieve locale-specific data in an application. The abstract class `java.util.ResourceBundle` is the key to managing locale-specific data in a Java application.

Resource Bundle Families

A *resource bundle* essentially defines *key–value pairs* that are associated with a specific locale. The synonyms *resources* and *properties* are also used for *key–value pairs*, depending on how a resource bundle is implemented. The application can retrieve locale-specific resources from the appropriate resource bundle.

A specific naming convention is used to create resource bundles. This naming convention allows resource bundles to be associated with specific locales, thereby defining *resource bundle families*. All bundles in a resource bundle family have a common *base name*, along with other locale-specific extensions, but the language and country extensions are the important ones to consider. Best practice is to use the following name for a resource bundle that defines all country-specific resources:

Click here to view code image

```
baseName_languageCode_countryCode
```

and to use the following name for a resource bundle that defines all language-specific resources:

```
baseName_languageCode
```

In addition, it is also recommended to include a *default resource bundle* that has only the common base name. The underscore (`_`) is mandatory. The extensions with the language and country codes are according to locale conventions discussed earlier (p. 1096). The following resource bundle family, used in Example 18.3, has the common base name `BasicResources`:

Click here to view code image

```
BasicResources          Default resource bundle
BasicResources_no_NO    Resource bundle for Norwegian (Norway) locale
BasicResources_fr       Resource bundle for all locales with French language
```

An application need not store all resources associated with a locale in a single resource bundle family. The resources can be organized in different resource bundle families for a given locale.

This naming scheme allows a resource bundle to be associated with a specific locale. Note that an application provides a version of each resource bundle for every locale supported by the application, unless they are shared. An example of such sharing is shown above: the locales for France and French-Canada both share the `BasicResources_fr` resource bundle. We have not defined separate `BasicResources` bundles for these two locales. We will have more to say on this matter later when we discuss how resources are located for a given locale in a resource bundle family.

Creating Resource Bundles

A resource bundle can be a *property resource file* (as shown in **Example 18.2**) or a *resource bundle class*, which is a *subclass of the abstract class* `java.util.ResourceBundle`. A resource bundle class can be used to implement resources that are not strings. We will not discuss resource bundle classes here as they are beyond the scope of this book.

Property Resource Files

A *property resource file* is a *properties file*, in which each line defines a *key–value pair* that designates a *property*. The discussion on properties files (**p. 1100**) also applies to a property resource file. However, note that a property resource file must be named according to the resource bundle naming scheme outlined above, and has the mandatory file extension `.properties` in addition.

Example 18.2 shows the three property resource files used by **Example 18.3**. The property resource file `BasicResources.properties` defines the default resource bundle for the resource bundle family `BasicResources` that applies for all locales. The property resource files `BasicResources_no_NO.properties` and `BasicResources_fr.properties` define resource bundles for the Norwegian (Norway) locale and the French locale, respectively. Note the appending of the language/country code to the bundle family name using the underscore (`_`).

The first line in each of the three property resource files in **Example 18.2** is a comment documenting the name of the file. Typically, the property resource files are placed in a directory, usually called `resources`, which is in the same location as the application.

Note also that we use the same key name for a property in *all* property resource files of a resource bundle family. The greeting, gratitude, and the farewell messages are designated by their respective key names in all property resource files. In **Example 18.2**, the astute reader will notice that the key name `company` is only specified in the default property resource file `BasicResources.properties`, but not in the other property resource files. If the default resource bundle for a resource bundle family is provided, it is always in the search path when locating the value associated with a key.

Modifying an existing property resource file or adding a new property resource file may not require recompiling of the application, depending on the implication of the changes made to the property resource file.

Example 18.2 *The* `BasicResources` *Bundle Family (See Also* **Example 18.3***)*

Click here to view code image

```
# File: BasicResources.properties
company = GLOBUS
greeting = Hi!
gratitude = Thank you!
farewell = See you!
```

Click here to view code image

```
# File: BasicResources_no_NO.properties
greeting = Hei!
gratitude = Takk!
farewell = Ha det!
```

Click here to view code image

```
# File: BasicResources_fr.properties
greeting = Bonjour!
gratitude = Merci!
farewell = Au revoir!
```

Locating, Loading, and Searching Resource Bundles

Once the necessary resource bundle families have been specified, the application can access the resources in a specific resource bundle family for a particular locale using the services of the `java.util.ResourceBundle` class. First, a locale-specific resource bundle is *created* from a resource bundle family using the `getBundle()` method—an elaborate process explained later in this section.

Click here to view code image

```
static ResourceBundle getBundle(String baseName)
static ResourceBundle getBundle(String baseName, Locale locale)
```

Return a resource bundle using the specified base name for a resource bundle family, either for the default locale or for the specified locale, respectively.

The resource bundle returned by this method is *chained* to other resource bundles (called *parent resource bundles*) that are searched if the key-based lookup in this resource bundle fails to find the value of a resource.

An unchecked `java.util.MissingResourceException` is thrown if no resource bundle for the specified base name can be found.

Also, it should be noted that bundles are loaded by the classloader, and thus their bundle names are treated exactly like fully qualified class names; that is, the package name needs to be specified when a resource bundle is placed in a package, such as `"resources.BasicResources"`.

If the resource bundle found by the `getBundle()` method was defined as a *property resource file*, its contents are read into an instance of the concrete class `Prop-ertyResourceBundle` (a

subclass of the abstract `ResourceBundle` class) and this instance is returned.

The resource bundle instances returned by the `getBundle()` methods are immutable and are cached for reuse.

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```
Object getObject(String key)
String getString(String key)
```

The first method returns an object for the given key from this resource bundle.

The second method returns a string for the given key from this resource bundle. This is a convenience method, if the value is a string. Calling this method is equivalent to `(String) getObject(key)`. A `ClassCastException` is thrown if the object found for the given key is not a string.

An unchecked `java.util.MissingResourceException` is thrown if no value for the key can be found in this resource bundle or any of its parent resource bundles. A `NullPointerException` is thrown if the key is `null`.

```
Set<String> keySet()
```

Returns a `Set` of all keys contained in this `ResourceBundle`.

```
Locale getLocale()
```

Returns the locale of this resource bundle. The locale is derived from the naming scheme for resource bundles.

We will use **Example 18.3** to illustrate salient features of localizing an application using resource bundles. The application has the following data, which should be localized:

```
Company: GLOBUS
Greeting: Hi!
Gratitude: Thank you!
Farewell: See you!
```

The example illustrates how the application can localize this data for the following locales: default (`"en_US"`), Norway (`"no_NO"`), French-Canada (`"fr_CA"`), and France (`"fr_FR"`). The company name is the same in every locale. The greeting, gratitude, and farewell messages are all grouped in one resource bundle family (`BasicResources`). For each locale, the application reads this data from the appropriate resource bundles and prints it to the terminal (see the output from **Example 18.3**).

Example 18.3 *Using Resource Bundles (See Also* **Example 18.2***)*

Click here to view code image

```
import java.util.Locale;
import java.util.ResourceBundle;
public class UsingResourceBundles {
```

```
  // Supported locales:                                                    // (1)
  public static final Locale[] locales = {
    Locale.getDefault(),                                  // Default: US (English)
    new Locale("no", "NO"),                               // Norway (Norwegian)
    Locale.FRANCE,                                        // France (French)
    Locale.CANADA_FRENCH                                  // Canada (French)
  };

  // Localized data from property resource files:                          // (2)
  private static String company;
  private static String greeting;
  private static String gratitude;
  private static String farewell;

  public static void main(String[] args) {                              // (3)
    for (Locale locale : locales) {
      setLocaleSpecificData(locale);
      printLocaleSpecificData(locale);
    }
  }

  private static void setLocaleSpecificData(Locale locale) {            // (4)
    // Get resources from property resource files:
    ResourceBundle properties =
        ResourceBundle.getBundle("resources.BasicResources", locale);   // (5)
    company = properties.getString("company");                          // (6)
    greeting = properties.getString("greeting");
    gratitude = properties.getString("gratitude");
    farewell = properties.getString("farewell");
  }

  private static void printLocaleSpecificData(Locale locale) {          // (7)
    System.out.println("Resources for " + locale.getDisplayName() + " locale:");
    System.out.println("Company: " + company);
    System.out.println("Greeting: " + greeting);
    System.out.println("Gratitude: " + gratitude);
    System.out.println("Farewell: " + farewell);
    System.out.println();
  }
}
```

Output from running the program:

Click here to view code image

```
Resources for English (United States) locale:
Company: GLOBUS
Greeting: Hi!
Gratitude: Thank you!
Farewell: See you!

Resources for Norwegian (Norway) locale:
Company: GLOBUS
Greeting: Hei!
Gratitude: Takk!
Farewell: Ha det!

Resources for French (France) locale:
Company: GLOBUS
Greeting: Bonjour!
```

```
Gratitude: Merci!
Farewell: Au revoir!

Resources for French (Canada) locale:
Company: GLOBUS
Greeting: Bonjour!
Gratitude: Merci!
Farewell: Au revoir!
```

In **Example 18.3**, the static method `getBundle()` of the `ResourceBundle` class is called at (5) to create a resource bundle for the specified locale from the resource bundle family with the base name `BasicResources`. In **Example 18.3**, the resource bundle family is located in the `resources` directory, which is also the location of the package with the same name.

Click here to view code image

```
String company;
...
ResourceBundle properties =
    ResourceBundle.getBundle("resources.BasicResources", locale);    // (5)
company = properties.getString("company");                           // (6)
```

Since all the resource bundles in the resource bundle family `BasicResources` are property resource files, both the key and the value are `String` objects. It is convenient to use the `getString()` method in the `ResourceBundle` class to do lookup for resources, as shown at (6). The key is passed as an argument. Searching the resource for a given key is explained later in this section.

Locating Locale-Specific Resources

A broad outline of the steps is given below to locate and create the resource bundle (and its parent bundles) returned by the `getBundle()` static method of the abstract class `java.util.ResourceBundle` for a specific locale. For the nitty-gritty details of locating resource bundles, we recommend consulting the Java SE API documentation for the `java.util.ResourceBundle` class.

Exactly which resource bundle (and its parent bundles) will be returned by the `getBundle()` static method depends on the following factors:

- The *resource bundles included in the resource bundle family* specified by its fully qualified base name in the call to the `getBundle()` method
- The *specified locale* in the call to the `getBundle()` method
- The *current default locale* of the application

For the explanation given below, assume that the default local is `"en_US"` and the following resource files (from **Example 18.2**) in the resource bundle family with the base name `BasicResources` reside in a directory named `resources`:

Click here to view code image

```
BasicResources.properties
BasicResources_no_NO.properties
BasicResources_fr.properties
```

Also assume the following call is made to the `getBundle()` method to retrieve the resource bundle (and its parent resource bundles) for the `baseName` bundle family and the specified

locale:

Click here to view code image

```
ResourceBundle resources = ResourceBundle.getBundle(baseName, specifiedLocale);
```

Step 1: Create a list of candidate bundle names based on the specified locale.

The `getBundle()` method first generates a list of *candidate bundle names* by appending the attributes of the locale argument (specified language code, specified country code) to the base name of the resource bundle family that is passed as an argument. Typically, this list would have the following candidate bundle names, where the order in which the names are generated is important in locating resources:

Click here to view code image

```
baseName_specifiedLanguageCode_specifiedCountryCode
baseName_specifiedLanguageCode
```

For example, if the base name is `BasicResources` and the locale that is passed as an argument is `"fr_CA"` in the call to the `getBundle()` method, the list of candidate bundle names generated would be as follows:

```
BasicResources_fr_CA
BasicResources_fr
```

Note that more specific bundles are higher in this list, and more general ones are lower in the list. The bundle `BasicResources_fr_CA` is more specific than the bundle `BasicResources_fr`, as the former is only for France (French), whereas the latter is for all French-speaking countries.

A candidate bundle name in this list is a *parent* resource bundle for the one above it.

Step 2: Find the result bundle that can be instantiated in the candidate bundle list.

The `getBundle()` method then iterates over the list of candidate bundle names from the beginning of the list to find the *first* one (called the *result bundle*) for which it can instantiate an actual resource bundle.

Finding the result bundle depends on whether it is possible to instantiate a resource bundle class or load the contents of a property resource file into an instance of the `PropertyResourceBundle` class, where the resource bundle class or the property resource file has the same name as the candidate bundle name.

In our example regarding the `"fr_CA"` locale, the candidate resource name `BasicResources_fr_CA` in the list of candidate resource names does not qualify as a result resource bundle because it cannot be created based on any resource bundles in the resource bundle family `BasicResources.` Only the candidate resource name `BasicResources_fr` can be created and is the result resource bundle, as there is a resource bundle named `BasicResources_fr.properties` in the resource bundle family.

Once a result resource bundle has been found, its *parent chain* is constructed and returned (p. 1109). In our example with the `"fr_CA"` locale, the parent chain for the result source bundle named `BasicResources_fr.properties` is created and returned.

Step 3: If no result resource bundle is found in Step 2, the search for a result bundle is conducted with the default locale.

It is possible that no result resource bundle is found in the previous step. Only in that case is the search for a result resource bundle repeated with the current *default locale* (default language code, default country code). A new list of candidate bundle names is generated, which will typically include the following names, and is instantiated to find a result bundle name:

Click here to view code image

```
baseName_defaultLanguageCode_defaultCountryCode
baseName_defaultLanguageCode
```

In our example, this second step is not performed since a result resource bundle (`BasicResources_fr`) was found in the previous step.

Once a result resource bundle using the default locale has been found, its *parent chain* is constructed and returned (**p. 1109**).

Step 4: If no result resource bundle is found in Step 3 using the current default locale either, an attempt is made to instantiate the default resource bundle designated by `baseName`.

If successful, this instantiation of the default resource bundle is returned by the `getBundle(baseName, specifiedLocale)` method.

In our example, this step with the bundle name `BasicResources` is not performed since a result resource bundle (`BasicResources_fr`) was already found.

Step 5: If the steps above do not yield a result resource bundle, an unchecked `java.util.MissingResourceException` *is thrown.*

In our example, no exception is thrown since a result resource bundle (`BasicResources_fr`) was found in Step 2.

Constructing the Parent Chain of a Result Resource Bundle

Once a result resource bundle is identified (see Step 2 and Step 3 in the previous section), a *parent chain* for the result source bundle is constructed and returned by the `getBundle()` method as follows:

- All candidate bundle names that are below the result bundle name in the candidate bundle list are iterated over, and those candidate bundles that can be instantiated are *chained* in the order in which they appear in the list.
  In our example, the result resource bundle `BasicResources_fr` was found last in the list of candidate bundle names, and therefore does not get any parent according to this step.
- Lastly, an attempt is also made to chain the *default resource bundle* (with the base name) into the parent chain of the result resource bundle which is then returned by the `getBundle(baseName, specifiedLocale)` method.

In our example, the default resource bundle `BasicResources` is provided and is therefore set as the parent bundle to the result resource bundle `Basic-Resources_fr`.

Click here to view code image

```
BasicResources_fr.properties
BasicResources.properties (parent)
```

This will result in the parent chain being searched, if necessary, when a lookup is performed for a resource in this result bundle for the `"fr_CA"` locale, where the most specific bundle (`BasicResources_fr.properties`) is researched first and the most general one (`BasicResources.properties`) last.

Note that an attempt is also made to include the default resource bundle when no result resource bundle can be found in the candidate bundle list, as shown in Step 4 earlier.

Best practice recommends including a default resource bundle as *fallback* in a resource bundle family. This bundle will then always be searched last to find the value associated with a key.

Table 18.5 shows the result resource bundles with the parent bundle chain from the resource bundle family `BasicResources` that will be located and loaded for each locale supported by **Example 18.3**. We have shown property resource file names in the table and indicated the parent resource bundle. Actually, resource bundle classes are instantiated at runtime, based on the contents of the property resource files. Note that the resource bundle `BasicResources_fr.properties` is searched for both the `"fr_FR"` locale and the `"fr_CA"` locale.

Table 18.5 *Result and Parent Bundles (See Example 18.3)*

Specified locale	Result resource bundles	Step that creates the parent chain:
`Locale("en", "US")`	`BasicResources.properties`	*Step 4*
`Locale("no", "NO")`	`BasicResources_no_NO.properties` `BasicResources.properties` *(parent)*	*Step 2*
`Locale("fr", "FR")`	`BasicResources_fr.properties` `BasicResources.properties` (*parent*)	*Step 2*
`Locale("fr", "CA")`	`BasicResources_fr.properties` `BasicResources.properties` *(parent)*	*Step 2*

Searching in Resource Bundles

Example 18.4 is instructive in understanding which resource bundles for a given locale will be searched when performing key-based lookups for locale-specific values. Each resource bundle in the resource family `MyResources` has only one key, and the name of the key is different in all resource bundles. The value of the key in each file is the name of the resource bundle. The program prints the value of all the keys found in the resource bundles for a given locale. The method `keySet()`, called at (1), returns a set with all the keys from the resource bundles that can be searched for the locale specified in the `getBundle()` method. Any value written out will be the name of the resource bundle that is searched. Since a key set is returned, the key or-

der in the set is not guaranteed. However, this key set is converted to a sorted key set to reflect the hierarchy of resource bundles for each locale.

From the program output, we can see that the default resource bundle is always searched (for all the locales in **Example 18.4**). Only if no corresponding resource bundle for the given locale can be found in the resource bundle family will the resource bundle for the current default locale be searched (`"no_NO"` locale in **Example 18.4**). For a language-country locale, both the country and the language resource bundles are included, if any of them are in the resource bundle family (the `"fr_CA"` locale in **Example 18.4**). For a language locale, only the language resource bundle is included, if it is in the resource bundle family (`"fr"` locale in **Example 18.4**).

Example 18.4 *Locating Resource Bundles*

Click here to view code image

```
# MyResources_fr_CA.properties
file1 = MyResources_fr_CA
```

Click here to view code image

```
# MyResources_fr.properties
file2 = MyResources_fr
```

Click here to view code image

```
# MyResources_en_US.properties
file3 = MyResources_en_US
```

Click here to view code image

```
# MyResources_en.properties
file4 = MyResources_en
```

Click here to view code image

```
# MyResources.properties
file5 = MyResources
```

Click here to view code image

```
import java.util.Locale;
import java.util.ResourceBundle;
import java.util.TreeSet;

public class LocatingBundles {
  public static void main(String[] args) {

    Locale[] locales = {
        new Locale("no", "NO"),                          // Norway
        Locale.CANADA_FRENCH,                            // Canada (French)
        Locale.FRENCH,                                   // French
        Locale.getDefault(),                             // Default: en_US
    };
```

```
    for (Locale locale: locales) {
      System.out.println("Locating resource bundles for " + locale + " locale:");
      ResourceBundle resources = ResourceBundle.getBundle("resources.MyResources",
                                                          locale);
      for (String key : new TreeSet<>(resources.keySet())) {              // (1)
        System.out.println(resources.getString(key));
      }
      System.out.println();
    }
  }
}
```

Output from the program:

Click here to view code image

```
Locating resource bundles for no_NO locale:
MyResources_en_US
MyResources_en
MyResources

Locating resource bundles for fr_CA locale:
MyResources_fr_CA
MyResources_fr
MyResources

Locating resource bundles for fr locale:
MyResources_fr
MyResources

Locating resource bundles for en_US locale:
MyResources_en_US
MyResources_en
MyResources
```

Review Questions

18.1 Given the following resource bundle in the `pkg` package directory:

Click here to view code image

```
# File: MyResources_en_US.properties
greeting = Howdy!
gratitude = Thank you!
farewell = See ya!
farewell = Bye!
```

Assume that the current default locale is `"en_US"`. What will be the result of compiling and running the following program?

Click here to view code image

```
import java.util.*;
public class TestResourceBundles {
  public static void main(String[] args) {
    ResourceBundle resources = ResourceBundle.getBundle("pkg.MyResources",
```

```
                                                    Locale.FRANCE);
    for (String key : resources.keySet()) {
      System.out.println(resources.getString(key));
    }
  }
}
```

Select the one correct answer.

a. The program output will contain the following lines:

```
Howdy!
Bye!
Thank you!
```

b. The program output will contain the following lines:

```
 Howdy!
See ya!
Thank you!
```

c. When run, the program will throw a `MissingResourceException`.

d. When run, the program will terminate normally without printing anything.

18.2 Given the following three resource bundles in the `pkg3` package:

Click here to view code image

```
# MyResources_en_US.properties
farewell = See ya!
_____________________________________________________________________________
# MyResources_en.properties
farewell = Have a good one!
_____________________________________________________________________________
# MyResources.properties
farewell = Goodbye!
```

Assume that the current default locale is `"en_US"`. What will be the result of compiling and running the following program?

Click here to view code image

```
import java.util.*;
public class TestResourceBundles3 {
  public static void main(String[] args) {
    ResourceBundle resources = ResourceBundle.getBundle("pkg3.MyResources",
                                                        Locale.ENGLISH);
    System.out.println(resources.getString("farewell"));
  }
}
```

Select the one correct answer.

a. `See ya!`

b. `Have a good one!`

c. `Goodbye!`

d. When run, the program will throw a `MissingResourceException`.

e. When run, the program will terminate normally without printing anything.

18.3 Given the following code:

Click here to view code image

```
import java.util.*;
public class RQ4_2 {
  public static void main(String[] args) {
    ResourceBundle rb = ResourceBundle.getBundle("resources", new Locale("en"));
    for (String key : new TreeSet<String>(rb.keySet())) {
      System.out.print(key+"="+rb.getString(key)+" ");
    }
  }
}
```

and the file `resources.properties`

```
k1=a
k2=b
```

and the file `resources_en.properties`

```
k1=c
```

and the file `resources_en_GB.properties`

```
k1=d
k2=e
```

What is the result?

Select the one correct answer.

a. `k1=d k2=e`

b. `k1=c k2=b`

c. `k1=a k2=b`

d. `k1=d k2=e`

e. The program will throw an exception at runtime.

18.4 Given the following code:

Click here to view code image

```
import java.util.*;
public class RQ4_3 {
  public static void main(String[] args) {
    Locale.setDefault(new Locale("ru"));
    ResourceBundle rb = ResourceBundle.getBundle("resources",new Locale("en"));
    for (String key : new TreeSet<String>(rb.keySet())) {
      System.out.print(key+"="+rb.getString(key)+" ");
    }
  }
}
```

and the file `resources.properties`

```
k1=a
k2=b
```

and the file `resources_en.properties`

```
k1=c
```

and the file `resources_ru.properties`

```
k1=A
k2=B
```

What is the result?

Select the one correct answer.

a. `k1=c k2=B`

b. `k1=c k2=b`

c. `k1=A k2=B`

d. The program will throw an exception at runtime.

18.4 Core API for Formatting and Parsing of Values

The abstract class `Format` and its subclasses in the `java.text` package provide support for formatting and parsing of dates, times, numbers, currencies, and percentages (**Figure 18.1**).

A *formatter* has two primary functions. The first is to create a human-readable text representation of a value, called *formatting*. The second is to create a value from a character sequence, such as a string, containing a text representation of the value, called *parsing*.

In the rest of this chapter, we emphasize the *locale-sensitive* nature of formatting and parsing of different kinds of values.

- *Formatting numbers, currencies, and percentages (p. 1116)*
  The support for formatting numbers, currencies, and percentages is provided by the abstract class `java.text.NumberFormat` and its subclasses `java.text.DecimalFormat` and `java.text.CompactNumberFormat`.
- *Formatting dates and times (p. 1127)*

The support provided for formatting dates and times by the abstract class `java.text.DataFormat` and its subclass `java.text.SimpleFormat` is aimed at objects of the `java.util.Date` legacy class, and is *not* covered in this book.
Support for the new Date and Time API is provided by the `java.time` package, which is covered extensively in **Chapter 17**, **p. 1023**. The class `java.time.format.DateTimeFormatter` provides the support for formatting date and time values created using the new Date and Time API.

- *Formatting messages (**p. 1139**)*
  The support for formatting *messages* containing numbers, currencies, dates, and times is provided by the concrete class `java.text.MessageFormat`. The class `java.text.ChoiceFormat` allows a choice of formatting dependent on numerical values, and is typically used for *conditional formatting* of messages.
  The support provided by the `MessageFormat` class for date and time values is aimed at objects of the legacy class `Date`, but there are a number of ways that the `MessageFormat` class can be utilized with formatting objects of the new Date and Time API, and they are discussed later (**p. 1139**).

18.5 Formatting and Parsing Number, Currency, and Percentage Values

The abstract class `java.text.NumberFormat` and its subclasses `java.text.Decimal-Format` and `java.text.CompactNumberFormat` provide methods for locale-sensitive formatting and parsing of *number*, *currency*, and *percentage* values.

Static Factory Methods to Create a Formatter

The abstract class `NumberFormat` provides static factory methods for creating locale-sensitive formatters for number, currency, and percentage values. However, the locale cannot be changed after the formatter is created. The factory methods return instances of the concrete classes `DecimalFormat` and `CompactNumberFormat` for formatting number, currency, and percentage values.

Click here to view code image

```
static NumberFormat getNumberInstance()
static NumberFormat getNumberInstance(Locale locale)
```

Return a general formatter for numbers—that is, a number formatter.

Click here to view code image

```
static NumberFormat getCurrencyInstance()
static NumberFormat getCurrencyInstance(Locale locale)
```

Return a formatter for currency values—that is, a currency formatter.

Click here to view code image

```
static NumberFormat getPercentInstance()
static NumberFormat getPercentInstance(Locale locale)
```

Return a formatter for percentages—that is, a percentage formatter.

Click here to view code image

```
static NumberFormat getCompactNumberInstance()
static NumberFormat getCompactNumberInstance(Locale locale,
                                             NumberFormat.Style formatStyle)
```

Return a compact number formatter with the default compact format style or a specific compact format style, respectively (p. 1120). For example, the value `2_345_678` can be formatted by a compact number formatter as `"2M"` with the `SHORT` compact form style and as `"2 million"` with the `LONG` compact form style, respectively, for the `US` locale.

In all cases, a locale can be specified to localize the formatter.

Formatting Number, Currency, and Percentage Values

A number formatter can be used to format a `double`, a `long` value, or an object. The abstract class `NumberFormat` provides the following concrete methods for this purpose. Depending on the number formatter, the formatting is locale-sensitive, determined by the default or a specific locale.

```
String format(double d)
String format(long l)
```

Formats the specified number and returns the resulting string.

Click here to view code image

```
String format(Object obj)              // inherited from the Format class.
```

Formats the specified object and returns the resulting string. For example, it can be used to format `BigInteger` and `BigDecimal` numbers.

The following code shows how we can create a *number formatter* for the Norwegian locale and one for the US locale, and use them to format numbers according to rules of the locale. The number formatted is a `double` (1a) or a `BigDecimal` (1b), giving the same results. Note that the grouping of the digits and the decimal separator used in formatting is according to the locale.

Click here to view code image

```
double num = 12345.6789;                                  // (1a)
// BigDecimal num = new BigDecimal("12345.6789");         // (1b)

Locale locNOR = new Locale("no", "NO");                   // Norway
NumberFormat nfNOR = NumberFormat.getNumberInstance(locNOR);
System.out.println(nfNOR.format(num));                    // 12 345,679

NumberFormat nfUS = NumberFormat.getNumberInstance(Locale.US);
System.out.println(nfUS.format(num));                     // 12,345.679
```

The following code shows how we can create a *currency* formatter for the Norwegian locale, and use it to format currency values according to this locale. Note the currency symbol and the

grouping of the digits, with the amount being rounded to two decimal places. Also note that the delimiter between the currency symbol and the first digit is a *non-breaking space* (*nbsp*), having the unicode `\u00a0`; that is, it is not a normal space (`\u0020`). The grouping of digits is also with a nbsp. Such use of a nbsp is also locale-specific—formatting for the US locale has no nbsp, as can be seen below.

Click here to view code image

```
NumberFormat cfNOR = NumberFormat.getCurrencyInstance(locNOR);
String formattedCurrStr = cfNOR.format(num);
System.out.println(formattedCurrStr);              // kr 12 345,68 (with 2 nbsp)

NumberFormat cfUS = NumberFormat.getCurrencyInstance(Locale.US);
String formattedCurrStrUS = cfUS.format(num);
System.out.println(formattedCurrStrUS);            // $12,345.68
```

The value 1.0 is equivalent to 100%. A value is converted to a percentage by multiplying it by 100, and by default rounding it to an integer. By default, the result is rounded up only if the decimal part is *equal to or greater than* 0.5 after multiplying by 100. However, both the number of decimal places and the rounding behavior for the percentage value can be changed (**p. 1122**).

The following code shows how we can create a *percentage* formatter for the Norwegian locale, and use it to format percentage values according to this locale. Also note that the delimiter between the percentage number and the currency symbol is a *non-breaking space*. Again, such use of a nbsp is also locale-specific—formatting percentages for the US locale has no nbsp, as can be seen below. Note the rounding of the percentage values.

Click here to view code image

```
double rebate = 0.746;
NumberFormat pfNOR = NumberFormat.getPercentInstance(locNOR);
String formattedPStr = pfNOR.format(rebate);
System.out.println(formattedPStr);                 // 75 %  (with nbsp)

NumberFormat pfUS = NumberFormat.getPercentInstance(Locale.US);
String formattedPStrUS = pfUS.format(rebate);
System.out.println(formattedPStrUS);               // 75%

System.out.println(pfUS.format(0.745));            // 74%
```

Accounting Currency Formatting

By default, the minus sign (`-`) is used as a prefix when formatting negative numbers using a currency formatter returned by the `NumberFormat.getCurrencyInstance()` method.

Click here to view code image

```
NumberFormat df0 = NumberFormat.getCurrencyInstance(Locale.US);
System.out.println(df0.format(-9.99));             // -$9.99
```

However, in accountancy, it is a common practice to enclose a negative currency value in parentheses, `()`. For example, `($9.99)` is interpreted as `-$9.99`. One way to format negative currency values with parentheses for a given locale is to create the locale so that it allows this style for currency formatting. The code below illustrates how this can be achieved for the US locale.

A US locale is created at (1) below that formats negative currency values with parentheses. The `Locale.forLanguageTag()` method creates a locale from the specified language tag `en-US-u-cf-account` that consists of several subtags separated by a hyphen:

- `en` : Represents the English language
- `US` : Represents the United States
- `u` : Indicates that a *Unicode locale/language extension* is specified as a *key–value* pair
- `cf-account` : The key–value pair, where the key `cf` stands for *currency format*, and the value `account` means to use parentheses for negative numbers

The language tag `en-US-u-cf-standard` will result in a US locale that is the same as `Locale.US`. For further details, kindly consult the Unicode Locale Data Markup Language (LDML).

The currency formatter created at (2) for the locale created at (1) will now use parentheses for negative currency values.

Click here to view code image

```
Locale loc = Locale.forLanguageTag("en-US-u-cf-account");   // (1)
NumberFormat df = NumberFormat.getCurrencyInstance(loc);    // (2)
System.out.println(df.format(-9.99));                       // ($9.99)
```

Parsing Strings to Number, Currency, and Percentage Values

A *number* formatter can be used to parse strings that contain text representations of *numeric* values. The abstract class `NumberFormat` provides the following concrete methods for this purpose.

Click here to view code image

```
Number parse(String str) throws ParseException
```

Parses the text in the specified string from the beginning of the string to produce a `Number`. No leading whitespace is allowed. Any trailing characters after the parsed text are ignored. This method throws the checked `java.text.Parse-Exception` if unsuccessful.

Click here to view code image

```
void setParseIntegerOnly(boolean intOnly)
boolean isParseIntegerOnly()
```

Set or get the status if this formatter should only parse integers.

The class `DecimalFormat` specifically provides the following concrete methods to customize the formatter to parse `BigDecimal` numbers.

Click here to view code image

```
void setParseBigDecimal(boolean newValue)
boolean isParseBigDecimal()
```

Set or get the status if this formatter should parse `BigDecimal` numbers.

The code calling the `parse()` method must be prepared to handle a checked `ParseException`—for brevity, exception handling is omitted in the code below.

The following code shows the Norwegian number formatter from earlier being used to parse strings. At (1), the result is a `long` value because the dot (`.`) in the input string is a delimiter and not a legal character according to the number format used in the Norwegian locale. At (2), the result is a `double` value because the comma (`,`) in the input string is the decimal separator in the Norwegian locale. Note that the print statement prints the resulting number according to the *default* locale (U.S., in this case). For the US locale, the dot (.) and the comma (,) are interpreted as the decimal separator and the group separator, respectively.

Click here to view code image

```
System.out.println(nfNOR.parse("9876.598"));     // (1) 9876
System.out.println(nfNOR.parse("9876,598"));     // (2) 9876.598

System.out.println(nfUS.parse("9876.598"));      // (3) 9876.598
System.out.println(nfUs.parse("9876,598"));      // (4) 9876598
```

In order to parse a string to a `BigDecimal`, we can proceed via a `DecimalFormat` that is customized to parse a `BigDecimal`. The overloaded `parse()` method below returns a `Number`, which is actually a `BigDecimal` in this case.

Click here to view code image

```
DecimalFormat dfUS = (DecimalFormat) nfUS;
dfUS.setParseBigDecimal(true);
BigDecimal bd = (BigDecimal) dfUS.parse("9876,598");
```

The following code demonstrates using a *currency* formatter as a parser. Note that the currency symbol is interpreted according to the locale in the currency formatter.

In the Norwegian locale, the decimal symbol is not a period (`.`) when parsing numbers; it is a *delimiter* in the input string, as can be seen at (1) below. For some locales, a *non-breaking space* (`\u00a0`) may be required between the currency symbol and the first digit, as can be seen at (2).

The grouping symbol in the Norwegian locale is not a space, and therefore, it is interpreted as a delimiter, as can be seen at (3). An explicit nbsp can be used for grouping digits, if necessary, in order to parse the input string, as at (4). For the US locale, no such considerations are necessary, as can be seen at (5).

Click here to view code image

```
System.out.println(cfNOR.parse("kr\u00a09876.59"));        // (1) 9876
System.out.println(cfNOR.parse("kr\u00a09876,59"));        // (2) 9876.59
System.out.println(cfNOR.parse("kr\u00a09 876,59"));       // (3) 9
System.out.println(cfNOR.parse("kr\u00a09\u00a0876,59"));  // (4) 9876.59

System.out.println(cfUS.parse("$9876.59"));                // (5) 9876.59
```

When parsing percentages, a *nbsp* might be required between the percentage value and the percent sign (`%`) in the input string, as can be seen at (1) below for the Norwegian locale. For parsing a percentage value according to the US locale, no such consideration is necessary, as can be seen at (2). However, the format of the percentage value is according to the locale used by the formatter, as can be seen at (1) and (2).

Click here to view code image

```
System.out.println(pfNOR.parse("15,75\u00a0%"));          // (1) 0.1575
System.out.println(pfUS.parse("25.5%"));                  // (2) 0.255
```

Compact Number Formatting

A *compact number formatter* creates a textual representation that represents the *compact form* of a number. This formatter is an instance of the `CompactNumberFormat` that can be created by calling the `getCompactNumberInstance()` factory method of the `NumberFormat` class. For example, the value `1_000_000` can be formatted in a compact form as `"1M"` or `"1 million"`.

The compact form can be specified by the constants of the enum type `Number-Format.Style`, shown in **Table 18.6**. The compact form has a suffix, depending on the value of the number and the locale. Suffixes for the US locale are shown in **Table 18.6**. The compact form of numbers below 1000 is without any suffix.

Table 18.6 *Compact Number Styles*

Styles for compact number form	Verbosity	Suffix for the US locale in compact form
`NumberFormat.Style.SHORT`	Short number format style (default)	`T` (Trillion), `B` (Billion), `M` (Million), `K` (Thousand) Examples: `2T`, `2.5M`, `1.5K`
`NumberFormat.Style.LONG`	Long number format style	`trillion, billion, million, thousand` Examples: `2 trillion`, `2.5 million`, `1.5 thousand`

The code below creates two compact number formatters for the US locale that use the `SHORT` and the `LONG` compact number styles, respectively, to format numbers to their compact form.

Click here to view code image

```
NumberFormat shortCompactFormat = NumberFormat.getCompactNumberInstance(
    Locale.US, NumberFormat.Style.SHORT)
NumberFormat longCompactFormat = NumberFormat.getCompactNumberInstance(
    Locale.US, NumberFormat.Style.LONG);
```

The compact number formatters are used on different numerical values to create their compact form, as shown in **Table 18.7**.

Table 18.7 *Formatting Numbers to Compact Form*

Number `n`	**Compact form returned by `shortCompactFormatter.format(n)` method**	Compact form returned by `longCompactFormatter.format(n)` method
`9_400_000`	`"9M"`	`"9 million"`
`9_500_000`	`"10M"`	`"10 million"`
`12_500`	`"12K"`	`"12 thousand"`
`12_510`	`"13K"`	`"13 thousand"`
`999`	`"999"`	`"999"`
	(Max fraction digits = 2)	*(Max fraction digits = 2)*
`9_400_000`	`"9.4M"`	`"9.4 million"`
`9_500_000`	`"9.5M"`	`"9.5 million"`
`12_500`	`"12.5K"`	`"12.5 thousand"`
`12_510`	`"12.51K"`	`"12.51 thousand"`
`999`	`"999"`	`"999"`

Click here to view code image

```
System.out.println(shortCompactFormat.format(9_400_000));    // 9M
System.out.println(longCompactFormat.format(9_400_000));     // 9 million
```

The second row in Table 18.7 shows the compact form generated after the number of maximum fraction digits is set to 2 (p. 1122):

Click here to view code image

```
shortCompactFormat.setMaximumFractionDigits(2);
longCompactFormat.setMaximumFractionDigits(2);
```

Note the rounding that takes place depending on the value of the number. By default, `RoundingMode.HALF_EVEN` is used (see Table 18.9).

Compact Number Parsing

The `parse()` method of the compact number formatter can be used to parse a string that contains a compact form to a numerical value.

Click here to view code image

```
try {
  System.out.println(shortCompactFormat.parse("9M"));        // 9000000
  System.out.println(longCompactFormat.parse("9 million"));  // 9000000
} catch (ParseException pe) {
  System.out.println(pe);
}
```

The compact number formatters above are used to parse different compact forms to numerical values, as shown in **Table 18.8**. Note that parsing requires that the compact form ends in an appropriate suffix; otherwise, the suffix is ignored, as we can see in **Table 18.8**.

Table 18.8 *Parsing Compact Form to Numbers*

Compact form string `s`	Number returned by `shortCompactFormatter.parse(s)` method	Number returned by `longCompactFormatter.parse(s)` method
`"9M"`	`9000000`	`9`
`"9.5M"`	`9500000`	`9.5`
`"2K"`	`2000`	`2`
`"1.5K"`	`1500`	`1.5`
`"999"`	`999`	`999`
`"9 million"`	`9`	`9000000`
`"9.5 million"`	`9.5`	`9500000`
`"2 thousand"`	`2`	`2000`
`"1.5 thousand"`	`1.5`	`1500`

Specifying the Number of Digits

The following methods of the `NumberFormat` abstract class and its subclass `Decimal-Format` allow formatting of numbers to be further refined by setting the number of digits to be allowed in the integral and the decimal part of a number. This also applies for `BigDecimal` numbers. However, a concrete number formatter can enforce certain limitations on these bounds. In addition, a rounding mode can be set as explained below.

Click here to view code image

```
void setMinimumIntegerDigits(int n)
int  getMinimumIntegerDigits()

void setMaximumIntegerDigits(int n)
int  getMaximumIntegerDigits()

void setMinimumFractionDigits(int n)
int  getMinimumFractionDigits()

void setMaximumFractionDigits(int n)
int  getMaximumFractionDigits()
```

Set or get the minimum or maximum number of digits to be allowed in the integral or decimal part of a number.

Click here to view code image

```
void setRoundingMode(RoundingMode roundingMode)
```

Sets the *rounding mode* used in this number formatter—that is, how the resulting value is rounded by the formatter. The enum type `java.math.RoundingMode` defines constants for such modes (see **Table 18.9**) .

Table 18.9 *Selected Rounding Modes*

Enum type `java.math.RoundingMode` constants	Description

`CEILING`	Rounds toward *positive infinity*.
	`1.1 -> 2 (same as UP)`
	`-1.8 -> -1 (same as DOWN)`

`FLOOR`	Rounds toward *negative infinity*.
	`1.8 -> 1 (same as DOWN)`
	`-1.1 -> -2 (same as UP)`

`UP`	Rounds *away from zero*. Never *decreases* the *magnitude* of the calculated value.
	`1.1 -> 2`
	`-1.1 -> -2`

`DOWN`	Rounds *toward zero*. Never *increases* the *magnitude* of the calculated value.
	`1.8 -> 1`
	`-1.8 -> -1`

`HALF_UP`	Rounds toward the nearest neighboring value, unless both neighboring values are eq tant, in which case it rounds *up*. This is the same as *normal rounding*.
	Click here to view code image
	`1.5 -> 2 (same as UP, if discarded fraction is >= 0.5)`
	`1.4 -> 1 (same as DOWN, if discarded fraction is < 0.5)`
	`-1.4 -> -1 (same as DOWN, if discarded fraction is < 0.5)`
	`-1.5 -> -2 (same as UP, if discarded fraction is >= 0.5)`

`HALF_DOWN`	Rounds toward the nearest neighboring value, unless both neighboring values are eq tant, in which case it rounds *down*.
	Click here to view code image
	`1.6 -> 2 (same as UP, if discarded fraction is > 0.5)`
	`1.5 -> 1 (same as DOWN, if discarded fraction is <= 0.5)`

Enum type `java.math.RoundingMode` constants	Description
	`-1.5 -> -1 (same as DOWN, if discarded fraction is <= 0.5)` `-1.6 -> -2 (same as UP, if discarded fraction is > 0.5)`

`HALF_EVEN`	Rounds toward the nearest neighboring value, unless both neighboring values are eq tant, in which case it rounds toward the even neighbor. This rounding policy is used i ing-point arithmetic in Java.
	Click here to view code image
	`2.5 ->  2 (same as HALF_DOWN, if digit left of discarded fraction is e`
	`1.5 ->  2 (same as HALF_UP, if digit left of discarded fraction is odd`
	`-1.5 -> -2 (same as HALF_UP, if digit left of discarded fraction is odd`
	`-2.5 -> -2 (same as HALF_DOWN, if digit left of discarded fraction is e`

Example 18.5 demonstrates the rounding modes defined by the enum type `java.math.RoundingMode`. The examples in Table 18.9 are computed in Example 18.5. A number format is created at (1) for the US locale. The maximum number of digits in the fraction part is set to 0 at (2); that is, the floating-point value will be rounded to an integer before formatting.

The method `roundIt()` at (3) does the rounding and the formatting when passed a formatter, the maximum number of digits (0) required in the fraction part, the rounding mode, and the two values to round and format. The method sets the maximum number of digits required in the fraction part and the rounding mode at (4) and (5), respectively, in the formatter. The formatting of the values is done by calling the `format()` method at (6) and (7). We encourage checking the output against the rules for rounding for each mode shown in Table 18.9.

Example 18.5 *Rounding Modes*

Click here to view code image

```
import java.math.RoundingMode;
import java.text.NumberFormat;
import java.text.ParseException;
import java.util.Locale;

public class Rounding {

  public static void main(String[] args) {
    System.out.println(" Rounding:   v1          v2");
    NumberFormat nfmtUS = NumberFormat.getNumberInstance(Locale.US);     // (1)
    int maxFractionDigits = 0;                                           // (2)
    roundIt(nfmtUS, maxFractionDigits, RoundingMode.CEILING,   1.1, -1.8);
    roundIt(nfmtUS, maxFractionDigits, RoundingMode.FLOOR,     1.8, -1.1);
    roundIt(nfmtUS, maxFractionDigits, RoundingMode.UP,        1.1, -1.1);
    roundIt(nfmtUS, maxFractionDigits, RoundingMode.DOWN,      1.8, -1.8);
    roundIt(nfmtUS, maxFractionDigits, RoundingMode.HALF_UP,   1.5, 1.4);
    roundIt(nfmtUS, maxFractionDigits, RoundingMode.HALF_UP,   -1.4, -1.5);
    roundIt(nfmtUS, maxFractionDigits, RoundingMode.HALF_DOWN, 1.6, 1.5);
    roundIt(nfmtUS, maxFractionDigits, RoundingMode.HALF_DOWN, -1.5, -1.6);
    roundIt(nfmtUS, maxFractionDigits, RoundingMode.HALF_EVEN, 2.5, 1.5);
```

```
      roundIt(nfmtUS, maxFractionDigits, RoundingMode.HALF_EVEN, -1.5, -2.5);
    }

    static void roundIt(NumberFormat nf, int maxFractionDigits, RoundingMode rMode,
                        double v1, double v2) {                  // (3)
      nf.setMaximumFractionDigits(maxFractionDigits);            // (4)
      nf.setRoundingMode(rMode);                                 // (5)
      System.out.printf("%9s: ", rMode);
      System.out.printf("%5s -> %2s ", v1, nf.format(v1));       // (6)
      System.out.printf("%5s -> %2s%n", v2, nf.format(v2));      // (7)
    }
  }
```

Output from the program:

Click here to view code image

```
  Rounding:   v1          v2
   CEILING:   1.1 ->  2  -1.8 -> -1
     FLOOR:   1.8 ->  1  -1.1 -> -2
        UP:   1.1 ->  2  -1.1 -> -2
      DOWN:   1.8 ->  1  -1.8 -> -1
   HALF_UP:   1.5 ->  2   1.4 ->  1
   HALF_UP:  -1.4 -> -1  -1.5 -> -2
 HALF_DOWN:   1.6 ->  2   1.5 ->  1
 HALF_DOWN:  -1.5 -> -1  -1.6 -> -2
 HALF_EVEN:   2.5 ->  2   1.5 ->  2
 HALF_EVEN:  -1.5 -> -2  -2.5 -> -2
```

Customizing Decimal Number Formatting

The `java.text.DecimalFormat` class formats and parses numbers (including `BigDecimal`) according to a *string pattern*, specified using special *pattern symbols* (**Table 18.10**) and taking into account any locale considerations. It can format numbers as integers (`1234`), fixed-point notation (`3.14`), scientific notation (`2.99792458E8`), percentages (`60%`), and currency amounts (`$64.00`).

Table 18.10 *Selected Number Format Pattern Symbols for the United States*

Pattern symbol	Purpose
`0` (Zero)	Placeholder for a digit. Can result in leading and/or trailing zeroes. Can result in rounding up of the fractional part of a number.
`#` (Hash sign)	Placeholder for a digit. Leading and/or trailing zeroes may be absent. Can result in rounding up of the fractional part of a number.
`.` (Dot)	Placeholder for *decimal separator*. If omitted, a floating-point number is rounded up to the nearest integer. Can be different for other countries. For example, in Germany, the decimal separator is the comma (`,`).
`,` (Comma)	Placeholder for *grouping separator* (a.k.a. *thousands separator*).

Pattern symbol	Purpose
	Can be different for other countries. For example, in Germany, the grouping separator is the period (`.`).

Although the `DecimalFormat` class defines constructors, the Java API recommends using the factory methods of its abstract superclass `NumberFormat` to create an instance of this class.

Click here to view code image

```
NumberFormat df = NumberFormat.getNumberInstance(Locale.US);
if (nf intanceof DecimalFormat) {
  DecimalFormat df = (DecimalFormat) nf;
  df.applyPattern(pattern);                // Supply the pattern.
  String output = df.format(number);       // Format the number.
}
```

The idiom is to create a `DecimalFormat` object as shown above, localized if necessary, and customizing it with a pattern using the method shown below. The overloaded `format()` methods inherited by the `DecimalFormat` class from its superclass `Number-Format` can now be called to format a number. The pattern can also be changed on the fly.

Click here to view code image

```
void applyPattern(String pattern)
```

Applies the given pattern to this `DecimalFormat` object.

Example 18.6 shows formatting of a number, either a `double` at (1a) or a `BigDecimal` at (1b), using different patterns at (2) and different locales at (3). Decimal formatters are created at (4), as explained above. A decimal formatter is customized with a pattern at (5) and the number is formatted at (6). In particular, note how the decimal and group separators are localized for each locale. The currency amounts are also formatted according to the particulars of each locale, and not according to the currency symbol that is specified in the currency patterns.

Example 18.6 *Using the* `DecimalFormat` *class*

Click here to view code image

```
import java.math.BigDecimal;
import java.text.DecimalFormat;
import java.text.NumberFormat;
import java.util.ArrayList;
import java.util.List;
import java.util.Locale;

public class FormattingDecimalNumbers {

  public static void main(String[] args) {
    // The number to format.
    double number = 1234.567;                                          // (1a)
//  BigDecimal number = new BigDecimal("1234.567");                    // (1b)

    // Formats to use:
    String[] patterns = {                                              // (2)
```

```
        "#",
        "###,###.##",
        "###.##",
        "00000.00",
        "BTC ###,###.##",                                          // BTC: Bitcoin
    };

    // Locales to consider:
    Locale[] locales = { Locale.US, Locale.GERMANY };                    // (3)

    // Create localized DecimalFormats:                                     (4)
    List<DecimalFormat> dfs = new ArrayList<>(locales.length);
    for (int i = 0; i < locales.length; i++) {
      NumberFormat nf = NumberFormat.getNumberInstance(locales[i]);
      if (nf instanceof DecimalFormat) {
        dfs.add((DecimalFormat) nf);
      }
    }

    // Write the header:
    System.out.printf("%15s", "Patterns");
    for (Locale locale : locales) {
      System.out.printf("%15s", locale);
    }
    System.out.println();

    // Do formatting and print results:
    for (String pattern : patterns) {
      System.out.printf("%15s", pattern);
      for (DecimalFormat df : dfs) {
        df.applyPattern(pattern);                                      // (5)
        String output = df.format(number);                             // (6)
        System.out.printf("%15s", output);
      }
      System.out.println();
    }
  }
}
```

Output from the program:

Click here to view code image

```
        Patterns          en_US          de_DE
               #           1235           1235
     ###,###.##       1,234.57       1.234,57
         ###.##        1234.57        1234,57
        00000.00       01234.57       01234,57
  BTC ###,###.##   BTC 1,234.57   BTC 1.234,57
```

18.6 Formatting and Parsing Date and Time

The class `java.time.format.DateTimeFormatter` provides the support for locale-sensitive formatting and parsing of *date* and *time* values.

In this section we take a closer look at formatting temporal objects and parsing character sequences for temporal objects. In particular, we consider the following formatters, which provide increasing flexibility in customizing formatting and parsing:

- *Default formatters* are implicitly used by such methods as the `toString()` method of the temporal classes.
- *Predefined formatters* are ready-made formatters provided as constants by the `java.time.format.DateTimeFormatter` class, such as those that adhere to the ISO standard (**Table 18.11**, **p. 1130**).

Table 18.11 *Selected ISO-Based Predefined Formatters for Date and Time*

`DateTimeFormatter`	Examples	Formatting	Parsing

`ISO_LOCAL_TIME`	`12:30:15`	`LocalTime`
		Time part of:
		`LocalDateTime`
		`ZonedDateTime`
			`LocalTime`

`BASIC_ISO_DATE`	`20210428`	`LocalDate`
		Date part of:
		`LocalDateTime`
		`ZonedDateTime`
			`LocalDate`

`ISO_LOCAL_DATE`	`2021-04-28`	`LocalDate`
		Date part of:
		`LocalDateTime`
		`ZonedDateTime`
			`LocalDate`

`ISO_LOCAL_DATE_TIME`	`2021-04-28T12:30:15`	`LocalDateTime`
		Date-time part of:
		`ZonedDateTime`
			`LocalTime`
			`LocalDate`
			`LocalDateTime`

`ISO_ZONED_DATE_TIME`	`2021-04-28T12:30:15+01:00[Europe/Paris]`	`ZonedDateTime`	`LocalTime`
			`LocalDate`
			`LocalDateTime`
			`ZonedDateTime`

`ISO_INSTANT`	`2021-04-28T12:30:15.000000500Z`	`Instant`	`Instant`

- *Style-based formatters* are formatters that use the format styles defined by the constants of the `java.time.format.FormatStyle` enum type (**Table 18.12**, **p. 1132**). These formatters

are created by the static factory methods `ofLocalized*Type*()` of the `DateTimeFormatter` class, where *`Type`* is either `Time`, `Date`, or `DateTime` (Table 18.13, p. 1132).

Table 18.12 *Format Styles for Date and Time*

Styles for date/time	Verbosity	Example formatting a date (default locale: United States)
`FormatStyle.SHORT`	Short-style pattern	`1/11/14`
`FormatStyle.MEDIUM`	Medium-style pattern	`Jan 11, 2014`
`FormatStyle.LONG`	Long-style pattern	`January 11, 2014`
`FormatStyle.FULL`	Full-style pattern	`Saturday, January 11, 2014`

- *Pattern-based formatters* use customized format styles defined by *pattern letters* (Table 18.15, p. 1135). These formatters are created by the static factory method `ofPattern()` of the `DateTimeFormatter` class.

The `DateTimeFormatter` class provides static factory methods for obtaining a formatter. The idiom for using a formatter is to obtain a formatter first, localize it if necessary, and then pass it to the methods responsible for formatting and parsing temporal objects. Each of the temporal classes `LocalTime`, `LocalDate`, `LocalDateTime`, and `ZonedDateTime` provides the following methods: an instance method `format()` and a static method `parse()`. These two methods do the formatting and the parsing according to the rules of the formatter that is passed as an argument, respectively.

Analogous methods for formatting and parsing temporal objects passed as an arguments are also provided by the `DateTimeFormatter` class (see below). For example, the following code lines give the same result string, where `date` and `df` refer to a `LocalDate` object and a `DateTimeFormatter` object for formatting dates, respectively:

Click here to view code image

```
String resultStr1 = date.format(df);
String resultStr2 = df.format(date);
boolean eqStr = resultStr1.equals(resultStr2);    // true
```

From the method headers of the `format()` and the `parse()` methods of the temporal classes, we can see that these methods will readily compile with *any* `DateTime-Formatter`. The validity of the formatter for a given temporal object is resolved at runtime, resulting in a resounding exception if it is not valid.

Click here to view code image

```
// Defined by LocalTime, LocalDate, LocalDateTime, and ZonedDateTime
String format(DateTimeFormatter formatter)
```

Formats this temporal object using the specified formatter, and returns the resulting string. Each temporal class provides this method. The temporal object is formatted according to the

rules of the formatter. The method throws a `java.time.DateTimeException` if formatting is not successful.

Click here to view code image

```
static TemporalType parse(CharSequence text)
static TemporalType parse(CharSequence text, DateTimeFormatter formatter)
```

Each temporal class provides these two static methods, where *`TemporalType`* can be any of the temporal classes `LocalTime`, `LocalDate`, `LocalDateTime`, or `Zoned-DateTime`.

The first method returns an instance of the *`TemporalType`* from a character sequence, using the default parsing rules for the *`TemporalType`*.

The second method obtains an instance of the *`TemporalType`* from a character sequence using the specified formatter.

Both methods return an object of a specific temporal class, and both throw a `java.time.format.DateTimeParseException` if parsing is not successful.

Formatters supplied by the `DateTimeFormatter` class are immutable and thread-safe. All formatters created using static methods provided by the `DateTimeFormatter` class can be localized by `the localizedBy()` method in this class. The `DateTimeFormatter` class provides methods that can be used to format and parse temporal objects.

Click here to view code image

```
// Defined by DateTimeFormatter
DateTimeFormatter localizedBy(Locale locale)
```

Returns a copy of this formatter that will use the specified locale (**§18.1**, **p. 1096**). Although the formatters in the examples presented in this section use the default locale (the US locale in this case), we encourage the reader to experiment with changing the locale of a formatter with this method in the examples.

Click here to view code image

```
String format(TemporalAccessor temporal)
```

Formats a temporal object using this formatter. The main temporal classes implement the `TemporalAccessor` interface.

This method throws an unchecked `java.time.DateTimeException` if an error occurs during formatting.

Click here to view code image

```
TemporalAccessor parse(CharSequence text)
```

This method fully parses the text to produce a temporal object. It throws an unchecked `java.time.DateTimeException` if an error occurs during parsing.

Click here to view code image

```
DateTimeFormatter withZone(ZoneId zone)
```

Returns a copy of this formatter with a new override zone—that is, a formatter with similar state to this formatter but with the override zone set.

Default Formatters for Date and Time Values

Default formatters rely on the `toString()` method of the individual temporal classes for creating a text representation of a temporal object. The default formatter used by the `toString()` method applies the formatting rules defined by the ISO standard.

In the following code, the result of formatting a `LocalTime` object is shown at (1):

Click here to view code image

```
LocalTime time = LocalTime.of(12, 30, 15, 99);
String strTime = time.toString();                // (1) 12:30:15.000000099
LocalTime parsedTime = LocalTime.parse(strTime);  // (2)
System.out.println(time.toString().equals(parsedTime.toString())); // true
```

Each temporal class provides a static method `parse(CharSequence text)` that parses a character sequence using a default formatter that complies with the ISO standard. In the preceding code, the text representation created at (1) is parsed at (2) to obtain a new `LocalTime` object. Not surprisingly, the text representations of the two `LocalTime` objects referred to by the references `time` and `parsedTime` are equal.

The line of code below shows that the argument string passed to the `parse()` method is not in accordance with the ISO standard, resulting in a runtime exception:

Click here to view code image

```
LocalTime badTime = LocalTime.parse("12.30.15");  // DateTimeParseException
```

The examples in this section make heavy use of the `toString()` method to format temporal objects according to the ISO standard.

Predefined Formatters for Date and Time Values

The `DateTimeFormatter` class provides a myriad of predefined formatters for temporal objects, the majority of which comply with the ISO standard. **Table 18.11** shows selected ISO-based predefined formatters from this class. We have also indicated in the last column which temporal classes a formatter can be used with for formatting and parsing.

For example, the row for the `ISO_LOCAL_DATE` formatter in **Table 18.11** indicates that this formatter can be used for formatting a `LocalDate` and for formatting the date part of a `LocalDateTime` or a `ZonedDateTime`. It can parse the text representation of a `LocalDate`. In contrast, the row for the `ISO_LOCAL_DATE_TIME` formatter indicates that this formatter can be used for formatting a `LocalDateTime` and for formatting the date-time part of a `ZonedDateTime.` It can parse the text representation of a `Local-DateTime`. In addition, the text representation of a `LocalDateTime` can be parsed by this formatter to a `LocalTime` or a `LocalDate` by the `parse(text, formatter)` method of the appropriate class.

An example of using an ISO-based predefined formatter is given next. Note that the formatter obtained at (1) is a formatter for date fields. It can be used only with temporal objects that have date fields—in other words, the `LocalDate`, `LocalDateTime`, and `ZonedDateTime` classes. This formatter is passed at (2) to the `format()` method, to create a text representation of a date. The resulting string is parsed at (3) by the `parse()` method that uses the same formatter. The resulting date is also formatted using the same formatter at (4). It is hardly surprising that the text representations of both dates are equal.

Click here to view code image

```
DateTimeFormatter df = DateTimeFormatter.ISO_LOCAL_DATE;     // (1)
LocalDate date = LocalDate.of(1935, 1, 8);
String strDate = date.format(df);                            // (2) 1935-01-08
LocalDate parsedDate = LocalDate.parse(strDate, df);         // (3)
System.out.println(strDate + "|" +
                   parsedDate.format(df));          // (4) 1935-01-08|1935-01-08
```

As this code shows, a formatter can be reused, both for formatting and for parsing. The code at (4) in the code below applies the formatter from (1) in the preceding code snippet to format a `LocalDateTime` object. It should not come as a surprise that the resulting text representation of the `LocalDateTime` object pertains to only date fields in the temporal object; the time fields of the `LocalDateTime` object are ignored. Parsing this text representation back with the same formatter at (5) will yield only a `LocalDate` object.

Click here to view code image

```
LocalDateTime dateTime = LocalDateTime.of(1935, 1, 8, 12, 45);
String strDate2 = dateTime.format(df);                       // (4) 1935-01-08
LocalDate parsedDate2 = LocalDate.parse(strDate2, df);       // (5) LocalDate
```

To summarize, the `DateTimeFormatter.ISO_LOCAL_DATE` can be used to format and parse a `LocalDate`, but can only format the date part of a `LocalDateTime` object (or a `ZonedDateTime` object).

Using this date formatter with a `LocalTime` object is courting disaster, as shown by the following code. Formatting with this formatter results in an unchecked `java.time.temporal.UnsupportedTemporalTypeException`, and parsing results in an unchecked `java.time.format.DateTimeParseException`.

Click here to view code image

```
String timeStr2 = LocalTime.NOON.format(df);   // UnsupportedTemporalTypeException
LocalTime time2 = LocalTime.parse("12:00", df);// DateTimeParseException
```

The `DateTimeFormatter.ISO_INSTANT` predefined formatter shown in **Table 18.11** is implicitly used by the `parse(text)` and `toString()` methods of the `Instant` class.

Style-Based Formatters for Date and Time Values

For more flexible formatters than the predefined ISO-based formatters, the `DateTimeFormatter` class provides the static factory methods `ofLocalized`*`Type`*`()`, where *`Type`* is either `Time`, `Date`, or `DateTime`. These methods create formatters that use a specific format style. However, the format style cannot be changed after the formatter is created. Format

styles are defined by the enum type `java.time.format.Format-Style`, and are shown in **Table 18.12**. The styles define format patterns that vary in their degree of verbosity.

The format style in a style-based formatter can be made locale-specific by setting the desired locale in the formatter using the `localizedBy()` method of the `DateTime-Formatter` class (p. 1128).

Click here to view code image

```
static DateTimeFormatter ofLocalizedTime(FormatStyle timeStyle)
static DateTimeFormatter ofLocalizedDate(FormatStyle dateStyle)
static DateTimeFormatter ofLocalizedDateTime(FormatStyle dateTimeStyle)
static DateTimeFormatter ofLocalizedDateTime(FormatStyle dateStyle,
                                             FormatStylse timeStyle)
```

These static factory methods of the `DateTimeFormatter` class create a formatter that will format a time, a date, or a date-time, respectively, using the specified format style. The formatter can also be used to parse a character sequence for a time, a date, or a date-time, respectively.

In the discussion below, we will make use of the following temporal objects.

Click here to view code image

```
LocalTime time = LocalTime.of(14, 15, 30);             // 14:15:30
LocalDate date = LocalDate.of(2021, 12, 1);            // 2021-12-01
LocalDateTime dateTime = LocalDateTime.of(date, time); // 2021-12-01T14:15:30
// 2021-12-01T14:15:30-06:00[US/Central]
ZonedDateTime zonedDateTime = ZonedDateTime.of(dateTime, ZoneId.of("US/Central"));
```

Table 18.13 shows which temporal classes can be formatted by a combination of a format style from **Table 18.12** and an `ofLocalized`*`Type`*`()` method of the `DateTimeFormatter` class, where *`Type`* is either `Time`, `Date`, or `DateTime`. For example, in **Table 18.13** we can see that the method call `DateTimeFormatter.ofLocalizedDate(FormatStyle.SHORT)` will return a formatter that can be used to format instances of the `LocalDate` class, but will only format the date part of a `LocalDateTime` or a `ZonedDateTime` instance, as can be seen in the code below. This particular formatter requires date fields in the temporal object, and instances of these three temporal classes fit the bill.

Table 18.13 *Using Style-Based Formatters*

	Using formatters created by factory methods of the `DateTimeFormatter` class: *`temporalReference`*`.format(formatter)`		
`Format-Style`	`ofLocalizedTime(style)`	`ofLocalizedDate(style)`	`ofLocalizedDateTime(style)`

`SHORT`
`MEDIUM`
	`LocalTime`
	Time part of:
	`LocalDateTime`
	`ZonedDateTime`
		`LocalDate`
		Date part of:
		`LocalDateTime`
		`ZonedDateTime`
			`LocalDateTime`
			Date-time part of:
			`ZonedDateTime`

Using formatters created by factory methods of the `DateTimeFormatter` class: *`temporalReference`*`.format(formatter)`			
`Format-Style`	`ofLocalizedTime(style)`	`ofLocalizedDate(style)`	`ofLocalizedDateTime(style)`

`LONG`
`FULL`
	Time part of:
	`ZonedDateTime`
		`LocalDate`
		Date part of:
		`LocalDateTime`
		`ZonedDateTime`
			`ZonedDateTime`

Click here to view code image

```
DateTimeFormatter dfs = DateTimeFormatter.ofLocalizedDate(FormatStyle.SHORT);
String str1 = date.format(dfs);           // 12/1/21
String str2 = dateTime.format(dfs);       // Date part: 12/1/21
String str3 = zonedDateTime.format(dfs);  // Date part: 12/1/21
```

Similarly, the method call `DateTimeFormatter.ofLocalizedTime(FormatStyle.LONG)` will return a formatter that will only format temporal objects that have a time part *and* are compatible with the rules of `FormatStyle.LONG`. Only instances of the `Zoned-DateTime` class fit the bill. The code below shows that we can format the time part of a `ZonedDateTime` instance with this formatter.

Click here to view code image

```
DateTimeFormatter tff = DateTimeFormatter.ofLocalizedTime(FormatStyle.FULL);
String str4 = zonedDateTime.format(tff);  // Time part:
                                          //   2:15:30 PM Central Standard Time
String str5 = time.format(tff);           // java.time.DateTimeException
String str6 = date.format(tff);           // java.time.temporal.
                                          //      UnsupportedTemporalTypeException
String str7 = dateTime.format(tff);       // java.time.DateTimeException
```

In summary, a style-based formatter will only format a temporal object (or its constituent parts) if the temporal object has the temporal parts required by the formatter *and* is compatible with the rules of the format style of the formatter.

Table 18.14 shows how the style-based formatters can be used as parsers. As in **Table 18.13**, this table also shows the combination of a format style from **Table 18.12** and an `ofLocalizedType()` method of the `DateTimeFormatter` class, where *`Type`* is either `Time`, `Date`, or `DateTime`. From the table, we can read which temporal objects can be parsed from a character sequence that is compatible with the rules of a formatter for a given combination of the format style and a specific factory method.

Table 18.14 *Using Style-Based Parsers*

	Using parsers created by factory methods of the `DateTimeFormatter` class: *`TemporalClass`*`.parse(characterSequence,formatter)`		
`Format-Style`	`ofLocalizedTime(style)`	`ofLocalizedDate(style)`	`ofLocalizedDateTime(style)`
`SHORT` `MEDIUM`	`LocalTime`	`LocalDate`	`LocalTime` `LocalDate` `LocalDateTime`
`LONG` `FULL`	`LocalTime`	`LocalDate`	`LocalTime` `LocalDate` `LocalDateTime` `ZonedDateTime`

For any format style, the two methods `ofLocalizedTime()` and `ofLocalizedDate()` return formatters that can be used to parse a compatible character sequence to a `LocalTime` or a `LocalDate` instance, respectively.

In the code that follows, the date formatter created at (1) is used at (3) to parse the input string at (2) to create a `LocalDate` object.

Click here to view code image

```
DateTimeFormatter df = DateTimeFormatter.ofLocalizedDate(FormatStyle.SHORT);// (1)
String inputStr = "2/29/21";                        // (2) en_US date, SHORT style
LocalDate parsedDate = LocalDate.parse(inputStr, df);    // (3)
System.out.println(parsedDate);                          // (4) 2021-02-28
```

In the above code, the input string `"2/29/21"` is specified in the short style of the default locale (which in our case is the US locale). The input string is parsed by the date formatter (using the `SHORT` format style) to create a new `LocalDate` object.

Although the value 29 is invalid for the number of days in February for the year 2021, the output shows that it was adjusted correctly. The contents of the input string (in this case, `"2/29/21"`) must be compatible with the rules of the format style in the date formatter (in this case, `FormatStyle.SHORT`). If this is not the case, a `DateTimeParse-Exception` is thrown. Note that in the print statement at (4), the `LocalDate` object from the parsing is converted to a string by the `LocalDate.toString()` method using the implicit ISO-based formatter.

A formatter returned by the `ofLocalizedDateTime()` method can parse a character sequence to instances of different temporal classes, as shown in the rightmost column of **Table 18.14**. This is illustrated by the code below. Such a formatter is created at (1) and localized to the locale for France. It is first used to format a zoned date-time object at (2) to obtain a character string that we can parse with the formatter. At (3), (4), (5), and (6), this sequence is parsed to obtain a `LocalTime`, a `Local-Date`, a `LocalDateTime`, and a `ZonedDateTime`, respectively, as

these temporal objects can be constructed from the format of the character string representing a zoned date-time.

Click here to view code image

```
DateTimeFormatter dtff
    = DateTimeFormatter.ofLocalizedDateTime(FormatStyle.FULL)
                       .localizedBy(Locale.FRANCE);          // (1)

// "mercredi 1 décembre 2021 à 14:15:30 heure normale du centre nord-américain"
String charSeq = zonedDateTime.format(dtff);                 // (2)
LocalTime pTime = LocalTime.parse(charSeq, dtff);            // (3) 14:15:30
LocalDate pDate = LocalDate.parse(charSeq, dtff);            // (4) 2021-12-01

// 2021-12-01T14:15:30
LocalDateTime pDateTime = LocalDateTime.parse(charSeq, dtff);         // (5)

// 2021-12-01T14:15:30-06:00[America/Chicago]
ZonedDateTime pZonedDateTime = ZonedDateTime.parse(charSeq, dtff);    // (6)
```

In summary, a character sequence can be parsed to a temporal object by a style-based formatter if the character sequence is in the format required by the formatter to create the temporal object.

Pattern-Based Formatters for Date and Time Values

For more fine-grained formatting and parsing capabilities for temporal objects, we can use the `ofPattern()` method of the `DateTimeFormatter` class. This method creates immutable formatters that interpret temporal objects according to a string pattern that is defined using the *pattern letters* shown in **Table 18.15**.

Table 18.15 *Selected Date/Time Pattern Letters*

Date or time component	Pattern letter	Examples

Year
(2: two rightmost digits) Proleptic year: use `u` Year of era (AD/BC): use `y`
	`u`
	`uu`
	`uuu`
	`uuuu`
	`uuuuu`
		`2021; -2000 (2001 BC)`
		`15;  0 (i.e., 1 BC); -1 (i.e., 2 BC)`
		`2021; -2021 (i.e., 2022 BC)`
		`02021 (padding)`

Month in year
(1–2: number)
(3: abbreviated text form)
(4: full text form)
	`M`
	`MM`
	`MMM`
	`MMMM`
		`8`
		`08`
		`Aug`
		`August`

Day in month	`d`	`6`

Date or time component	Pattern letter	Examples
	`dd`	`06`

Day name in week
(1–3: abbreviated text form)
(4: full text form)
	`E`
	`EE`
	`EEE`
	`EEEE`
		`Tue`
		`Tue`
		`Tue`
		`Tuesday`

Hour in day (0–23)	`H` `HH`	`9` `09`
Hour in am/pm (1–12) (does not include the AM/PM marker, but required for parsing)	`h` `hh`	`7` `07`
Minute in hour (0–59)	`m` `mm`	`6` `06`
Second in minute (0–59)	`s` `ss`	`2` `02`

Fraction of a second (`S`)	`SSS`
	`SSSSSS`
	`SSSSSSSSS`
		`123`
		`123456`
		`123456789`

Era designator (AD/BC)	`G`	`AD`
Time zone name (1 to 4)	`z` `zzzz`	`CST` `Central Standard Time`

Date or time component	Pattern letter	Examples

Time zone offset (1 to 5)	`Z`
	`ZZZZ`
	`ZZZZZ`
		`-0600`
		`GMT-06:00`
		`-06:00`

Time zone ID (must be two)	`VV`	`US/Central`
AM/PM marker	`a`	`AM`

Period-of-day (used with temporal values having time units)	`B`	`at night`
		`in the morning`
		`noon`
		`in the afternoon`
		`in the evening`

Escape for text	`'`	`'T'` prints as `T`
Single quote	`''`	`'`

Click here to view code image

```
static DateTimeFormatter ofPattern(String pattern)
```

This static method creates a formatter using the specified pattern. The set of temporal objects it can be used with depends on the pattern letters used in the specification of the pattern. The letter pattern defines the rules used by the formatter. The method throws an `IllegalArgumentException` if the pattern is invalid.

Table 18.15 provides an overview of selected pattern letters. All letters are reserved when used in a letter pattern. A sequence of characters can be escaped by enclosing it in single quotes (e.g., `"EEEE 'at' HH:mm"`). Non-letter characters in the string are interpreted verbatim and need not be escaped using single quotes (e.g., `"uuuu.MM.dd @ HH:mm:ss"`). The number of times a pattern letter is repeated can have a bearing on the interpretation of the value of the corresponding date or time field. The uppercase letter `M` (Month of the year) should not be confused with the lowercase letter `m` (minutes in the hour).

A letter pattern can be used to format a temporal object if the temporal object has the temporal fields required by the pattern. The pattern `"'Hour': HH"` can be used to format the hour part of any `LocalTime` object or a `LocalDateTime` object, but not a `LocalDate`.

A letter pattern can be used to parse a string if the string matches the pattern *and* the letter pattern specifies the mandatory parts needed to construct a temporal object. The pattern

`"MM/dd/uuuu"` can be used to parse the string `"08/13/2009"` to obtain a `LocalDate` object, but not a `LocalDateTime` object. The latter requires the time part as well.

Example 18.7 demonstrates both formatting temporal objects and parsing character sequences for temporal objects using letter patterns. The `main()` method at (1) calls four methods to format and parse different temporal objects. The formatting of the temporal object can be localized by specifying the desired locale in the `main()` method.

- The method `usingTimePattern()` at (2) demonstrates using a letter pattern for the time part to both format a `LocalTime` and parse a text representation of a `LocalTime`, respectively. The same pattern is used to format only the time part of a `Local-DateTime` and a `ZonedDateTime`, respectively.
- The method `usingDatePattern()` at (3) demonstrates using a letter pattern for the date part to both format a `LocalDate` and parse a text representation of a `Local-Date`, respectively. The same pattern is used to format only the date part of a `LocalDateTime` and a `ZonedDateTime`, respectively.
- The method `usingDateTimePattern()` at (4) demonstrates using a letter pattern for the date and time parts to both format a `LocalDateTime` and parse a text representation of a `LocalDateTime`, respectively. The same pattern is also used to parse the text representation of a `LocalDateTime` to obtain a `LocalDate` and a `LocalTime`, respectively.
- The method `usingZonedDateTimePattern()` at (5) demonstrates using a letter pattern for the date, time, and zone parts to both format a `ZonedDateTime` and parse a text representation of a `ZonedDateTime`, respectively. The same pattern is also used to parse the text representation of a `ZonedDateTime` to obtain a `LocalDateTime`, a `LocalDate`, and a `LocalTime`, respectively.

The usage of letter patterns with the `ofPattern()` method in **Example 18.7** is analogous to the usage of style-based formatters provided by the `ofLocalized`*`Type`*`()` methods (**Table 18.13**, **p. 1132**). The main difference is that letter patterns provide great flexibility in creating customized format styles.

Example 18.7 *Formatting and Parsing with Letter Patterns*

Click here to view code image

```
import java.time.*;
import java.time.format.*;
import java.util.Locale;

public class FormattingParsingWithPatterns {

  /** Temporals */
  private static LocalTime time = LocalTime.of(12, 30, 15, 99);
  private static LocalDate date = LocalDate.of(2021, 4, 28);
  private static LocalDateTime dateTime = LocalDateTime.of(date, time);
  private static ZoneId zID = ZoneId.of("US/Central");
  private static ZonedDateTime zonedDateTime = ZonedDateTime.of(dateTime, zID);

  public static void main(String[] args) {                              // (1)
    Locale locale = Locale.US;
    usingTimePattern(locale);
    usingDatePattern(locale);
    usingDateTimePattern(locale);
    usingZonedDateTimePattern(locale);
  }

  /** Pattern with time part. */
```

```
  public static void usingTimePattern(Locale locale) {                    // (2)
    String timePattern = "HH::mm::ss:SSS";
    DateTimeFormatter timeFormatter = DateTimeFormatter.ofPattern(timePattern)
                                                       .localizedBy(locale);
    String strTime = time.format(timeFormatter);
    LocalTime parsedTime = LocalTime.parse(strTime, timeFormatter);
    String strTime2 = dateTime.format(timeFormatter);
    String strTime3 = zonedDateTime.format(timeFormatter);

    System.out.printf("Time pattern: %s%n", timePattern);
    System.out.printf("LocalTime (formatted): %s%n", strTime);
    System.out.printf("LocalTime (parsed):    %s%n", parsedTime);
    System.out.printf("LocalDateTime (formatted time part): %s%n", strTime2);
    System.out.printf("ZonedDateTime (formatted time part): %s%n%n", strTime3);
  }

  /** Pattern with date part. */
  public static void usingDatePattern(Locale locale) {                    // (3)
    String datePattern = "EEEE, uuuu/MMMM/dd";
    DateTimeFormatter dateFormatter = DateTimeFormatter.ofPattern(datePattern)
                                                       .localizedBy(locale);
    String strDate = date.format(dateFormatter);
    LocalDate parsedDate = LocalDate.parse(strDate, dateFormatter);
    String strDate2 = dateTime.format(dateFormatter);
    String strDate3 = zonedDateTime.format(dateFormatter);

    System.out.printf("Date pattern: %s%n", datePattern);
    System.out.printf("LocalDate (formatted): %s%n", strDate);
    System.out.printf("LocalDate (parsed)   : %s%n", parsedDate);
    System.out.printf("LocalDateTime (formatted date part): %s%n", strDate2);
    System.out.printf("ZonedDateTime (formatted date part): %s%n%n", strDate3);
  }

  /** Pattern with date and time parts. */
  public static void usingDateTimePattern(Locale locale) {                // (4)
    String dtPattern = "EE, HH::mm::ss 'on' uuuu/MM/dd";
    DateTimeFormatter dtFormatter = DateTimeFormatter.ofPattern(dtPattern)
                                                     .localizedBy(locale);
    String strDateTime = dateTime.format(dtFormatter);
    LocalDateTime parsedDateTime = LocalDateTime.parse(strDateTime,
                                                       dtFormatter);
    LocalDate parsedDate3 = LocalDate.parse(strDateTime, dtFormatter);
    LocalTime parsedTime3 = LocalTime.parse(strDateTime, dtFormatter);

    System.out.printf("DateTime pattern: %s%n", dtPattern);
    System.out.printf("LocalDateTime (formatted):    %s%n", strDateTime);
    System.out.printf("LocalDateTime (parsed):       %s%n", parsedDateTime);
    System.out.printf("LocalDate (parsed date part): %s%n", parsedDate3);
    System.out.printf("LocalTime (parsed time part): %s%n%n", parsedTime3);
  }

  /** Pattern with time zone, date and time parts. */
  public static void usingZonedDateTimePattern(Locale locale) {           // (5)
    String zdtPattern = "EE, HH::mm::ss 'on' uuuu/MM/dd VV";
    DateTimeFormatter zdtFormatter = DateTimeFormatter.ofPattern(zdtPattern)
                                                      .localizedBy(locale);
    String strZonedDateTime = zonedDateTime.format(zdtFormatter);
    ZonedDateTime parsedZonedDateTime
        = ZonedDateTime.parse(strZonedDateTime, zdtFormatter);
    LocalDateTime parsedDateTime2
        = LocalDateTime.parse(strZonedDateTime, zdtFormatter);
    LocalDate parsedDate4 = LocalDate.parse(strZonedDateTime,
```

```
                                          zdtFormatter);
    LocalTime parsedTime4 = LocalTime.parse(strZonedDateTime,
                                          zdtFormatter);

    System.out.printf("ZonedDateTime pattern: %s%n", zdtPattern);
    System.out.printf("ZonedDateTime (formatted):    %s%n", strZonedDateTime);
    System.out.printf("ZonedDateTime (parsed):       %s%n", parsedZonedDateTime);
    System.out.printf("LocalDateTime (parsed):       %s%n", parsedDateTime2);
    System.out.printf("LocalDate (parsed date part): %s%n", parsedDate4);
    System.out.printf("LocalTime (parsed time part): %s%n", parsedTime4);
  }
}
```

Probable output from the program:

Click here to view code image

```
Time pattern: HH::mm::ss:SSS
LocalTime (formatted): 12::30::15:000
LocalTime (parsed):    12:30:15
LocalDateTime (formatted time part): 12::30::15:000
ZonedDateTime (formatted time part): 12::30::15:000

Date pattern: EEEE, uuuu/MMMM/dd
LocalDate (formatted): Wednesday, 2021/April/28
LocalDate (parsed)   : 2021-04-28
LocalDateTime (formatted date part): Wednesday, 2021/April/28
ZonedDateTime (formatted date part): Wednesday, 2021/April/28

DateTime pattern: EE, HH::mm::ss 'on' uuuu/MM/dd
LocalDateTime (formatted):    Wed, 12::30::15 on 2021/04/28
LocalDateTime (parsed):       2021-04-28T12:30:15
LocalDate (parsed date part): 2021-04-28
LocalTime (parsed time part): 12:30:15

ZonedDateTime pattern: EE, HH::mm::ss 'on' uuuu/MM/dd VV
ZonedDateTime (formatted):    Wed, 12::30::15 on 2021/04/28 US/Central
ZonedDateTime (parsed):       2021-04-28T12:30:15-05:00[US/Central]
LocalDateTime (parsed):       2021-04-28T12:30:15
LocalDate (parsed date part): 2021-04-28
LocalTime (parsed time part): 12:30:15
```

18.7 Formatting and Parsing Messages

A *compound message* may contain various kinds of data: strings, numbers, currencies, percentages, dates, and times. The locale-sensitive values in such messages should be formatted according to an appropriate locale. In this section we first consider a solution provided by the `java.text.MessageFormat` class for formatting compound messages. Later we consider the `java.text.ChoiceFormat` class that supports conditional formatting (p. 1145).

An overview of various other support in the Java SE APIs for formatting compound messages can be found at the end of this section (p. 1152).

Format Patterns

The modus operandi of formatters provided by the `MessageFormat` class is a classic one, as exemplified by the `printf()` method called on the `System.out` static field (§1.9, p. 24). A *string pattern* designating *placeholders* for values is specified. `MessageFormat` takes a list of values

and formats them, and then inserts their text representation into the respective placeholders in the pattern to create the final result. The simple example below illustrates the basic use of the `MessageFormat` class.

Click here to view code image

```
String pattern = "At {3} on {2} Elvis landed at {0} and was greeted by {1} fans.";
String output = MessageFormat.format(pattern, "Honolulu", 3000,
                              LocalDate.of(1961,3,25), LocalTime.of(12,15));
System.out.println(output);
```

Output from the code:

Click here to view code image

```
At 12:15 on 1961-03-25 Elvis landed at Honolulu and was greeted by 3,000 fans.
```

The pattern specifies placeholders (called *format elements*) using curly brackets `{}` to designate where text representations of values are to be inserted. The number specified in a format element is the *argument index* of a particular argument in the list of arguments submitted to the formatter. In the code above, the pattern has four format elements.

The variable arity static method `MessageFormat.format()` is passed the pattern and a list of arguments to format. Below, we can see which argument in the method call is indicated by the argument index in a format element that is specified in the pattern above.

Click here to view code image

```
Format element:     {0}      {1}          {2}                    {3}
Arguments:       "Honolulu", 3000, LocalDate.of(1961,3,25), LocalTime.of(12,15)
```

Care must be taken that an argument index in a format element designates the right argument. The same argument index in multiple format elements just means that the argument it designates is applied to all of those format elements.

Note that the text outside of the format elements is copied verbatim to the result string. A single quote (`'`) can be used to quote arbitrary characters, and two single quotes (`''`) can be used to escape a single quote in a pattern. For example, the pattern `"'{1}'"` represents the string `"{1}"`, and not a format element.

The flexibility of the `MessageFormat` class will become clear as we dig into its functionality.

The general syntax of a format element is shown below:

Click here to view code image

```
{ Argument_Index }
{ Argument_Index, Format_Type }
{ Argument_Index, Format_Type, Format_Style }
```

The format type and the format style allow further control over the formatting. The *format type* indicates what kind of argument (e.g., `number`, `date`, or `time`) is to be formatted, and the *format style* indicates how the argument will be formatted (e.g., `currency` format for a `num-`

`ber`, `short` format for a `date`). Legal combinations of format type and format style are shown in **Table 18.16**.

Table 18.16 *Format Type and Format Style Combinations for Format Elements*

Format type value	Format style value that can be specified for a format type
none	*none*
`number`	*none,* `integer, currency, percent,` *subformat pattern*
`date` *or* `time`	*none,* `short, medium, long, full,` *subformat pattern*
`choice` (p. 1145)	*subformat pattern*

The first variant of the format element (first row in **Table 18.16**) was used in the code earlier, where neither format type nor format style is specified. In this case, the text representation of the argument as defined by the `toString()` method is used in the pattern to create the final result. We will explore other combinations from **Table 18.16** in this section.

When format type and format style values are used in a format element, an appropriate formatter is implicitly created to format the argument corresponding to that particular format element. The formatters created are instances of the formatter classes shown in **Figure 18.1**, **p. 1115**. For example, the format element `{3,time,short}` results in a locale-specific formatter being created implicitly by the following method call:

Click here to view code image

```
DateFormat.getTimeInstance(DateFormat.SHORT, getLocale())
```

This formatter will format a `java.util.Date` object (which represents both date and time) by extracting its time components and formatting them according to the format defined by `DateFormat.SHORT` and taking the locale into consideration. If a `MessageFormat` instance does not specify the locale, then the default locale is used.

Format elements that specify the format types `date` and `time` are compatible with the `java.util.Date` legacy class, with subsequent reliance on the `DateFormat` class to provide an appropriate formatter. This presents a slight problem when we want to format date and time values of the new Date and Time API. We will use the static methods of the utility class `ConvertToLegacyDate` (**§17.8**, **p. 1088**) to convert `Local-Date`, `LocalTime`, `LocalDateTime`, and `ZonedDateTime` objects to `Date` objects in order to leverage the format element handling functionality of the `MessageFormat` class.

The pattern that we saw earlier with just vanilla format elements (i.e., format elements with just the argument index) is now shown at (1) below to include the specification of the type and style of the format elements. A `MessageFormat` instance that is based on the pattern at (1) is created at (2) using a constructor of the `Message-Format` class. The arguments that we want to format are included in the `Object` array at (3). Note that the element index in this array corresponds to an argument index in the format elements specified in the pattern. We use the methods from the utility class `ConvertToDate` to convert `LocalTime` and `LocalDate` values to `Date` values (**§17.8**, **p. 1088**). Finally, at (4), the argument array is passed for formatting to the `format()` method inherited by the `MessageFormat` class from its superclass `Format`. The code

below also outlines the pertinent steps that are involved when using a `Message-Format` instance to format compound messages.

Click here to view code image

```
// Specify the pattern:                                                    (1)
String pattern2 = "At {3,time,short} on {2,date,medium} Elvis landed at {0} "
               +  "and was greeted by {1,number,integer} fans.";

// Create a MessageFormat based on the given pattern:                      (2)
MessageFormat mf2 = new MessageFormat(pattern2);

// Create the array with the arguments to format:                          (3)
Object[] messageArguments = {
    "Honolulu",                                          // argument index 0
    3000,                                                // argument index 1
    ConvertToDate.ldToDate(LocalDate.of(1961,3,25)),     // argument index 2
    ConvertToDate.ltToDate(LocalTime.of(12,15))          // argument index 3
};

// Format the arguments:                                                   (4)
String output2 = mf2.format(messageArguments);
System.out.println(output2);
```

Output from the code:

Click here to view code image

```
At 12:15 PM on Mar 25, 1961 Elvis landed at Honolulu and was greeted by 3,000 fans.
```

This output is different from the output we saw earlier when using vanilla format elements. In this case, appropriate formatters are implicitly created for each format element that apply the format style and take into consideration the locale (in this case, it is the default locale, which happens to be the US locale).

The following constructors defined by the `MessageFormat` class are used in the examples in this section:

Click here to view code image

```
MessageFormat(String pattern)
MessageFormat(String pattern, Locale locale)
```

Create a message formatter to apply the specified pattern. The created formatters will format or parse according to the default locale or the specified locale, respectively.

Selected methods are provided by the `MessageFormat` class, many of which are used in the examples in this section:

Click here to view code image

```
final String format(Object obj)       // Inherited from the Format class.
```

Returns a string that is the result of formatting the specified object. Passing an `Object[]` formats the elements of the array individually.

Click here to view code image

```
static String format(String pattern, Object... arguments)
```

This static method implicitly creates a one-time formatter with the given pattern, and returns the result of using it to format the variable arity arguments.

```
void setLocale(Locale locale)
```

Sets the locale to be used when creating subformats. Subformats already created are not affected.

```
Locale getLocale()
```

Returns the locale used by this formatter.

```
void applyPattern(String pattern)
```

Sets the pattern used by this formatter by parsing the pattern and creating the necessary subformats.

```
String toPattern()
```

Returns a pattern that represents the current state of this formatter.

Click here to view code image

```
void setFormat(int formatElementIndex, Format newFormat)
void setFormats(Format[] newFormats)
```

The first method sets the format to use for the format element indicated by the `formatElementIndex` in the previously set pattern string.

The second method sets the formats to use for the format elements in the previously set pattern string. Note that the order of formats in the `newFormats` array corresponds to *the order of format elements in the pattern string*. Contrast this method with the `setFormatsByArgumentIndex()` method.

More formats provided than needed by the pattern string are ignored. Fewer formats provided than needed by the pattern string results in only the provided formats being inserted.

Click here to view code image

```
void setFormatByArgumentIndex(int argumentIndex, Format newFormat)
void setFormatsByArgumentIndex(Format[] newFormats)
```

The first method sets the format to use for the format element indicated by the `argumentIndex` in the previously set pattern string.

The second method sets the formats to use for the format elements in the previously set pattern string. However, note that the order of formats in the `new-Formats` array corresponds to *the order of elements in the arguments array* passed to the format methods or returned by the parse methods. Contrast this method with the `setFormats()` method.

Any argument index not used for any format element in the pattern string results in the corresponding new format being ignored.

Fewer formats being provided than needed results in only the formats for provided argument indices being replaced.

Formatting Compound Messages

If the application is intended for an international audience, we need to take the locale into consideration when formatting compound messages.

Example 18.8 illustrates formatting compound messages for different locales, where locale-sensitive data is contained in resource bundles (**p. 1102**). The program output shows stock information about an item according to the requested locale, showing how formatting of number, currency, date, and time is localized. A resource bundle file is created for each locale. The resource bundle for the US locale is shown in **Example 18.8**. The program output shows stock information for the US locale and the locale for Spain.

Example 18.8 *Formatting Compound Messages*

Click here to view code image

```
# File: StockInfoBundle.properties
pattern = Stock date: {3,time,short}, {4,date,long}\n\
          Item name: {0}\n\
          Item price: {1,number,currency}\n\
          Number of items: {2,number,integer}
item.name = Frozen pizza
item.price = 9.99
```

Click here to view code image

```
import java.text.*;
import java.time.*;
import java.util.*;

public class CompoundMessageFormatting {
  static void displayStockInfo(Locale requestedLocale) {                  // (1)
    System.out.println("Requested Locale: " + requestedLocale);

    // Fetch the relevant resource bundle:                                    (2)
    ResourceBundle bundle =
        ResourceBundle.getBundle("resources.StockInfoBundle", requestedLocale);

    // Create a formatter, given the pattern and the locale:                  (3)
    MessageFormat mf = new MessageFormat(bundle.getString("pattern"),
                                         requestedLocale);

    // Argument values:                                                       (4)
    String itemName = bundle.getString("item.name");
    double itemPrice = Double.parseDouble(bundle.getString("item.price"));
```

```
      int numOfItems = 1234;
      Date timeOnly = ConvertToLegacyDate.ltToDate(LocalTime.of(14,30));
      Date dateOnly = ConvertToLegacyDate.ldToDate(LocalDate.of(2021,3,1));

      // Create argument array:                                          (5)
      Object[] messageArguments = {
          itemName,       // {0}
          itemPrice,      // {1,number,currency}
          numOfItems,     // {2,number,integer}
          timeOnly,       // {3,time,short}
          dateOnly,       // {4,date,long}
      };

      // Apply the formatter to the arguments:                           (6)
      String result = mf.format(messageArguments);
      System.out.println(result);
    }

    public static void main(String[] args) {
      displayStockInfo(Locale.US);
      System.out.println();
      displayStockInfo(new Locale("es", "ES"));
      System.out.println();
    }
  }
```

Output from the program:

Click here to view code image

```
Requested Locale: en_US
Stock date: 2:30 PM, March 1, 2021
Item name: Frozen pizza
Item price: $9.99
Number of items: 1,234

Requested Locale: es_ES
Fecha de stock: 14:30, 1 de marzo de 2021
Nombre del ártículo: Pizza congelada
Precio del articulo: 8,99 ?
Número de artículos: 1.234
```

In **Example 18.8**, the method `displayStockInfo()` at (1) epitomizes the basic steps for using `MessageFormat` for formatting compound messages. The method is passed the requested locale for which the stock information should be displayed. It goes without saying that the stock information is printed only if the relevant resource bundle files can be found.

The `MessageFormat` instance created at (2) is locale-specific. The pattern is read from the resource bundle. It is composed of several lines, and appropriate format elements for each kind of value in the pattern are specified, as shown in the resource bundle for the US locale. The `MessageFormat` instance implicitly creates the necessary formatters for type and style specified in the format elements, and applies them to the corresponding arguments.

The arguments to format are set up at (4). We convert `LocalTime` and `LocalDate` instances to `Date` instances. Another solution is to convert these instances to their text representation beforehand using an appropriate `DateTimeFormatter`. It is also possible to set specific formatters for any argument that is to be formatted. We leave the curious reader to explore these solutions for formatting compound messages.

At (5), an `Object` array is initialized with the arguments. Finally, at (6), the `format()` method is invoked on the formatter, passing the argument array. Again note that the currency delimiter for `?` (euro) is a nbsp in the formatted output, as discussed earlier (p. 1116).

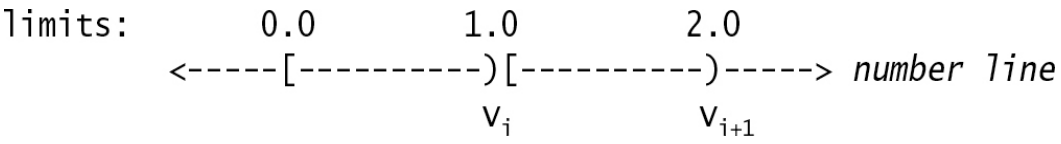
Keep in mind that a `MessageFormat` can be reused, with a new locale, a new pattern, and new arguments:

Click here to view code image

```
MessageFormat mf = new MessageFormat(previousPattern);
mf.setLocale(newLocale);
mf.applyPattern(newPattern);
String output = mf.format(newMessageArguments);
```

Conditional Formatting

Consider *contiguous half-open intervals* on the number line, as shown below. The (lower and upper) *limits* of these intervals can be any numbers, which will always be in ascending order as they are on the number line. Below we see two half-open intervals with limits 0.0, 1.0, and 2.0.



If a value v falls in the half-open interval $[v_i, v_{i+1})$, then we select the (lower) limit v_i. So, if v is any number in the half-open interval `[0.0, 1.0)`, the limit 0.0 is selected. Similarly, if v is any number in the half-open interval `[1.0, 2.0)`, the limit 1.0 will be selected, and so on.

From Table 18.16, we see that the format element having the format type `choice` requires a *subformat pattern*. This subformat pattern specifies a *choice format*. The general syntax of the choice format is shown below, where limit v_i and its associated subformat pattern f_i are separated by the hash sign (#). Each $v_i\#f_i$ constitutes *a choice*, and choices are separated by the vertical bar (|). Two consecutive limits constitute a half-open interval: $[v_i, v_{i+1})$. Note that the last choice uses `<`, meaning any value greater than or equal to v_n. Also, the limits $v_1, v_2, \ldots, v_n$ must be in ascending order for the choice format to work correctly.

$$v_1\#f_1 \mid v_2\#f_2 \mid \ldots \mid v_n<f_n$$

The choice format thus defines the limits and the corresponding choices. When a value is supplied for formatting, the choice format determines the limit, as explained above, and the formatter uses the choice associated with this limit— hence the term *conditional formatting*.

Below is a pattern that uses a choice format. The pattern's only format element has *argument index* 0 and *format type* `choice`, and its subformat pattern specifies a *choice format* (underlined below, but see also Table 18.16). The argument index `0` in the pattern designates the value that is used to determine the limit, and thereby, select the corresponding choice in the choice format.

Click here to view code image

```
"There {0,choice,0#are no bananas|1#is only one banana|\
                                2<are {1,number,integer} bananas}."
```

The choice format above has three choices, separated by the vertical bar (`|`). Its limits are 0, 1, and 2. Each limit in a choice is associated with a subformat pattern. For limits 0 and 1, the subformat pattern is just text. The subformat pattern for limit 2 specifies a format element to format a number as an integer, as it expects an argument to be supplied for this format element. Note that the argument index in this embedded format element is 1.

Example 18.9 uses a pattern that includes the choice format above to illustrate handling of plurals in messages. Resource bundles for different locales contain the pattern with the choice format. An appropriate resource bundle for a locale is fetched at (1). The choice pattern is read from the resource bundle and a `MessageFormat` is created at (2), based on the choice pattern and the requested locale. For each locale, the formatter is tested for three cases, exemplified by the rows of two-dimensional array `messageArguments` at (3). Each row of arguments is passed to the `format()` method at (5) for formatting. The program output shows the arguments passed and the corresponding result.

In the argument matrix, the first row, `{0.5}`, specifies the argument `0.5`, which falls in the half-interval `[0, 1)`. Limit `0` is chosen, whose choice is selected. This results in the following pattern to be applied:

```
"There are no bananas."
```

Similarly for the second row, `{1.5}`, the limit is determined to be `1`, resulting in the following pattern to be applied:

```
"There is only one banana."
```

For the third row, `{2.5, 2}`, the argument `2.5` determines the limit `2`, resulting in the pattern below to be applied. The second element (value `2`) in this row is the argument that is formatted according to the format element in this pattern.

Click here to view code image

```
"There are {1,number,integer} bananas."
```

We see from the program output that the correct singular or plural form is selected depending on the value of the argument passed to the formatter. It is instructive to experiment with passing different values to the formatter.

Example 18.9 *Using Choice Pattern*

Click here to view code image

```
# File: ChoiceBundle.properties
choice.pattern = There {0,choice,0#are no bananas|1#is only one banana|\
                                2<are {1,number,integer} bananas}.
...
```

Click here to view code image

```
import java.text.*;
import java.util.*;

public class ChoicePatternUsage {

  static void displayMessages(Locale requestedLocale) {
    System.out.println("Requested Locale: " + requestedLocale);

    // Fetch the resource bundle:                                          (1)
    ResourceBundle bundle =
        ResourceBundle.getBundle("resources.ChoiceBundle", requestedLocale);

    // choice.pattern = There {0,choice,0#are no bananas|1#is only one banana
    //                                |2#are {1,number,integer} bananas}.
    // Create formatter for specified choice pattern and locale:           (2)
    MessageFormat mf =
        new MessageFormat(bundle.getString("choice.pattern"), requestedLocale);

    // Create the message argument arrays:                                 (3)
    Object[][] messageArguments = { {0.5}, {1.5}, {2.5, 2} };

    // Test the formatter with arguments:                                  (4)
    for (int choiceNumber = 0;
         choiceNumber < messageArguments.length; choiceNumber++) {
      String result = mf.format(messageArguments[choiceNumber]);          // (5)
      System.out.printf("Arguments:%-10sResult: %s%n",
                 Arrays.toString(messageArguments[choiceNumber]),result);
    }
  }

  public static void main(String[] args) {
    displayMessages(new Locale("en", "US"));
    System.out.println();
    displayMessages(new Locale("es", "ES"));
  }
}
```

Output from the program:

Click here to view code image

```
Requested Locale: en_US
Arguments:[0.5]     Result: There are no bananas.
Arguments:[1.5]     Result: There is only one banana.
Arguments:[2.5, 2]  Result: There are 2 bananas.

Requested Locale: es_ES
Arguments:[0.5]     Result: Ahí no hay plátanos.
Arguments:[1.5]     Result: Ahí es solo un plátano.
Arguments:[2.5, 2]  Result: Ahí son 2 plátanos.
```

Example 18.9 illustrates using a choice format for handling plurals. Example 18.10 illustrates an alternative approach where the choice format is created programmatically using the `ChoiceFormat` class.

The class `ChoiceFormat` provides the following constructors for creating a choice format either programmatically or using a pattern.

Click here to view code image

```
ChoiceFormat(double[] limits, String[] formats)
```

Creates a `ChoiceFormat` with the limits specified in ascending order and the corresponding formats.

Click here to view code image

```
ChoiceFormat(String newPattern)
```

Creates a `ChoiceFormat` with limits and corresponding formats based on the specified pattern string.

The `ChoiceFormat` class is locale-agnostic—that is, providing no locale-specific operations. However, the class `MessageFormat` implements locale-specific operations, and allows formats to be set for individual format elements in its pattern. By setting a `ChoiceFormat` as a format for a choice format element in a locale-sensitive `MessageFormat`, it is possible to achieve locale-specific formatting behavior in a `ChoiceFormat`. This approach is illustrated in **Example 18.10**. The numbers below correspond to the numbers on the lines in the source code for **Example 18.10**.

(1) The locale-specific resource bundle with resources for the pattern and for constructing the choice format is fetched. See the listing of the resource bundle file in **Example 18.10**.
(2) A locale-specific `MessageFormat` is created based on the pattern (`"There {0}."`) which is read from the resource bundle.
(3) To create a `ChoiceFormat` programmatically requires two equal-length arrays that contain the limits and the corresponding subformats, respectively. The `double` array `limits` is created with the limit values `0`, `1`, and `2`. A `String` array `messageFormats` is created by reading the values of the keys `none`, `singular`, and `plural` from the resource bundle. These are the subformats corresponding to the limits that we saw in the choice format in **Example 18.9**.
(4) Given the arrays for the limits and the subformats, the `ChoiceFormat` constructor creates the choice format.
(5) and (6) One way to set customized formats for individual format elements in a `MessageFormat` is by first creating an array of `Format` (superclass of format classes in `java.text` package). The order of the formats in this array must be the same as either *the order of format elements in the pattern string* or *the order of elements in the argument array passed to the format methods.* There is only one format element in the pattern (`"There {0}."`). The array of `Format` thus has only one element which is the choice format for this format element, and therefore, both orders are valid in this case. We can use either the `setFormats()` or the `setFormatsByArgumentIndex()` method, as shown at (6a) and (6b), respectively. Either method will associate the choice format with the format element having the argument index 0 in the pattern.
However, the format for the format element at the argument index 0 in the pattern can easily be set by calling the `setFormat()` method, as shown at (6c).
(7) through (9) The behavior of the program is exactly the same as for **Example 18.9**.
Experimenting with other limits and arguments is recommended.

Example 18.10 *Using the* `ChoiceFormat` *Class*

Click here to view code image

```
# File: ChoiceBundle.properties
...
pattern = There {0}.
none = are no bananas
singular = is only one banana
plural = are {1,number,integer} bananas
```

Click here to view code image

```
import java.text.*;
import java.util.*;

public class ChoiceFormatUsage {

  static void displayMessages(Locale requestedLocale)  {
    System.out.println("Requested locale: " + requestedLocale);

    // Fetch the resource bundle:                                          (1)
    ResourceBundle bundle =
        ResourceBundle.getBundle("resources.ChoiceBundle", requestedLocale);

    // Create formatter for specified pattern and locale:                  (2)
    MessageFormat mf = new MessageFormat(
        bundle.getString("pattern"),       // pattern = There {0}.
        requestedLocale
        );

    // Create the limits and the formats arrays:                           (3)
    double[] limits = {0,1,2};                                          // (3a)
    String [] grammarFormats = {                                        // (3b)
        bundle.getString("none"),       // none = are no bananas
        bundle.getString("singular"),   // singular = is only one banana
        bundle.getString("plural")      // plural = are {1,number,integer} bananas
    };

    // Create the choice format:                                           (4)
    ChoiceFormat choiceForm = new ChoiceFormat(limits, grammarFormats);

    // Create the formats:                                                 (5)
    Format[] formats = {choiceForm};

    // Set the formats in the formatter:                                   (6)
    mf.setFormats(formats);                                             // (6a)
//  messageForm.setFormatsByArgumentIndex(formats);                     // (6b)
//  mf.setFormat(0, choiceForm);                                        // (6c)

    // Create the arguments arrays:                                        (7)
    Object[][] messageArguments = { {0.5}, {1.5}, {2.5, 2} };

    // Test the formatter with arguments:                                  (8)
    for (int choiceNumber = 0;
         choiceNumber < messageArguments.length; choiceNumber++) {
      String result = mf.format(messageArguments[choiceNumber]);        // (9)
      System.out.printf("Arguments:%-10sResult: %s%n",
          Arrays.toString(messageArguments[choiceNumber]),result);    }
  }

  public static void main(String[] args)   {
    displayMessages(new Locale("en", "US"));
    System.out.println();
    displayMessages(new Locale("es", "ES"));
```

```
    }
  }
```

Output from the program:

Click here to view code image

```
Arguments:[0.5]     Result: There are no bananas.
Arguments:[1.5]     Result: There is only one banana.
Arguments:[2.5, 2]  Result: There are 2 bananas.

Requested locale: es_ES
Arguments:[0.5]     Result: Ahí no hay plátanos.
Arguments:[1.5]     Result: Ahí es solo un plátano.
Arguments:[2.5, 2]  Result: Ahí son 2 plátanos.
```

Parsing Values Using Patterns

An instance of the `MessageFormat` class can be used both for formatting and for parsing of values. The class provides the parse() methods for parsing text. We will primarily use the one-argument method shown below to demonstrate parsing with the `MessageFormat` class.

Click here to view code image

```
Object[] parse(String source) throws ParseException
Object[] parse(String source, ParsePosition position)
```

The first method parses text from the beginning of the string `source` to return an `Object` array with the parsed values.

The second method parses from the `position` in the string `source` where the parsing should start.

Both methods may not use the entire text of the given string `source`.

The `parse()` methods return an `Object` array with the parsed values, which means that the parsed values must be extracted from the array and cast to the appropriate type in order to compute with them. The cast to the appropriate type must be done safely—typically by determining the type with the `instanceof` operator before applying the cast.

As the one-argument `parse()` method throws a checked `ParseException` when an error occurs under parsing, the code snippets in this subsection must be executed in a context that handles this exception.

The round trip of formatting values and then parsing the formatted result to obtain the same values back is illustrated below. It should not come as a surprise that this round trip always works, as demonstrated by the code below. We see that the argument of type `double` that was formatted and the value of type `double` that was parsed according to the pattern at (1) are equal.

Click here to view code image

```
String pattern = "foo {0,number,currency} bar";                    // (1)
MessageFormat mfp = new MessageFormat(pattern, Locale.US);
Object[] arguments = new Object[] {10.99};            // [10.99]
String formattedResult = mfp.format(arguments);       // "foo $10.99 bar"
Object[] parsedResult = mfp.parse(formattedResult);   // [10.99]
System.out.println((double)arguments[0] == (double)parsedResult[0]); // true
```

A vanilla format element, `{i}`, in a pattern matches a string in the source, as no format type or style is specified for such a format element. The source at (3) matches the format element in the pattern at (2), as is evident from the parse result at (4).

Click here to view code image

```
String patternA = "{0}";                                           // (2)
MessageFormat mfpA = new MessageFormat(patternA, Locale.US);
Object[] parsedResultA = mfpA.parse("One Two Three");              // (3)
System.out.println(parsedResultA[0] instanceof String);   // true
System.out.println(Arrays.toString(parsedResultA));       // (4) [One Two Three]
```

Any text in a pattern must be matched verbatim in the source. Note how the text in the pattern at (5) is matched in the source at (6), with the string `"2"` being returned as the result of parsing.

Click here to view code image

```
String patternB = "One {0} Three";                                 // (5)
MessageFormat mfpB = new MessageFormat(patternB, Locale.US);
Object[] parsedResultB = mfpB.parse("One 2 Three");                // (6)
System.out.println(parsedResultB[0].equals("2"));                  // true
System.out.println(Arrays.toString(parsedResultB));                // [2]
```

The code below illustrates that the `parse()` method may not use the entire text in the source, only what is necessary to declare a match. Parsing stops after the word `Three` in the source at (7) when a match for the pattern has been found in the source.

Click here to view code image

```
Object[] parsedResultC = mfpB.parse("One 2 Three whatever");       // (7)
System.out.println(Arrays.toString(parsedResultC));                // [2]
```

In order for the parse to succeed, the source must contain text that is compatible with the pattern so that it can be parsed according to any type or style specified in the format elements defined in the pattern. At (8) below, the pattern contains two format elements that require an integer and a currency value specified according to the US locale. The source at (9) meets the requirements to match the pattern. The parse result shows that an `int` value and a `double` value were parsed.

Click here to view code image

```
String patternD = "foo {0,number,integer} {1,number,currency} bar";  // (8)
MessageFormat mfpD = new MessageFormat(patternD, Locale.US);
Object[] parsedResultD = mfpD.parse("foo 2021 $64.99 bar");        // (9)
System.out.println(Arrays.toString(parsedResultD));        // [2021, 64.99]
```

We have seen earlier in this chapter that a *nbsp* is necessary in the source in order to parse certain currencies (p. 1119). That is also the case when parsing such currency values with the `MessageFormat` class, and is illustrated below for the Norwegian locale. Unless a *nbsp* is the delimiter between the currency symbol and the first digit of the amount, as shown at (10b), parsing will result in a checked `Parse-Exception` being thrown.

Click here to view code image

```
Locale locale = new Locale("no", "NO");
String pattern1 = "foo {0,number,currency} bar";
MessageFormat mfp1 = new MessageFormat(pattern1, locale);
// String parseSource = "foo kr 10,99 bar";              // (10a) ParseException
String parseSource = "foo kr\u00a010,99 bar";            // (10b) nbsp. OK.
Object[] parsedResults = mfp1.parse(parseSource);
if (parsedResults[0] instanceof Double dValue) {
  System.out.println(dValue);                            // 10.99
}
```

Additional Support for Formatting in the Java SE Platform APIs

In this subsection we mention additional support for formatting values that is provided by various classes in the Java SE Platform APIs.

The class `java.util.Formatter` provides the core support for *formatted text representation* of primitive values and objects through its overloaded `format()` methods. See the Java SE Platform API documentation for the nitty-gritty details on how to specify the format.

Click here to view code image

```
format(String format, Object... args)
format(Locale loc, String format, Object... args)
```

Write a string that is a result of applying the specified `format` string to the values in the variable arity parameter `args`. The resulting string is written to the *destination object* that is associated with the formatter.

The destination object of a formatter is specified when the formatter is created. The destination object can, for example, be a `String`, a `StringBuilder`, a file, or any `OutputStream`.

Return the current formatter.

The classes `java.io.PrintStream` and `java.io.PrintWriter` also provide an overloaded `format()` method with the same signature for formatted output. These streams use an associated `Formatter` that sends the output to the `PrintStream` or the `PrintWriter`, respectively. We have used the `printf()` method of the `PrintStream` class for sending output to the terminal every time this method is invoked on the `System.out` field (§1.9, p. 24).

The `String` class also provides an analogous `format()` method, but it is static. This method also uses an associated `Formatter` for formatting purposes. Unlike the `format()` method of the classes mentioned earlier, this static method returns the resulting string after formatting the values (§8.4, p. 457).

The `java.io.Console` only provides the first form of the `format()` and the `printf()` methods (without the locale specification). These methods too use an associated `Formatter`. They write the resulting string to the console's output stream, and return the current console (§20.4, p. 1256).

Review Questions

18.5 Given the following code:

Click here to view code image

```
import java.text.DecimalFormat;
import java.text.NumberFormat;
import java.util.Locale;

public class DecimalNumberPatternsRQ {
  public static void main(String[] args) {
    // (1) INSERT CODE HERE
    double value = 0.456;
    DecimalFormat df = (DecimalFormat) NumberFormat.getNumberInstance(Locale.US);
    df.applyPattern(pattern);
    String output = df.format(value);
    System.out.printf("|%s|", output);
  }
}
```

Which code, when inserted independently at (1), will result in the following output: `|.46|`?

Select the five correct answers.

a. `String pattern = ".00";`

b. `String pattern = ".##";`

c. `String pattern = ".0#";`

d. `String pattern = "#.00";`

e. `String pattern = "#.0#";`

f. `String pattern = "#.##";`

g. `String pattern = ".#0";`

18.6 Given the following code:

Click here to view code image

```
import java.math.*;
import java.text.*;
import java.util.*;
public class RQ7 {
  public static void main(String[] args) {
    NumberFormat nf = NumberFormat.getCurrencyInstance(Locale.US);
    nf.setMaximumFractionDigits(2);
    nf.setRoundingMode(RoundingMode.HALF_DOWN);
```

```
    double value = 9876.54321;
    String s1 = nf.format(value);
    nf.setRoundingMode(RoundingMode.HALF_UP);
    String s2 = nf.format(value);
    System.out.println(s1 + " " + s2);
  }
}
```

What is the result?

Select the one correct answer.

a. `$9,876.54 $9,876.55`

b. `$9,876.53 $9,876.53`

c. `$9,876.54 $9,876.54`

d. `$9,876.53 $9,876.55`

e. The program will throw an exception at runtime.

18.7 Given the following code:

Click here to view code image

```
import java.math.*;
import java.text.*;
import java.util.*;
public class RQ7Alt {
  public static void main(String[] args) {
    BigDecimal value = new BigDecimal("9876.545");
    NumberFormat nf = NumberFormat.getCurrencyInstance(Locale.US);
    nf.setMaximumFractionDigits(2);
    nf.setRoundingMode(RoundingMode.HALF_DOWN);
    String s1 = nf.format(value);
    System.out.println();
    nf.setRoundingMode(RoundingMode.HALF_UP);
    String s2 = nf.format(value);
    System.out.println(s1+" "+s2);
  }
}
```

What is the result?

Select the one correct answer.

a. `$9,876.55 $9,876.55`

b. `$9,876.54 $9,876.54`

c. `$9,876.55 $9,876.54`

d. `$9,876.54 $9,876.55`

e. The program will throw an exception at runtime.

18.8 Given the following code:

Click here to view code image

```
import java.time.*;
import java.time.format.*;
import java.util.*;
public class RQ8 {
  public static void main(String[] args) {
    LocalDate foolsDay = LocalDate.of(2021, Month.APRIL, 1);
    DateTimeFormatter df = DateTimeFormatter
                              .ofLocalizedDateTime(FormatStyle.SHORT)
                              .localizedBy(Locale.UK);
    System.out.print(df.format(foolsDay));
  }
}
```

What is the result?

Select the one correct answer.

a. `04/01/2021`

b. `01/04/2021`

c. The program will throw an exception at runtime.

d. The program will fail to compile.

18.9 Given the following code:

Click here to view code image

```
import java.time.*;
import java.time.format.*;
import java.util.*;
public class RQ9 {
  public static void main(String[] args) {
    LocalDateTime foolsDay = LocalDateTime.of(2021, Month.APRIL, 1, 14, 30, 0);
    DateTimeFormatter df = DateTimeFormatter.ofPattern("day")
                                            .localizedBy(Locale.UK);
    System.out.print(df.format(foolsDay));
  }
}
```

What is the result?

Select the one correct answer.

a. `1`

b. `01`

c. `1am`

d. `1am21`

e. `1am2021`

f. `1pm`

g. `1pm21`

h. `1pm2021`

i. The program will throw an exception at runtime.

18.10 Given the following code:

Click here to view code image

```
import java.time.*;
import java.time.format.*;
import java.util.*;
public class RQ10 {
  public static void main(String[] args) {
    LocalDate d = LocalDate.of(2021, Month.APRIL, 1);
    Locale.setDefault(Locale.UK);
    DateTimeFormatter df = DateTimeFormatter.ofLocalizedDate(FormatStyle.MEDIUM);
    String s1 = df.format(d);
    Locale.setDefault(Locale.FRANCE);
    String s2 = df.format(d);
    df.localizedBy(Locale.US);
    String s3 = df.format(d);
    if("Apr 1, 2021".equals(s1)) {
      System.out.print("UK ");
    }
    if("1 avr. 2021".equals(s2)) {
      System.out.print("FR ");
    }
    if("1 Apr 2021".equals(s3)) {
      System.out.println("US");
    }
  }
}
```

What is the result?

Select the one correct answer.

a. `UK FR US`

b. `UK US`

c. `UK FR`

d. `FR US`

e. `UK`

f. `FR`

g. `US`

18.11 Given the following code:

Click here to view code image

```
import java.text.*;
import java.util.*;
```

```
public class RQ11 {
  public static void main(String[] args) {
    double x = 0.987654321;
    NumberFormat nf = NumberFormat.getPercentInstance(Locale.US);
    System.out.println(nf.format(x));
  }
}
```

What is the result?

Select the one correct answer.

a. `0.98%`

b. `0.99%`

c. `98%`

d. `99%`

e. `0.987654321%`

f. `987654321%`

18.12 Given the following code:

Click here to view code image

```
import java.text.*;
import java.time.*;
import java.time.format.*;
public class RQ12 {
  public static void main(String[] args) {
    ZoneId london = ZoneId.of("Europe/London");
    ZoneId paris = ZoneId.of("Europe/Paris");
    LocalDateTime date1 = LocalDateTime.parse("2021-01-01T01:01:01",
                                              DateTimeFormatter.ISO_DATE_TIME);
    ZonedDateTime date2 = date1.atZone(london);
    DateTimeFormatter df1 = DateTimeFormatter.ofPattern("hz")
                                             .withZone(london);
    DateTimeFormatter df2 = DateTimeFormatter.ofPattern("hz")
                                             .withZone(paris);
    String result = MessageFormat.format("{0} {1} {2} {3}",
                                         df1.format(date1), df1.format(date2),
                                         df2.format(date1), df2.format(date2));
    System.out.println(result);
  }
}
```

Given that London (GMT) and Paris (CET) time zones are exactly one hour apart, what is the result?

Select the one correct answer.

a. `1GMT 1GMT 1CET 2CET`

b. `1GMT 2GMT 1CET 2CET`

c. `1GMT 1CET 1CET 2CET`

d. `1GMT 2CET 1GMT 2CET`

e. `1GMT 1GMT 2CET 2CET`

18.13 Given the following code:

Click here to view code image

```
import java.text.MessageFormat;
public class RQ13 {
  public static void main(String[] args) {
    String a = "A", b = "B";
    String result = MessageFormat.format("{0}-'{1}'-{3}-{0}-{1}-'{2}'", a, b);
    System.out.println(result);
  }
}
```

What is the result?

Select the one correct answer.

a. `A-{1}--A-B-{2}`

b. `A-B--A-B-{2}`

c. `A-B-{3}-A-B-`

d. `A-{1}-{3}-A-B-{2}`

e. The program will throw an exception at runtime.

18.14 Given the following code:

Click here to view code image

```
import java.text.*;
public class RQ14 {
  public static void main(String[] args) {
    double[] limits = {0,1,2,3,4};
    String[] formats = {"zero","{1}st","{1}nd","{1}rd","{1}th"};
    ChoiceFormat cf = new ChoiceFormat(limits, formats);
    MessageFormat mf = new MessageFormat("{0}");
    mf.setFormat(0, cf);
    Object[] values = {4,5};
    System.out.println(mf.format(values));
  }
}
```

What is the result?

Select the one correct answer.

a. `4th`

b. `5th`

c. `{1}th`

d. The program will throw an exception at runtime.

18.15 Given the following code:

Click here to view code image

```
import java.text.*;
public class RQ15 {
  public static void main(String[] args) {
    double[] limits = {0,-1,1};
    String[] formats = {"zero","negative","positive"};
    ChoiceFormat cf = new ChoiceFormat(limits, formats);
    MessageFormat mf = new MessageFormat("{0}");
    mf.setFormat(0, cf);
    Object[] values = {0.9};
    System.out.println(mf.format(values));
  }
}
```

What is the result?

Select the one correct answer.

a. `zero`

b. `negative`

c. `positive`

d. The program will throw an exception at runtime.

18.16 Given the following code:

Click here to view code image

```
import java.time.*;
import java.time.format.*;
import java.util.*;
public class RQ16 {
  public static void main(String[] args) {
    Locale.setDefault(Locale.US);
    DateTimeFormatter dtf = DateTimeFormatter.ofLocalizedDate(FormatStyle.MEDIUM);
    LocalDate d = LocalDate.parse("Apr 1, 2021", dtf);  // (1)
    d = LocalDate.parse("2021-04-01");                  // (2)
    String s = d.format(dtf);                           // (3)
    System.out.println(s);
  }
}
```

What is the result?

Select the one correct answer.

a. `Apr 1, 2021`

b. `2021-04-01`

c. The program will throw a runtime exception at (1).

d. The program will throw a runtime exception at (2).

e. The program will throw a runtime exception at (3).

18.17 Given the following code:

Click here to view code image

```
import java.time.*;
import java.time.format.*;
import java.util.*;
public class RQ17 {
  public static void main(String[] args) {
    Locale.setDefault(Locale.US);
    DateTimeFormatter dtf = DateTimeFormatter.ofLocalizedDate(FormatStyle.SHORT);
    LocalDate d = LocalDate.parse("2021-04-01");    // (1)
    d = LocalDate.parse("4/1/21", dtf);              // (2)
    System.out.println(d);
  }
}
```

What is the result?

Select the one correct answer.

a. `Apr 1, 2021`

b. `4/1/21`

c. `2021-04-01`

d. The program will throw a runtime exception at (1).

e. The program will throw a runtime exception at (2).

18.18 Which statement is true about localization?

Select the one correct answer.

a. The default locale is `Locale.US`.

b. The default locale is `Locale.ISO`.

c. The default format for the `LocalDate` object is `DateTimeFormatter.BASIC_ISO_DATE`.

d. The default format for the `LocalDate` object is `DateTimeFormatter.ISO_DATE`.